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Activities of daily living in heart transplant candidates.

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ACTIVITIES OF DAILY LIVING
IN HEART TRANSPLANT CANDIDATES

by

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A DISSERTATION

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ABSTRACT OF DISSERTATION
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Title Activities of Daily Living In Heart Transplant Candidates.

The capacity to perform instrumental activities of daily living (IADL; e.g., meal preparation, medication usage, transportation) is largely determined by an individual's cognitive functioning and physical health status. Cognitive deficits among heart transplant candidates have been well documented. Moreover, only patients in poor physical health with end-stage cardiac disease are considered for cardiac transplantation. Thus, heart transplant candidates may be at increased risk for compromised IADL functioning. The current study was designed to examine the predictive validity of neuropsychological test variables and cardiac function measures to IADL capacity among heart transplant candidates. A clinical series of 75 heart transplant candidates and 38 controls completed a battery of neuropsychological tests and a performance-based measure of IADL functioning (i.e., Everyday Problems Test; EPT). The neuropsychological battery consisted of the Abstraction and Vocabulary subscales of the Shipley Institute of Living Scale (SILS), the Reading subtest of the Wide Range Assessment Test (3rd Edition), Parts A and B of the Trail Making Test, Logical Memory I and II subtests of the Wechsler Memory Scale (Revised), Grooved Pegboard test, Short Category Test, and a computer-based task of visual attention (i.e., Useful Field of View; UFOV). Cardiac function data was available for 65 of the heart transplant candidates. Bivariate correlations between demographic characteristics and the EPT total score showed education and race to be significant predictors of overall IADL capacity. Partial correlation analyses, controlling for education and race, showed mild to moderate correlations (rs = 0.25 to 0.50) between most neuropsychological test variables, and the EPT total and subscale scores. Simple attention and memory functioning were largely unrelated to EPT performance. Hierarchical multiple regression analyses, controlling for education and race, showed long- standing verbal intellectual ability (SILS Vocabulary), psychomotor speed and mental flexibility (Trail Making Test Part B), and abstract thinking and problem solving (SILS Abstraction) to be the most consistently related to IADL performance. In general, the Shipley Institute of Living Abstraction subscale had the highest positive predictive power and specificity across all EPT domains, whereas Trail Making Test Part B and the Short Category Test tended to have the highest positive and negative predictive power. Implications and future directions are discussed.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF ABBREVIATIONS

MUGA	Multiple Gated Acquisition of Images
IADL	Instrumental Activities of Daily Living
NYHA	New York Heart Association
SILS	Shipley Institute of Living Scale
SILS-AB	Shipley Institute of Living Scale Abstraction subscale
SILS-VOC	Shipley Institute of Living Scale Vocabulary subscale
PEG	Grooved Pegboard Test
PEG-D	Grooved Pegboard Test dominant hand
PEG-ND	Grooved Pegboard Test nondominant hand
TMT	Trail Making Test
TMT-A	Trail Making Test - Part A
TMT-B	Trail Making Test - Part B
WMS-R-LMI	Wechsler Memory Scale (Revised) Logical Memory I
WMS-R-LMII	Wechsler Memory Scale (Revised) Logical Memory II
CATS	Category Test
WRAT	Wide Range Achievement Test - 3rd edition Reading subscale

INTRODUCTION

Transplantation is the final treatment option for end-stage heart disease patients. Over 34,000 heart transplants were performed through 1995 (Hosenpud et al., 1996). Unfortunately, demand for heart transplants substantially outweighs supply (Stevenson et al., 1994). An estimated 40,000 patients die each year of conditions for which heart transplantation was indicated (O'Connell et al., 1992). In the United States, the number of transplants performed each year has remained stable (2000 per year), while the number of patients on the waiting list continues to grow. Even when a patient is selected, the average waiting period may be one or two years before transplantation (Torre-Amione, Kapadia, Short, & Young, 1996). In an attempt to manage the severe organ shortage, potential recipients undergo a comprehensive medical evaluation to determine eligibility for transplantation.

Selection priority is generally given to patients with poor prognosis (i.e., short-term increased risk of a fatal event) and those with the best chances of successful recovery posttransplantation (Torre-Amione et al., 1996). Hemodynamic indicators of disease stage (e.g., cardiac output, diastolic pulmonary arterial pressure) are considered the primary short-term medical prognostic factors (Campana et al., 1993; Haywood et al., 1996), whereas transplantation recovery may be predicted by a combination of medical and behavioral variables (Miller et al., 1995; Paris, Muchmore, Pribil, Zuhdi, & Cooper, 1994).

A patient's ability to perform activities of daily living (ADL) tasks (e.g., medication use, monitor nutritional intake) are important behavioral variables associated with the prediction of morbidity posttransplant (e.g., psychiatric disturbance, number of rejection episodes, infections and hospital visits) (Brennan, Davis, Buchholz, Kuhn, & Gray, 1987; Paris et al., 1994; Shapiro et al., 1995). Cognitive functioning is thought to mediate ADL capacity and noncompliant behaviors (Kravitz et al., 1993). Indeed, cognitive evaluation of transplant candidates has become a routine part of the transplant evaluation process (Freeman, Watts, & Karp, 1984; Levenson & Olbrisch, 1993; Miller et al., 1995). Despite widespread acceptance, inferences of ADL capacity based on cognitive test performance have not been examined among heart transplant candidates. Identification of cognitive risk factors associated with compromised ADL functioning will benefit both medical staff and patients by targeting intervention and support services.

Activities of Daily Living

Activities considered essential for independent living are grouped into two domains consisting of basic hygiene tasks (e.g., bathing, grooming, transfer) and more complex, instrumental functions (e.g., managing finances and medications, telephone use, shop for necessities, prepare meals, perform basic housekeeping, and utilize transportation). Because instrumental functions are more sensitive to subtle decline (Willis, 1996c) and are more directly related to a patient's capacity to comply with a complex medical regimen, the proposed study will focus on instrumental activities of daily living (IADL) ability level.

In a model proposed by Willis (1991), IADL capacity is determined by individual and environmental antecedent factors. Individual factors include one's cognitive, emotional, and physical health status. Environmental factors include the supportive or limiting nature of an individual's social, cultural, and physical milieu. The model also includes mechanisms that may moderate IADL abilities. One of the best examples of mechanisms affecting IADL capacity is self-efficacy beliefs, which have been shown to either enhance or hinder IADL functioning in geriatric samples (Mendes de Leon, Seeman, Baker, Richardson, & Tinetti, 1996). Since actual IADL ability level is of primary interest in the current study, antecedent factors of IADL performance were examined. More specifically, the predictive validity to IADL capacity was examined for two antecedent factors, physical health and cognitive status, in a group of heart transplant candidates and controls.

Physical Health Markers Among Cardiac Disease Patients

Poor physical health is part-and-parcel of being considered for cardiac transplantation. Transplantation is the final treatment option for patients with end-stage cardiac disease, considered only after all other treatment options have been exhausted. Cardiac disease stage among transplant candidates is generally assessed using a combination of subjective functional limitations and objective attempts to quantify cardiac disease. The most commonly used functional measure is the New York Heart Association (NYHA) classification system, which has four, progressively deteriorating levels: Class I includes patients with cardiac disease, but without resulting limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnea, or anginal pain. Class II includes patients with cardiac disease resulting in slight limitation of physical activity. They are comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea, or anginal pain. Class III includes patients with cardiac disease resulting in marked limitation of physical activity. They are comfortable at rest. Less than ordinary activity causes fatigue, palpitation, dyspnea, or anginal pain. Class IV includes patients with cardiac disease resulting in inability to carry on any physical activity without discomfort. Symptoms of heart failure or anginal syndrome may be present even at rest. If any physical activity is undertaken, discomfort is increased. Objective quantitative attempts to capture cardiac function include numerous measures (i.e., hemodynamic functioning) which are discussed in detail below (see Physical Health and ADL Capacity). In short, measures of cardiac function quantify how efficient the heart is at delivering oxygenated blood to the body. In general, heart transplant candidates are experiencing at least Class III symptoms and have severely reduced cardiac efficiency. Thus, poor physical health may substantially limit IADL performance capacity among heart transplant candidates.

Physical Health and Activities of Daily Living Capacity

The relationship between physical health (e.g., somatic symptoms, self-reported disease states) and self-reported ADL capacity has been demonstrated in several community-based and medical populations (Fillenbaum, 1985; Lawton, 1987; Stewart et al., 1989). For instance, increased health service utilization, institutionalization, and mortality rate has been found among those with impaired basic ADL and IADL functioning (Fillenbaum, 1985; Wolinsky, Johnson, & Fitzgerald, 1992). More specific to the potential relationship between cardiac health status and IADL capacity are epidemiologic (Pinsky, Jette, Branch, Kannel, & Feinleib, 1990) and clinical studies (Hlatky et al., 1986; Neill et al., 1985; Nelson et al., 1991; Stewart et al., 1989; Willis & Marsiske, 1991) that have consistently demonstrated a significant association between indirect self-reported measures of cardiac disease (e.g., angina pectoris, number of cardiac medications) and self-reported IADL functioning. These studies support the assertion that objective measures of both cardiac disease stage and IADL capacity may be related among heart transplant candidates.

Common somatic symptoms (e.g., dyspnea, angina pectoris, fatigue) associated with end-stage cardiac disease are thought to be secondary to poor cardiac function (Torre-Amione et al., 1996). Since multiple homeostatic compensatory mechanisms regulate fluctuations in blood perfusion (Saxena & Schoemaker, 1993), there is no "gold-standard" indicator of cardiac function. Instead, a combination of multiple measures are used to help accurately capture the heart's capacity to perfuse the body. There are, however, several commonly used measures of cardiac function that are routinely collected as part of the heart transplant evaluation process. Heart catheterization is a common assessment procedure of transplant candidacy and yields the following measures of cardiac function: mean arterial pressure, right atrial mean pressure, pulmonary artery mean pressure, pulmonary artery systolic pressure, pulmonary artery diastolic pressure, pulmonary capillary wedge pressure, cardiac output, cardiac index, systemic vascular resistance, and pulmonary vascular resistance. The unit of measurement for all pressure variables is mmHg. Systemic vascular resistance and pulmonary vascular resistance, measured in $\text{dynes}\cdot\text{second}\cdot\text{cm}^{-5}$, are derived from pressure and blood flow variables across the systemic and pulmonary vascular beds, respectively. Cardiac output is an indicator of the amount of blood circulated in 1 min ($\text{l}\cdot\text{min}$). Cardiac index is obtained by dividing cardiac output by the square meters of body surface area to allow for comparisons across patients of different sizes ($\text{l}\cdot\text{min}\cdot\text{m}^2$). Left ventricular ejection fraction is also a commonly used measure of cardiac function. Ejection fraction is an estimate of overall left ventricular contractile strength. More specifically, left ventricular ejection fraction is the ratio of end-diastolic volume minus end-systolic volume divided by end diastolic volume. Left ventricular ejection fraction was estimated using the multiple gated acquisition of images scan.

The cardiac function profile can be separated into load- and non-load-dependent measures. Non-load-dependent measures (e.g., right atrial pressure, cardiac output) are indicative of overall cardiac disease stage and decreased blood perfusion, whereas load-dependent measures (e.g., left ventricular ejection fraction) are related to reduced motor movement tolerance. IADL tasks vary with regard to the amount of cognitive versus motor demand. For instance, financial management involves attention and concentration, problem solving, and mathematical ability. Performance of household chores, however, requires attention and concentration, planning, and sequencing, as well as considerable motor engagement. Thus, load-dependent measures of cardiac function may be related to IADL tasks involving significant motor engagement, but may be largely unrelated to IADL tasks that primarily involve a high cognitive demand. Interestingly, since non-load- dependent measures are related to decreased cerebral perfusion, non-load-dependent measures may act as a moderating variable between cognitive functioning and performance of IADL tasks with a high cognitive load.

Cardiac Function and Cognitive Performance

Fluctuations in cognitive performance have been shown to be directly related to cerebral blood flow among patients with vascular (Meyer, Rogers, Judd, Mortel, & Sims, 1988; Sabri et al., 1998) and Alzheimer's dementia (Bartenstein et al., 1997; Brown et al., 1996; Eberling, Reed, Baker, & Jagust, 1993; Hirsch et al., 1997; Sabbagh et al., 1997), amyotrophic lateral sclerosis (Kew et al., 1993), psychiatric disorders (Dolan, Bench, Brown, Scott, & Frackowiak, 1994), and among elderly community residents experiencing an age-related cognitive decline (Celsis et al., 1997). Moreover, performance on cognitive tests significantly increases cerebral blood flow demand as compared to resting states (Esposito, Van Horn, Weinberger, & Berman, 1996; Hartje, Ringelstein, Kistinger, Fabianek, & Willmes, 1994). These findings suggest that other medical patients with poor hemodynamic function may be at risk for experiencing cognitive deficits.

Cognitive deficits among heart transplant candidates have been well documented (Putzke et al., 1997a). The most common mechanism of cognitive impairment is thought to be decreased cerebral perfusion secondary to reduced cardiac function (Bornstein, Starling, Myerowitz, & Haas, 1995; Sulkava & Erkinjuntti, 1987). It is unclear, however, the extent to which cognitive deficits can be specifically attributed to poor cardiac function versus other risk factors (Putzke et al., 1997a). For instance, approximately 45% of heart transplant candidates have ischemic heart disease (Hosenpud et al., 1996; Putzke et al., 1997a), placing them at increased risk for cerebral vascular disease and peripheral vascular disease (Amarenco et al., 1994; Chimowitz & Mancini, 1992; Graor & Hetzer, 1988; Hertzer, Loop, Beven, O'Hara, & Krajewski, 1989; Hess, D'Cruz, Adams, & Nichols, 1993; Hoeg, 1997) both of which are associated with cognitive deficits (Bornstein & Brown, 1991; Phillips & Mate-Kole, 1997; Phillips, Mate-Kole, & Kirby, 1993). Moreover, cerebral emboli from previous cardiac surgery (e,g., coronary artery bypass graph, valvular surgery) may compromise cerebral vasculature and place those heart transplant candidates with a cardiac surgical history at increased risk for cognitive impairment (Newman et al., 1995; Pugsley et al., 1994; Stump, Rogers, Hammon, & Newman, 1996).

In an attempt to more specifically examine the possible association between cardiac function and cognitive performance, Vingerhoets, Van Nooten, and Jannes (1997) examined patients undergoing coronary artery bypass graft or valvular surgery and used strict inclusion criteria. Only presurgical patients with "no evidence of even minor stenosis in the arteriae carotis communis or interna on a duplex B mode Doppler scan" (p. 481, Vingerhoets et al., 1997) were included. Despite strict inclusion criteria that limited the influence of cerebral vascular disease, cognitive deficits were found on tests of verbal fluency, manual dexterity, verbal learning, and psychomotor speed in subjects compared to controls. These results suggest a direct relationship between cardiac disease and cognitive test performance. Consistent with this hypothesis, Gorkin et al. (1993) found those patients with more severely impaired cardiac function (i.e., NYHA class) showed impaired performance on tasks of simple attention and psychomotor speed. Similarly, a significant correlation between left ventricular ejection fraction and verbal list learning ability ($\underline{r} = .46$) was found among a small group ($\underline{n} = 29$) of heart transplant candidates (Nussbaum, Allender, & Copeland, 1995). In a more comprehensive study, Bornstein et al. (1995) examined 62 heart transplant candidates by using multiple measures of both cardiac function and cognitive ability. Partial correlation analysis controlling for age, education, and depression found that cardiac measures most sensitive to overall disease stage (i.e., right atrial mean pressure, cardiac index, stroke volume index) were moderately correlated ($\underline{r}s = 0.3$ to 0.5) to tasks of manual dexterity, visuospatial memory, psychomotor speed, and mental flexibility.

Recently, we designed a study to replicate and extend the findings of Bornstein et al. (1995). In order to minimize error variance attributable to changes in cardiac or cognitive functioning, only those patients undergoing heart catheterization for hemodynamic measurements within 1 day of the cognitive test performance were included (Putzke, Williams, Rayburn, Kirklin & Boll, 1998). Multiple gated acquisition of images testing was performed within an expanded time frame (mean delay between cognitive and MUGA testing = 3.1 days, maximum 7 days). Participants were 62 patients with end-stage cardiac disease undergoing evaluation for heart transplantation. Multiple demographic and patient characteristics were examined for their potential moderating role in the relationship between measures of cardiac function and cognitive performance, including age, education, race, gender, psychiatric history, medication usage, cardiac surgical history, and self-reported symptoms of depression and anxiety. Only age and education were significantly related to cognitive performance ($p < .01$). Thus, partial correlation analyses, controlling for age and education, were used to examine the relationship between cardiac function and cognitive performance. In general, increasing non-load-dependent hemodynamic pressure variables (i.e., pulmonary artery pressure and right atrial pressure) were related ($rs = -0.32$ to -0.43; $p < .01$) to decreased performance on cognitive tasks assessing simple attention, speeded mental processing and mental flexibility (Digit Span Forward, Trail Making Test Part B, Symbol Digits Modalities Test, Stroop Neuropsychological Screening Test). In contrast, left ventricular ejection fraction, systemic and pulmonary vascular resistance, mean arterial pressure, cardiac output, and cardiac index were largely unrelated to cognitive performance. Taken together, non-load-dependent hemodynamic variables may moderate the relationship between cognitive status and IADL capacity.

Cognitive Test Performance Among Transplant Candidates

Heart transplant candidates are at increased risk of neuropsychological impairment (Farmer, 1994; Nussbaum & Goldstein, 1992) secondary to multiple etiologies including low cardiac output (Bornstein, et al., 1995; Putzke et al., 1998), metabolic disturbances (Lishman, 1988), atherosclerosis (Madl et al., 1994), previous cardiac surgeries and myocardial infarcts (Newman et al., 1995; Pugsley et al., 1994; Stump et al., 1996), and the presence of comorbid medical disorders. Indeed, numerous studies have reported impaired neuropsychological functioning among heart transplant candidates (Augustine, Goldsborough, McKhann, Selnes, & Baumgartner, 1994; Bornstein et al., 1995; Deshields, McDonough, Mannen, & Miller, 1996; Grimm et al., 1996; Hecker, Norvell, & Hills, 1989; Nussbaum et al., 1995; Putzke et al., 1997a; Riether, Smith, Lewison, Cotsonis, & Epstein, 1992; Roman et al., 1997; Schall, Petrucci, Brozena, Cavarocchi, & Jessup, 1989; Strauss et al., 1992). The most consistent impairment has been found on tests of psychomotor speed, mental flexibility, abstract reasoning, and verbal memory functioning.

Although initial studies have found an increased prevalence of neuropsychological impairment among heart transplant candidates, methodological limitations must be considered. Three prominent limitations are of particular concern. First, several studies were preliminary reports examining small samples (Augustine et al., 1994 [n = 10]; Nussbaum et al., 1995 [n = 17]; Roman et al., 1997 [n = 29]). Second, the neuropsychological test batteries employed have sampled from a relatively limited number of cognitive domains (Augustine et al., 1994; Deshields et al., 1996; Grimm et al., 1996; Nussbaum et al., 1995; Riether et al., 1992). Finally, and most importantly, only one study included a normal control group (Grimm et al., 1996). The other studies either used patients undergoing coronary artery bypass graft surgery as a comparative group (Strauss et al., 1992) or compared transplant candidate performance to normative neuropsychological data (Augustine et al., 1994; Bornstein et al., 1995; Deshields et al., 1996; Hecker et al., 1989; Nussbaum et al., 1995; Putzke et al., 1997a; Riether et al., 1992; Roman et al., 1997; Schall et al., 1989). Although most of the neuropsychological test norms include potentially important per-formance adjustments for age, fewer include educational and gender corrections, and none of the normative tables adjust for race. All four of these demographic character-istics have been shown to be important independent predictors of neuropsychological performance within a large sample of 760 heart transplant candidates (Putzke et al., 1997a).

In an attempt to correct for previous methodological limitations, neuropsych-ological performance was examined among a group of patients with end-stage heart disease undergoing routine evaluation for transplantation by using a matched case-control design (Putzke et al., in press). Heart transplant candidates and controls were matched case by case for gender, race, education, and age range. In order to match all 44 controls, a clinical series of 303 heart transplant candidates evaluated between October 1995 through March 1998 were considered. Although not specifically matched on variables of estimated IQ and socioeconomic status, statistical analysis showed no group differences on these variables. A separate analysis of variance on each neuropsychological test indicated that the heart transplant candidates performed significantly worse than controls on tasks of fine motor speed and dexterity (i.e., Grooved Pegboard), psychomotor speed and mental flexibility (i.e., Trail Making Test Part B), and abstract reasoning and problem solving ability (i.e., Shipley Institute of Living Scale Abstraction subtest). Thus, even after controlling for important demographic characteristics, neuropsychological deficits in psychomotor speed, mental flexibility, abstract reasoning and problem solving are found among heart transplant candidates. Thus, cognitive deficits may substantially limit IADL performance among heart transplant candidates.

Cognitive Functioning and Performance-based Activities of Daily Living

A clear understanding of the relationship between cognitive functioning and performance-based IADL capacity has been limited by the use of brief cognitive screening tests (Nadler, Richardson, Malloy, & Marran, 1993; Rozzini, Frisoni, Bianchetti, & Zanetti, 1993; Sager, Dunham, Schwantes, & Mecum, 1992; Skurla et al., 1988; Warren et al., 1989), varying IADL and cognitive test measurement methods and domains assessed, and small sample size (DeBettignies, Mahurin, & Pirozzolo, 1990; Dunn, Searight, Grisso, & Margolis, 1990; Skurla et al., 1988; Warren et al., 1989). In addition, although evidence suggests the predictive validity of cognitive tests varies across populations (Goldstein, McCue, Rogers, & Nussbaum, 1992), previous research has largely focused on geriatric populations (e.g., community dwelling, neurologic, or psychiatric). Moreover, only correlational statistical information has largely been reported, which is of considerable empirical importance but is clinically less applicable. Operating characteristics based on "cut-off" criterion allow for improved clinical judgement by providing a cognitive test's sensitivity, specificity, positive predictive power, and negative predictive power to IADL capacity (see Methods section for explanation of operating characteristics). Two recent studies, however, have made considerable methodological improvements to the examination of the relationship between cognitive performance and IADL capacity.

Goldstein et al. (1992) examined the concurrent and predictive (6 months) validity of multiple memory measures to IADL tasks among three geriatric groups: normal (n = 23), depressed (n = 20), and demented (n = 12). In general, within each group, the total explained IADL variance ranged from 13% to 44%; however, the predictive validity varied substantially across groups. The poorest predictive validity was found among the dementia patients at both baseline and 6-month follow-up. Richardson, Nadler, and Malloy (1995) used an extensive cognitive test battery to predict both ADL and IADL capacity in a heterogeneous sample of 108 geriatric patients referred to a psychiatric hospital. In general, cognitive performance explained from 8% to 37% of the variance across IADL domains. Importantly, with regard to the importance of cognitive functioning in heart transplant candidates, medication administration performance was significantly correlated with every cognitive test. Basic ADL capacity was largely unrelated to cognitive test variables. Visual-spatial abilities tended to have the best specificity, positive predictive power, and negative predictive power across multiple IADL domains (range .61 to .81), whereas memory measures tended to have the highest sensitivity to IADL dependence (.69 to .80). Two tentative conclusions appear reasonable from these studies. First, the utility of cognitive tests as an indicator of ADL capacity tends to be strongest for IADL tasks, accounting for 8% to 44% of the variance. Second, the predictive validity of cognitive measures to IADL functioning tends to vary across groups.

Several factors limit inferences to IADL functioning in heart transplant candidates from previous studies that demonstrated the predictive validity of cognitive tests to IADL capacity. First, although overall intellectual functioning has been found to be strongly correlated with IADL capacity (Heaton & Pendleton, 1981), none of the more recent studies examining the relationship between cognitive functioning and IADL capacity have included a measure of intellectual functioning as a predictor variable. Second, operating characteristics are particularly sensitive to base rate variability in predictor or dependent variables (Retzlaff & Gibertini, 1994). Thus, different prevalence rates in either cognitive impairment or IADL dependence among heart transplant patients versus geriatric samples may significantly alter the predictive validity of cognitive tests. Concerning this possibility, the geriatric populations studied by Richardson et al. (1995) and Goldstein et al. (1992) contained a sizeable percentage of dementia patients (e.g., Alzheimer's disease; 48% and 22%, respectively) with global cognitive impairment typically not seen to that extent among transplant candidates (Farmer, 1994). In regard to the possibility of varying IADL dependence rates that may influence the predictive validity of cognitive measures (compared to heart transplant candidates), Richardson et al. (1995) reported 36% to 56% of the participants were dependent across various IADL tasks. We recently examined IADL capacity among heart transplant candidates, cardiac disease patients not undergoing evaluation for transplantation, and a community control group using a performance-based IADL criterion (Putzke, Williams, Daniel, Arron, Boll, 1999c). Results showed that overall IADL capacity was significantly lower among both the transplant and cardiac disease group than in controls. Moreover, between 22% and 48% of the heart transplant and cardiac disease patients scored within the "probable dependence or need for assistance" range, which is slightly less than that reported by Richardson et al. (1995) in their geriatric sample. Finally, over half of the variance on performance-based IADLs is not explained by cognitive functioning (Goldstein et al., 1992; Richardson et al., 1995), suggesting the presence of other important predictor variables. As previously argued, load-dependent cardiac function measures may be important physical health markers of IADL tasks with a high motor load among heart transplant candidates.

Activities of Daily Living Assessment

Three methods of IADL assessment each with varying strengths and weaknesses are available: self-report, caregiver-based information, and performance-based information. The validity of self-report measures among transplant candidates is particularly problematic because some patients may perceive acceptance into the transplant program to be contingent upon self-report responding (Carnrike, McCracken, & Aikens, 1996). Indeed, about 30% to 40% of patients with end-stage heart (Putzke et al., 1997b) and lung (Putzke, Williams, & Boll, 1998; Putzke, Williams, Daniel & Boll, 1999a; Williams et al., 1997) disease undergoing evaluation for transplantation display a defensive response set on the Minnesota Multiphasic Personality Inventory such as the Gough Dissimulation Index (1950). Furthermore, in an experimental between group study, transplant patients completed self-report measures of emotional functioning either as part of the psychosocial/cognitive exam ($\underline{n} = 56$) or as part of an anonymous research study ($\underline{n} = 30$). Results showed the evaluative group reported significantly less emotional disturbance than both the anonymous research group of cardiac disease control patients ($\underline{n} = 45$) and the normal community controls ($\underline{n} = 20$) (Putzke, Williams, Bourge, Kirklin & Boll, 1999b). Finally, even among patients admitted to a general hospital setting, self-reported ADL capacity tends to be over-estimated, particularly among those experiencing recent decline (Sager et al., 1992).

Similarly, caregiver-based self-report of patient IADL functioning may be limited due to (a) intentional distortion; (b) the lack of opportunities for caregivers to observe the patient engaging in the various IADL tasks; (c) assumed IADL responsibility by the caregiver without testing the patient's capacity; and (d) halo or criticalness errors (Beck, Heacock, Mercer, Walton, & Shook, 1991; DeBettignies et al., 1990; Freeman, Davis, Libb, & Craven, 1992; Meier, 1994; Richardson et al., 1995; Warren et al., 1989). Thus, performance-based tasks may be the most reliable and valid measurement of IADL capacity among heart transplant candidates.

Among the various performance-based measures, there are considerable differences in the methods of assessment. Paper and pencil measures generally involve items requiring basic problem-solving skills on tasks related to a broad range of IADL domains (Willis & Marsiske, 1993). Laboratory-based performance IADL measures attempt to capture real-world functioning by requiring actual motor engagement and often simulate day-to-day tasks (e.g., grocery store mock-up; Nadler et al., 1993). Finally, some performance-based measures involve actual in-home measurement of IADL tasks (Diehl, Willis, & Schaie, 1995). In-home assessment, although labor intensive, most closely captures actual IADL functioning. There are several clear advantages of paper and pencil measures that favor its use in an end-stage cardiac disease population, including ease of administration, minimal response burden, and assessment of a broad range of IADL tasks.

Summary

Cognitive and physical health status are important predictors of IADL capacity. Cognitive deficits among heart transplant candidates have been well documented on tests of fine motor and psychomotor speed, executive functioning, and abstract thinking. Poor cardiac physical health is part-and-parcel of end-stage cardiac disease. Taken together, cognitive deficits and poor physical health suggest heart transplant candidates are at increased risk of compromised IADL functioning. The current study examined the predictive validity of neuropsychological test variables and cardiac function measures to a performance-based IADL criterion among a group of heart transplant candidates. A community group ($\underline{n}$ = 31) without significant medical problems served as a control. It was hypothesized that both neuropsychological tests variables and cardiac function measures would independently predict IADL capacity. A performance-based IADL measure was used to limit the influence of poor insight, as well as the tendency of transplant candidates to minimize problems on self-report measures.

METHOD

Participants

Two groups of participants were included for study. The heart transplant group consisted of a clinical series of 85 patients with end-stage cardiac disease who were undergoing routine psychosocial evaluation prior to acceptance into the heart transplantation program at the University of Alabama at Birmingham. The control group consisted of 38 participants recruited from the community through local advertisement and paid $35.00 dollars for their participation. All controls had no self-reported history of traumatic brain injury, cardiovascular disease, pulmonary disease, or stroke. A fifth-grade reading level was required for study inclusion, which excluded 8 transplant candidates. Two heart transplant candidates refused to participate, leaving a total of 75 participants in the transplant group.

Socioeconomic status was coded using the Barona classification method (Barona, Reynolds, & Chastain, 1984) for the highest obtained occupation. Psychiatric history was operationalized as any previous or current use of anxiolytic or antidepressant medication, therapy, or counseling. It should be noted that this liberal definition of psychiatric history tended to include patients with no prior psychiatric diagnosis who were receiving medication to help cope with commonly seen emotional disruption secondary to their medical condition. Review of the clinical interview indicated none of the patients had a positive history of a psychiatric disorder with severe psychotic features.

Neuropsychological Measures

Patients and controls were administered a neuropsychological test battery that included measures of motor and psychomotor speed, executive functioning, and abstract thinking. The neuropsychological battery was part of a clinical service which limited the number of tests administered. The battery required about 1 hr to complete. The Shipley Institute of Living Scale (SILS; Zachary, 1986) consists of a 20-item test of abstraction and conceptual reasoning (SILS-AB), and a 40-item multiple choice vocabulary test (SILS-VOC). The SILS also provides conversion tables to estimate Wechler Adult Intelligence Scale (Revised) Full Scale IQ (Zachary, 1986). The Grooved Pegboard Test (Matthews & Klove, 1964) was used to assess fine motor speed and dexterity for both the dominant (PEG-D) and nondominant hand (PEG-ND). The Trail Making Test (TMT; 3-min maximum), parts A and B (TMT-A & TMT-B; Reitan & Davison, 1974), was used as a measure of attention/concentration, psychomotor speed, and mental flexibility. Immediate and delayed verbal memory abilities were assessed using the Logical Memory subtest of the Welschler Memory Scale Revised (WMS-R-LMI, WMS-R-LMII; Wechsler, 1987) which involves immediate and 30-minute delayed recall of two short stories (i.e., summed recall across both short stories). The Short Category Test (CATS; Wetzel & Boll, 1987), was used to assess complex reasoning and working memory. Reading achievement was assessed using the Reading subtest of the Wide Range Achievement Test-Third edition (WRAT; Wilkinson, 1993). Tests were given by psychometrists, graduate students, and neuropsychology fellows. One senior psychometrist trained all administrators in accordance with standardized administration and scoring procedures.

Useful Field of View

The Useful Field of View (UFOV; Ball & Owsley, 1993) is a measure of visual attention that has been found to be a general predictor of both retrospective (Ball & Owsley, 1991; Ball, Owsley, & Sloane, 1991; Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Owsley, Ball, Sloane, Roenker, & Bruni, 1991) and prospective (Duchek, Hunt, Ball, Buckles, & Morris, 1997; Owsley et al., 1998) car crashes, as well as a road-based driving test (Cushman, 1996; Roenker, Cissell, & Ball, 1998). The UFOV composite score is generated from three computer-administered subtests involving visual attention (UFOV-VA), divided attention (UFOV-DA), and selective attention (UFOV-SA). Administration time averaged about 10 to 15 min to complete. A composite score was used for analysis, which is generated by adding the three subtests scores.

Medical Variables

Medical records were reviewed for primary cardiac diagnosis, cardiac surgical history, medication usage, and cardiac function data. Heart catheterization data was available for 65 of the 75 transplant candidates and yielded the following measures of cardiac function; right atrial mean pressure, pulmonary artery mean pressure, pulmonary artery systolic pressure, pulmonary artery diastolic pressure, Pulmonary Capillary Wedge Pressure, cardiac output, cardiac index, systemic vascular resistance, and pulmonary vascular resistance. Left ventricular ejection fraction was estimated using the multiple gated acquisition of images scan. Ejection fraction is an estimate of overall left ventricular contractile strength. More specifically, left ventricular ejection fraction is the ratio of end-diastolic volume minus end-systolic volume divided by end diastolic volume.

Instrumental Activities of Daily Living Measure

The Everyday Problems Test (EPT; Willis & Marsiske, 1993) was chosen as the standardized behavioral criterion measure because of its advanced psychometric properties and low response burden. The EPT examines seven IADL domains: financial and medication management, shopping, transportation, telephone use, household maintenance, and food preparation (see Table 1 for examples). The EPT was developed on a sample of 417 non-demented elderly persons (M age = 74.7 years, range 54-95). A summary score is obtained by adding the subscale scores. Each page of the EPT contains two questions at the bottom of the page and the information needed to answer the questions at the top of the page. To minimize response burden, the open-ended 42-item short form was used (Willis & Marsiske, 1993). The EPT short form has acceptable psychometric properties with a Cronbach's alpha of 0.89 and 1-year test-retest reliability of 0.83 (Willis & Marsiske, 1993).

Table 2 presents Cronbach's alpha for the EPT total score (.87) and each subscale, as well as Guttman's split-half reliability estimate of the EPT total score (.87). With the exception of the shopping subscale (0.14), reliability estimates were generally in the acceptable range from 0.44 (medication usage) to 0.63 (housekeeping). Two raters, blind to the neuropsychological and cardiac function data, independently scored the EPT. Scores were compared, and all discrepancies between the two raters were resolved in arbitration with a third independent rater.

Procedure

Heart transplant patients were told about the study at the end of the neuropsychological evaluation and were asked to participate. After obtaining informed consent, patients completed the EPT (Willis & Marsiske, 1993) and UFOV test. Completion of the EPT and UFOV required about 1 hr. The transplant group completed the neuropsychological tests as part of the psychosocial evaluation for transplantation. Control subjects were recruited from the local community. After obtaining informed consent, control subjects completed a questionnaire of background and demographic information, and then completed the cognitive tests, EPT, and the UFOV. The EPT was timed to obtain a measure of IADL efficiency; however, each subject was told "we are more interested in you getting the items right than just rushing through." All participants were seated one arms-length away from a 15" computer screen during administration of the UFOV.

Analysis of the data involved several steps. First, an initial examination of the relationship between demographic characteristics and the EPT total score was explored using the combined groups to determine potential covariates to be controlled in subsequent analyses. Second, between-group analyses of raw scores were examined for the neuropsychological tests and EPT tasks. Third, in order to determine level of impairment, raw scores on the EPT and neuropsychological tests were converted into T-scores using available norms. For descriptive purposes, T-scores were then categorized into performance ranges for each group. Fourth, to determine the strength of the relationship between neuropsychological functioning and ability to perform IADL tasks, a canonical correlation analysis was conducted using the combined groups with the 10 neuropsychological tests as the independent variables and the 7 IADL domains (i.e., the EPT subscales) as dependent variables. Lastly, to determine independent predictors of IADL capacity, separate hierarchical regression analyses were performed using the combined groups with the EPT total and subscale scores as the outcome variable.

Because demographic and cognitive variables have been shown to be important predictors of IADL performance (Putzke et al., 1999c; Richardson et al., 1995), preference was given to these predictor variables in hierarchical regression analyses (i.e., entered in the first or second step). Thus, the first set of regression analyses entered the significant demo-graphic predictors of IADL capacity on the first step, then the neuropsychological test variables were entered in a stepwise fashion of the second step. The second set of hierarchical regression analyses examined the incremental predictive validity of cardiac function measures by entering the significant demographic and cognitive predictors of IADL capacity on the first step, then the cardiac function measures in a stepwise fashion on the second step. The next set of regression analyses examined the incremental predictive validity of cognitive test variables by entering the significant demographic on the first step, cardiac function measures in a stepwise fashion on the second step, the cognitive test variables in a stepwise fashion on the third step.

To more specifically determine which predictor variables are associated with IADL impairment, a series of logistic regressions were conducted with each subscale as the dependent measure dichotomized as independent or "probable dependence or need for assistance" (see below). Group membership, demographic characteristics, and cognitive test scores were entered as the independent variables. Finally, a total number of dependencies variable was calculated by counting the number of subscales that were in the range of "probable dependence or need for assistance" for each individual. Then, the total number of discrepancies was used as the dependent measure in a multiple regression analysis with group, demographic characteristics, and the cognitive test scores as the independent variables.

Besides regression, logistic and correlational analyses described, it was of interest to examine the ability of each neuropsychological test to classify a given individual in terms of independence and dependence within each IADL domain. For each neuropsychological test, a participant's performance was labeled as normal if within 1 standard deviation (or better) from normative means for that test or impaired if less than 1 standard deviation from the normative mean. Criteria for independent or dependent on the EPT task were established that attempted to best balance somewhat conflicting concerns. The criteria for independence or dependence on the EPT attempted to balance the conflicting concerns of (a) appropriate demographic adjustment to performance expectations, (b) actual ability level in each IADL domain irrespective of demographic adjustments, and (c) minimization of false positives. A reasonable compromise was decided that involved a raw score cut-off of 4 on each subtest. This criterion was establish because a raw score of 4 (rounded to the nearest whole number) tended to be slightly below the group mean for each subtest in the younger normative EPT sample (i.e., ages 54 to 74). There was one exception in that the medication subscale raw score cut-off was 5. Thus, the raw score cut-off for independence or dependence for each subscale was 4 except the medication subscale (raw score of 5). Since each subtest contained 6 items, an individual could miss up to 2 items within each IADL domain and still be considered independent (note: could miss only 1 item on the medication subscale). Using these criterion (Putzke et al., 1999c), a consistent percentage between 19% (shopping) and 39% (phone use and transportation) of individuals in the transplant group were categorized within the "probable dependence" range across the IADL domains. Chi-square analyses were then conducted for each neuropsychological test (impaired versus normal) by IADL domain (independent versus dependent), and values were computed to determine each neuropsychological test's positive predictive power (the extent to which an impairment on a given neuropsychological test is associated with dependence in a given IADL domain), negative predictive power (the extent to which a normal performance on a given neuropsychological test is associated with independence in a given IADL domain), sensitivity (the extent to which impairment in a given IADL domain is detected by a given neuropsychological test), and specificity (the extent to which independence in a given IADL domain is classified as normal by the neuropsychological test). This process was then repeated with 2 standard deviations away from normative means as the criterion of impairment on each neuropsychological test.

Raw score of performances on the neuropsychological and EPT tests were used for analyses. There were four separate missing data points on the neuropsychological tests (2 for TMT-B and 2 for PEG-D), which were substituted with the mean on regression analysis. None of the EPT data was missing. Catheterization data was available for 65 patients. Missing data appeared to be random and were first dealt with by deletion of missing cases in the multiple regression analyses. The data were reanalyzed with substitution of the mean to increase power, and the results did not differ from the more conservative analyses. Therefore, the results from mean substitution are presented. Because of the number of analyses conducted, a more stringent criterion for significance of $p < .01$ (Howell, 1982) was used to minimize the likelihood of Type I errors and has been used in previous studies examining IADL (Richardson et al., 1995).

Table 1

Everyday Problem Test Domains, Examples, and Percentage of Dependent Individuals (Combined Groups)

		% Dependent	
Domain	Exemplar task	Transplant candidates	Controls
Medication management	Determining how many doses of cough medicine can be taken in 24-hour period. Completing a patient medical history form.	28.0	18.4
Shopping	Ordering merchandise from a catalog. Comparison of brands of a product.	24.0	7.9
Financial management	Comparison of Medigap Insurance Plans. Completing tax return for income tax form.	33.3	15.8
Transportation	Computing taxi rates. Interpreting driver's right-of-way laws.	44.0	28.9
Telephone use	Determining amount to pay from phone bill. Determining emergency phone information.	49.3	18.4
Household chores	Following instructions for operating a household appliance. Comprehending appliance warrantee.	40.0	13.2
Meal preparation	Evaluating nutritional information on food label. Following recipe directions.	30.7	23.7

Table 2

Everyday Problems Test (EPT) Performance Reliability Estimates

	Cronbach's alpha	Guttman's split-half
EPT total score[a]	.87	.87
Subscales[b]		
Food preparation	.53	
Telephone use	.54	
Financial management	.46	
Transportation use	.60	
Medication use	.44	
Shopping	.14	
Housekeeping	.63	

[a]42 items.
[b]6 items.

RESULTS

The demographic characteristics of the two groups are presented in Table 3. Analysis of variance (ANOVA) and Chi-square analysis indicated that the heart transplant and controls groups did not differ on age (M age = 50 and 47 years, respectively), education (M length = 14 and 15 years, respectively), race (83% and 87% White, respectively), gender (69% and 63% male, respectively), marital status (72% and 55% married, respectively), and socioeconomic status, $p > .01$. The heart transplant group, however, had significantly fewer people currently working (20% versus 74% working in controls) versus a significantly lower estimated IQ (M = 96 versus 106 in controls). The heart transplant group also had significantly more people with a positive psychiatric history (51% versus 0% in controls) and significantly more people currently using psychiatric medications (44% versus 0% in controls).

Table 4 presents the medical information for the heart transplant group. The primary cardiac diagnoses of the transplant group included ischemic cardiac disease 49% ($n = 37$), idiopathic dilated cardiomyopathy 31% ($n = 23$), congenital 5% ($n = 4$), and other 15% ($n = 11$). Thirty-two percent ($n = 24$) of the transplant candidates had a positive history of valvular or coronary artery bypass graft surgery, and 22% had a positive history for myocardial infarction. Heart catheterization data was available for 65 of the heart transplant patients and was performed within 25 days of the neuropsychological evaluation. Mean catheterization data were as follows; right atrial mean pressure

= 8.6 mmHg (SD = 5.3), pulmonary artery mean pressure = 33.3 mmHg (SD = 14.1), pulmonary artery systolic pressure = 46.2 mmHg (SD = 20.6), pulmonary artery diastolic pressure = 23.8 mmHg (SD = 11.0), pulmonary calpillary wedge pressure = 20.9 mmHg (SD = 10.1), cardiac output = 4.3 liters per min (SD = 1.1), cardiac index = 2.2 $l \cdot min \cdot m^2$ (SD = 0.6), systemic vascular resistance = 1451.5 $dynes \cdot sec \cdot cm^{-5}$ (SD = 420.6), and pulmonary vascular resistance = 243.8 $dynes \cdot sec \cdot cm^{-5}$ (SD = 213.7). Mean left ventricular ejection fraction assessed using the multiple gated acquisition of images procedure was 26.5% (n = 69) and was performed within 20 days of the neuropsychological evaluation. Examination of the skewness statistic showed most cardiac function measures had a normal distribution (i.e., with the -1 to 1 range), however, three tests (multiple gated acquisitions--left ventricular ejection fraction, pulmonary vascular resistance, systemic vascular resistance) were outside the commonly accepted cut-off range. Closer examination revealed that all data points were within 3.5 standard deviations from the grand mean, and thus, were not transformed.

Table 5 lists the mean number of medications used and the types of medications used. The mean number of medications used was 8.0 (SD = 3.7) with 30% (n = 22) using ACE inhibitors, 43% (n = 32) antihypertensive agents, 4% (n = 3) beta blockers, 33% (n = 25) other vasodilators, 80% (n = 60) other antihypertensive agents, 77% diuretics, 16% (n = 12) benzodiazepines, and 13% (n = 10) antidepressants. In general, cardiac medication use appears to be unrelated to neuropsychological functioning; however, antidepressants and anxiolytics may reduce performance on tasks of memory and psychomotor speed (Stein & Strickland, 1998). In order to examine the potential detrimental impact of medication use on cognitive function, simple bivariate correlations were generated between the neuropsychological tests scores and medication usage.

Medication usage was coded as the total number of medications and as the presence or absence of each drug type. The only correlations found to be significant at the .01 level was between the CATS and other antihypertensive agent usage ($r = 0.40$).

Cognitive Performance

Group means and standard deviations of all neuropsychological test variables are given in Table 6. Examination of the skewness statistic showed most tests had a normal distribution (i.e., within the -1 to 1 range). Four tests, PEG-D, PEG-ND, TMT-B and UFOV composite score, tended to show a skewed distribution (i.e. outside the -1 to 1 range). Closer examination revealed, however, that all data points were within 3 (TMT-B, UFOV composite score) or 4 (PEG-D, PEG-ND) standard deviations from the grand mean, and thus, were not transformed. In order to determine overall group differences on cognitive test performance, a multivariate analysis of variance (MANOVA) was performed using the neuropsychological test scores as the dependent variables and group (i.e., transplant candidates, controls) as the between subjects factor. Results indicate a significant overall group effect, Wilks' $\lambda = .741$, $F(13,91) = 2.44$, $p = .007$. Follow-up univariate ANOVAs were performed on each neuropsychological variable. Despite the use of age- and education-matched controls, the heart transplant group showed a significantly lower long-standing vocabulary ability (SILS-VOC), $F(1,111) = 9.27$, $p = .003$. The heart transplant group also displayed significant bilateral slowing of fine motor speed and dexterity (PEG-D, PEG-ND), Fs $(1, 107) = 8.10$ and 6.50, ps $= .005$ and $.010$, respectively. The transplant group also performed significantly worse on a task of psychomotor speed and mental flexibility (TMT-B), $p = .008$, as well as a task of abstract reasoning and problem solving ability (SILS-AB), $p < .001$. The composite score of visual attention was also significantly different between groups (UFOV composite score), p < .01. Memory measures (WMS-R-LMI, WMS-R-LMII), working memory and spatial reasoning (CATS), and individual subtests of visual attention (UFOV-PS, UFOV-DA, UFOV-SA) were not significantly different between groups, p > .01.

To examine the utility of normative data as a comparative group, T-scores based on available norms were generated for each patient on each neuropsychological test variable. Results showed that mean T-scores for the heart transplant group were within the average range on all neuropsychological test variables (Table 7). These results suggest that for our sample, available norms tended to underestimate impairment in neuropsych-ological functioning, as compared to direct comparison of raw scores with controls. Clinically, categorical performance ranges are often used to identify level of neuropsychological impairment. Thus, T-scores were also separated into performance ranges by using a modification of commonly used criteria (Heaton, Grant, & Matthews, 1991). Specifically, T-scores 40 and above were considered as being within the normal range, 30-39 were considered mildly impaired, and below 30 were considered moderately to severely impaired. As shown in Table 7, there is considerable variability in the categorization of level of impairment between groups on several test variables.

Performance ranges on the UFOV was determined somewhat differently than the neuropsychological tests. Participants from both group were separated into five risk categories (Very Low to Very High) based on their performance on the three UFOV screening tests (Ball, 1998). Examination of the number of heart transplant candidates and controls showed 48 (67%) and 33 (86%) in the Very Low risk category level, 14 (19%) and 5 (13%) in the Low risk category, 5 (7%) and 0 (0%) with Low to Moderate risk, 2 (3%) and 0 (0%) with Moderate to High risk, and 3 (4%) and 0 (0%) in the High risk category, respectively (see Table 8). After collapsing scores across the Low and Low to Moderate category, and the Moderate to High and High risk category (leaving three levels; Very Low, Moderate, and High), chi-square analysis showed that the heart transplant candidates had a significantly higher proportion of individuals in the moderate to high risk range, $\chi^2 = 6.01$, $p = .05$.

Everyday Problems Test Performance

Group means and standard deviations of the EPT total and subscale scores are given in Table 9. Examination of the distribution of scores showed only the medication subscale to have a skewness statistic (i.e., -1.73) outside the -1 to 1 range (generally accepted cut-offs). Since 6 was the maximum score on any given subscale and the mean on the medication scale was 5, the negatively skewed distribution suggested the possibility of ceiling effects on the medication subscale. Since the groups were not different on important demographic predictors of EPT capacity (education and race; see correlational analysis below), group differences on the EPT were examined without covariates. Results show the EPT total score was significantly lower among the heart transplant group, $F(1,111) = 13.65$, $p < .001$. MANOVA using the EPT subscales as the dependent variables and group as the between subjects factor indicated a significant overall group effect, Wilks' $\lambda = .837$, $F(7,105) = 2.93$, $p = .008$. Follow-up univariate ANOVAs revealed that the heart transplant group also performed significantly worse on the telephone use, financial management, transportation, shopping, and housekeeping subscales, $p < .01$.

As with the neuropsychological tests, scores on the EPT test were separated into T-score performance ranges based on the EPT norms. The EPT manual provided both education- and gender-corrected norms (Willis & Marsiske, 1993). Education-corrected norms were used because gender was unrelated to EPT performance in our sample (see correlational analyses below). Table 10 shows the percentage of heart transplant and controls within each performance range. Again, considerable variability was found across all performance ranges.

Prediction of Everyday Problems Test Performance

The groups were combined, and bivariate correlational analyses between the EPT total score and demographic variables were examined to identify important covariates to be used in subsequent analyses. Table 11 shows that education and race were significantly related to the EPT total score, $p < .01$, whereas gender, age, marital status and socioeconomic status were unrelated to EPT performance. Whites and those with more education performed significantly better on the EPT. Table 12 displays the partial correlational analyses, controlling for education and race, between the neuropsychological tests and EPT subscales. Results showed SILS-AB and TMT-B were significantly related to every IADL domain (rs = 0.27 to 0.51), $p < .01$. In contrast, TMT-A, PEGS-D, WMS-R-LMII, UFOV-PS and CATS were largely unrelated to IADL functioning. SILS-VOC and UFOV composite scores were related to 6 of the 7 IADL domains; WRAT, UFOV-DA, and UFOV-SA were significantly related to 4 of the 7 IADL domains; and PEGS-ND was related to 3 of the 7 domains.

Canonical correlation analysis yielded 1 significant canonical variate, $F(17,89) = 2.36$, $p < .01$. The variate yielded a canonical correlation of .56, accounting for 31% of the variance and suggesting a moderate but significant relation among neuropsychological functioning and IADL performance. Examination of the canonical structure indicated that all neuropsychological variables were significantly correlated to the canonical variate except WSM-R-LMI, WSM-R-LMII, and CATS (with a standard cut-off of .30 for interpretation; Richardson et al., 1995). The SILS-AB had the highest correlation (.73), followed by SILS-VOC (.56), and TMT-B (-.45). Of the IADL variables, EPT Phone use had the highest loading (.67), followed by EPT Household chores (.50) and EPT Transportation (.45).

Because of potential equation instability secondary to multicollinearity, correlations between the cognitive predictor variables were examined prior to performing regression analyses. In general, the correlation coefficients were less than 0.5, minimizing concerns of multicollinearity. There were two exceptions to this general finding. The correlations between WMS-R-LMI and WMS-R-LMII, and between PEGS-D and PEGS-ND was .86 and .75, respectively. Hierarchical regression analyses, controlling for education and race, predicting the overall EPT total score indicated the same significant predictors if PEGS-D, WMS-R-LMII, or both were left out. Thus, all variables were included in the regression analyses.

Hierarchical regressions, controlling for education and race, were conducted separately for each of the outcome variables (i.e., EPT total and subscale scores). All predictor variables were transformed to standardized (i.e., z) scores before analysis. Table 13 gives a summary of the significant neuropsychological predictors of each EPT total and subscale score. Tables 14 through 21 provide more detailed information on each regression analyses. All regression equations were significant at the .01 level. The multiple Rs ranged from 0.58 to 0.82, indicating that the combination of race, education, and neuropsychological tests accounted for between 34% to 67% of the variance in IADL performance. After controlling for education and race, SILS-VOC and TMT-B were the most consistently related to IADL performance (βs ranged from .26 to .45, ps < .05). In each case, decreased neuropsychological performance was associated with decreased IADL functioning (note: timed neuropsychological tasks had negative β weights since increased time indicated worse performance). SILS-VOC was a significant independent predictor in 6 of the 8 regression models, TMT-B in 5 of the 8 regression models, UFOV composite in 3 of 8 regression models, SILS-AB, TMT-A, WRAT and PEG-ND in 2 of 8 regression models, and CAT and PEG-D were included in one regression model. WMS-R-LMI and WMS-R-LMII were not included in any of the regression models.

Because of potential equation instability secondary to multicollinearity, correlations between the cardiac function measures were examined prior to performing regression analyses. In general, the correlation coefficients were less than 0.5, minimizing concerns of multicollinearity. However, there were seven exceptions to this general finding. Correlations between the following pairs ranged from .70 and .87; right atrial mean pressure and pulmonary artery systolic pressure, right atrial mean pressure and pulmonary artery diastolic pressure, pumonary capillary wedge pressure and right atrial mean pressure, pulmonary artery mean pressure and pulmonary artery diastolic pressure, pulmonary capillary wedge pressure and pulmonary artery diastolic pressure, pulmonary vascular resistance and pulmonary artery mean pressure, cardiac index and cardiac output. Regression analyses, controlling for education and race, were performed leaving out the highly correlated cardiac function predictor variables (right atrial mean pressure, pulmonary artery diastolic pressure, pulmonary vascular resistance, and cardiac output) using the EPT total score as the outcome measure. Results show that the cardiac function data failed to significantly predict EPT total score even when entered in a stepwise fashion on the second step (first step, education and race; enter method; third step, neuropsychological test variables; stepwise entry). Since the findings were negative with (see below) or without the highly correlated cardiac function measures, they were all retained in the regression analyses examining the predictive validity of cardiac function data to IADL capacity.

In order to examine the incremental predictive validity of cardiac function, separate hierarchical regressions were conducted for each outcome variable (i.e., EPT total and subscale scores) with education and race entered on the first step, and the cognitive variables significantly predictive of each IADL domain (i.e., from the first set of regression analyses) on the second step, and then entering cardiac function data in a stepwise fashion on the third step. Only heart transplant patients with catheterization data were used for analyses (n = 65). Table 22 provides a summary of the hierarchical regression analyses, and Tables 23 through 39 provide detailed information for each model tested. With few exceptions, cardiac function data failed to provide incremental predictive validity to IADL capacity after controlling for education, race, and significant cognitive predictors. To further explore the predictive validity of cardiac function data, regression analyses were rerun, this time with education and race entered on the first step, cardiac function data entered in a stepwise fashion on the second step, and cognitive test variables entered in a stepwise fashion on the third step. Table 31 summarizes these results. In general, cardiac function data once again failed to predict IADL capacity. Equally important was the fact that the same two major cognitive predictors of IADL performance reappeared, SILS-VOC and TMT-B.

Operating Characteristics of Neuropsychological Tests

Contingency tables were generated to examine the association between rates of dependence within a given instrumental IADL domain and rates of impairment on a given neuropsychological test. Tables 32-51 contain the operating characteristics (i.e., positive and negative predictive power, sensitivity, and specificity) for each neuropsychological test. Each neuropsychological test has two tables of operating characteristics with impairment defined as either less than 1 standard deviation or less than 2 standard deviations from normative means. Three neuropsychological tests had clear T-score floor effects in that none of participants were categorized as impaired at the less than 2 standard deviation range, SILS-AB, CATS, and WRAT. Inadequate normative data are likely driving the possible floor effect seen in the SILS-AB and CATS since 28 and 23 are the lowest possible T-scores an individual can obtain, respectively. The lack of individuals in the 2 standard deviation range on the WRAT is due to the fifth-grade reading level for study inclusion criteria. Since the floor effects artificially inflated the test specificity (i.e., because the neuropsychological test never reached the impaired range [less than 2 standard deviations from normative mean], the test identified all those without IADL impairment), these tests were not considered as candidates for the highest specificity at the less than 2 standard deviation impairment range.

Table 52 provides a summary of neuropsychological tests (using the less than 1 standard deviation impairment range) with the highest sensitivity, specificty, positive predictive power, and negative predictive power for each IADL subscale. In general, SILS-AB had the highest positive predictive power and specificity across all EPT domains. TMT-B and CATS tended to have the highest negative predictive power, and CATS had the highest sensitivity to impaired IADL capacity. More specifically, for the

EPT Food subscale, examination of the operating characteristics for the neuropsychological test within the less than 1 standard deviation impairment range indicated SILS-AB had the highest positive predictive power (0.75), TMT-B had the highest negative predictive power (0.82), TMT-B and CATS had the highest sensitivity (0.50), and SILS-AB had the highest specificity (0.98). For the EPT Phone Use subscale, SILS-AB had the highest positive predictive power (0.75), PEGS-ND had the highest negative predictive power (0.68), CATS and PEGS-ND had the highest sensitivity (0.41), and SILS-ABST had the highest specificity (0.97). For the EPT Financial subscale, SILS-AB had the highest positive predictive power (0.63), CATS had the highest negative predictive power (0.83), CATS had the highest sensitivity (0.61), and SILS-AB had the highest specificity (0.96). For the EPT Transportation subscale, SILS-AB had the highest positive predictive power (1.00), TMT-B had the highest negative predictive power (0.71), CATS had the highest sensitivity (0.50) and SILS-AB had the highest specificity (1.00). For the EPT Medication subscale, SILS-AB had the highest positive predictive power (0.75), CATS had the highest negative predictive power (0.84), CATS had the highest sensitivity (0.61), and SILS-AB had the highest specificity (0.98). For the EPT Shopping subscale, SILS-AB had the highest positive predictive power (0.63), TMT-B, and CATS had the highest negative predictive power (0.87), CATS had the highest sensitivity (0.57), and SILS-AB had the highest specificity (0.97). For the EPT Housekeeping subscale, SILS-AB had the highest positive predictive power (0.88), TMT-B had the highest negative predictive power (0.76), CATS had the highest sensitivity (0.51), and SILS-AB had the highest specificity (0.99). Using 2 standard deviations from normative means as the criterion did not increase predictive power of the neuropsychological tests, and several tests had marked floor effects as mentioned above. Thus, operating characteristics of the neuropsychological tests using less than 2 standard deviations from normative means as the impaired range were not summarized, but are provided in Tables 32 through 51.

Instrumental Activities of Daily Living Dependence

To more specifically determine which demographic and cognitive variables are associated with IADL dependence, logistic regression analyses were conducted with each IADL subscale as the dependent variable dichotomized as described above into "probable dependence or need for assistance" versus independence. Demographic (including group membership) and cognitive variables were entered as predictor variables using an enter method. Overall correct classification rates ranged from to 78% to 88%. Education and marital status were the most consistent demographic predictors of dependence (significant in three of seven equations). Those with less education and single showed greater dependence. Group was a significant predictor for only one subscale with the controls showing less dependence. The SILS-VOC was the most consistent cognitive predictor of dependence (significant in three of seven equations), with increased vocabulary scores associated with greater independence. In addition to the entry method, logistic regression analyses for each subtest were conducted using a stepwise entry method. Results showed that the SILS-AB subtest and marital status were included in three of the seven equations; SILS-VOC, TMT-B, PEGS-D, and education were included in two of seven equations; and UFOV composite, TMT-A, WRAT, race, and socioeconomic status were included in one equation.

Lastly, a total dependence variable (range = 0 to 7) was generated by counting the number of subscales with probable dependence for each individual. A multiple regression analysis was conducted with total dependence as the outcome variable, and group, demographic, and cognitive variables as the independent variables. Results showed SILS-VOC, SILS-AB, TMT-B, PEGS-D, and education were significant, $p < .05$, predictors of the total number of subscales in the dependent range, accounting for 56% of the variance.

Table 3

Demographic Characteristics of Heart Transplant Candidates and Controls

	Transplant candidates		Community controls	
	M	SD	M	SD
Age	50.4	11.1	47.0	9.1
Education	14.0	6.0	14.9	2.2
Estimated IQ[a]	95.9	12.1	105.5	10.2*
Gender				
Male	52		24	
Female	23		14	
Race				
Black	13		5	
White	62		33	
Marital				
Single	21		17	
Married	54		21	
Highest previous occupation				
Professional/techinical	18		5	
Mangager/administrator	19		13	
Craftsmen/foreman	12		11	
Operator/service	23		5	
Laborer	3		4	
Currently working				
Yes	15		28*	
No	60		10	
Psychiatric history				
Yes	38		0*	
No	37		38	
Using psychiatric medication[b]				
Yes	33		0*	
No	42		38	

[a]Estimated Wechsler Adult Intelligence Scale (Revised) from the Shipley Institute of Living Scale.
[b]Anxiolytic or antidepressant medication.
*$p < .01$.

Table 4

Medical Variables of Heart Transplant Candidates

	M	SD
Cardiac measures		
MUGA LVEF	26.49	12.51
RAM (mm Hg)	8.61	5.27
PAS (mm Hg)	46.23	20.64
PAD (mm Hg)	23.76	10.96
PAM (mm Hg)	33.29	14.07
MAP (mm Hg)	84.56	16.23
PCWP (mm Hg)	20.90	10.11
Cardiac output (l per min)	4.29	1.06
Cardiac index ($l \cdot min \cdot m^2$)	2.24	0.62
SVR	1451.48	420.60
PVR	243.78	213.72
Number of comorbid medical disorders	1.64	1.53
Length of heart problems (months)	97.61	80.76
Cardiac surgical history[a]		
Yes	24	
No	51	
Myocardial infarct histroy		
Yes	15	
No	60	
Cardiac diagnosis		
Ischemic	37	
Idiopathic, dilated	23	
Other	4	
Unknown	11	

Note. MUGA LVEF = multiple gated acquisition of images left ventricular ejection fraction; RAM = right atrial mean pressure; PAS = pulmonary arterial systolic pressure; PAD = pulmonary arterial diastolic pressure; PAM = pulmonary arterial mean pressure; MAP = mean arterial pressure; PCWP = pulmonary capilary wedge pressure; SVR = systemic vascular resistance; PVR = pulmonary vascular resistance.
[a]Coronary artery bypass graph or valvular surgery.

Table 5

Medication Usage Among Heart Transplant Candidates

	M	SD
Total number of medications	8.04	3.69
ACE inhibitors		
Yes	22	
No	53	
Antihypertension agent		
Yes	32	
No	43	
Beta blocker		
Yes	3	
No	72	
Vasodilator		
Yes	25	
No	50	
Diuretic		
Yes	58	
No	17	
Other heart medication		
Yes	60	
No	15	
Benzodiazepine		
Yes	12	
No	63	
Antidepressant		
Yes	10	
No	65	

Note. ACE = Angiotensin Converting Enzyme.

Table 6

Neuropsychological Performance of Heart Transplant Candidates and Controls

	Transplant candidates		Community controls	
	M	SD	M	SD
SILS-VOC	29.69	4.55	32.53	4.90**
SILS-AB	20.96	9.27	28.95	7.00**
WRAT	46.01	4.36	48.13	4.66
PEG-D	82.42	25.31	70.05	12.02**
PEG-ND	90.14	30.15	76.53	17.95*
WMS-R-LMI	23.53	6.71	24.95	6.31
WMS-R-LMII	19.24	7.50	20.47	6.80
TMT-A	33.31	11.70	33.27	13.35
TMT-B	100.60	50.00	76.86	24.90*
CATS	39.51	11.91	36.63	13.45
UFOV-VA	27.35	35.77	17.81	3.70
UFOV-DA	88.24	117.03	42.30	42.53
UFOV-SA	167.50	102.59	138.16	57.77
UFOV composite	291.67	224.52	195.67	80.96*

Note. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; SILS-AB = Shipley Institute of Living Scale Abstraction subscale; WRAT = Wide Range Achievement Test-3rd edition Reading subscale; PEG-D = Grooved Pegboard dominant hand; PEG-ND = Grooved Pegboard nondominant hand; WMS-R-LMI = Wechsler Memory Scale (Revised) Logical Memory I subtest; WMS-R-LMII = Wechsler Memory Scale (Revised) Logical Memory II subtest; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; CATS = Category Test; UFOV-VA = Useful Field of View Visual Attention; UFOV-DA = Useful Field of View Divided Attention; UFOV-SA = Useful Field of View Selective Attention.

*$p < .01$. **$p < .001$.

Table 7

Neuropsychological T-score Performance of Heart Transplant Candidates and Controls

Variable	Transplant candidates/ controls M T-score	SD	T-score (%) 40+	30-39	<30
SILS-VOC[1]	50.1	8.40	88	11	1
	53.7	9.00	92	3	5
SILS-AB[1]	52.7	8.89	89	11	0
	58.9	7.40	100	0	0
WRAT[2]	48.1	6.93	87	13	0
	50.5	7.33	87	13	0
PEG-D[3]	41.9	12.48	70	14	16
	48.6	7.17	97	0	3
PEG-ND[3]	42.3	15.52	62	27	14
	48.3	9.91	92	5	3
WMS-R-LMI[4]	49.4	9.45	84	16	0
	50.2	8.42	92	8	0
WMS-R-LMII[4]	49.7	10.50	79	21	0
	50.0	8.23	87	13	0
TMT-A[3]	47.3	11.14	80	11	9
	46.2	13.10	70	16	14
TMT-B[3]	43.0	14.11	72	12	16
	48.9	8.23	89	8	3
CATS[5]	43.9	10.45	60	37	3
	46.1	11.92	63	34	3

Note. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; SILS-AB = Shipley Institute of Living Scale Abstraction subscale; WRAT = Wide Range Achievement Test-3rd edition Reading subscale; PEG-D = Grooved Pegboard dominant hand; PEG-ND = Grooved Pegboard nondominant hand; WMS-R-LMI = Wechsler Memory Scale (Revised) Logical Memory I subtest; WMS-R-LMII = Wechsler Memory Scale (Revised) Logical Memory II subtest; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; CATS = Category Test.

1. Zachary, 1986.
2. Wilkinson, 1993.
3. Bornstein, 1985.
4. Wechsler, 1987.
5. Wetzel & Boll, 1987.

Table 8

Useful Field of View (UFOV) Classification for Risk of Motor Vehicle Accident

Risk category	Transplant candidates	Community controls
Very low	48 (67%)	33 (86%)
Low	14 (19%)	5 (13%)
Low to moderate	5 (7%)	0 (0%)
Moderate to high	2 (3%)	0 (0%)
High	3 (4%)	0 (0%)

Table 9

Everyday Problems Test (EPT) Performance of Heart Transplant Candidates and Controls

	Transplant candidates		Community controls	
	M	SD	M	SD
EPT total score[a]	28.8	6.6	33.3	5.3***
Subscales[b]				
Food Preparation	4.1	1.3	4.6	1.3***
Telephone Use	3.5	1.5	4.7	1.2*
Financial Management	4.1	1.3	4.7	1.1*
Transportation Use	3.8	1.5	4.6	1.3**
Medication Use	5.0	1.0	5.2	0.9
Shopping	4.2	0.9	4.7	0.8**
Housekeeping	4.0	1.5	4.8	1.0**

[a]Maximum score = 42.
[b]Maximum score = 6.
*$p < .05$. ** $p < .01$. *** $p < .001$.

Table 10

Everyday Problems Test (EPT) Performance of Heart Transplant Candidates and Controls (T-scores)

	Transplant candidates/ controls		T-score (%)		
Variable	M T-score	SD	40+	30-39	<30
EPT total	51.3	11.16	88	4	8
	57.4	8.31	100	0	0
Subscales					
Food Preparation	52.4	10.74	88	9	3
	54.7	9.76	92	5	3
Telephone Use	51.6	10.94	83	13	4
	58.6	8.77	95	5	0
Financial Management	51.2	10.70	83	14	3
	55.6	10.92	94	3	3
Transportation Use	48.7	11.81	76	19	5
	54.4	9.75	92	8	0
Medication Use	50.1	9.37	88	9	3
	50.1	11.53	92	5	3
Shopping	50.4	10.07	83	13	4
	52.6	8.74	94	3	3
Housekeeping	52.1	9.28	89	10	1
	56.5	5.99	97	3	0

Table 11

Bivariate Correlations Between the Everyday Problems Test Total Score and Demographic Characteristics (Combined Groups)

Variable	Pearson r	p
Age	-.05	.62
Education	.24	.01
Gender	.13	.17
Race	.28	.01
Marital status	.13	.16
Socioeconomic status	-.14	.15

Table 12

Partial Correlations, Controlling for Race and Education, Between Neuropsychological Measures and Everyday Problems Test Subscales

	Everyday Problems Test subscales						
Variable	Food Prepar-ation	Medica-tion	Phone Use	Shop-ping	Fin-ances	House-hold Chores	Trans-portation
SILS-VOC	.30*	.30*	.45**	.26*	.23	.43**	.48**
SILS-AB	.40**	.28*	.40**	.31**	.36**	.50**	.48**
WRAT	.27*	.04	.33**	.11	.20	.29*	.32**
PEG-D	-.46**	-.20	-.19	-.28*	-.12	-.22	-.16
PEG-ND	-.39**	-.24	-.23	-.39**	-.19	-.28*	-.20
WMS-R-LMI	.23	.30*	.16	.17	.15	.18	.26*
WMS-R-LMII	.17	.28*	.12	.10	.07	.09	.16
TMT-A	-.11	-.10	.06	-.14	-.01	-.05	-.16
TMT-B	-.46**	-.39**	-.35**	-.34**	-.33**	-.45**	-.45**
CATS	-.11	-.23	-.14	-.22	-.26*	-.22	-.20
UFOV-PS	-.18	-.22	-.15	-.26*	-.12	-.20	-.24
UFOV-DA	-.26*	-.29*	-.28*	-.29*	-.14	-.26*	-.23
UFOV-SA	-.33**	-.20	-.23	-.32**	-.14	-.30*	-.30*
UFOV composite	-.33**	-.24*	-.25*	-.37**	-.15	-.35**	-.31**

Note. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; SILS-AB = Shipley Institute of Living Scale Abstraction subscale; WRAT = Wide Range Achievement Test Reading-3rd edition subscale; PEG-D = Grooved Pegboard dominant hand; PEG-ND = Grooved Pegboard nondominant hand; WMS-R-LMI = Wechsler Memory Scale (Revised) Logical Memory I subtest; WMS-R-LMII = Wechsler Memory Scale (Revised) Logical Memory II subtest; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; CATS = Category Test; UFOV-VA = Useful Field of View Visual Attention; UFOV-DA = Useful Field of View Divided Attention; UFOV-SA = Useful Field of View Selective Attention.

*$p < .01$. **$p < .001$.

Table 13

Summary of Multiple Regression Analysis for each Everyday Problems Test Score and Neuropsychological Test

	Everyday Problems Test - Scores							
Variable	Total Score	Food Prep	Phone Use	Fin-ance	Trans-porta-tion	Med-ica-tion	Shop ping	House Chores
SILS-VOC	X		X		X	X	X	X
SILS-AB				X				X
WRAT		X				X		
PEG-D		X						
PEG-ND	X						X	
WMS-R-LM-I								
WMS-R-LM-II								
TMT-A	X		X					
TMT-B	X	X	X		X	X		
CATS				X				
UFOV composite	X						X	X

Note. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; SILS-AB = Shipley Institute of Living Scale Abstraction subscale; WRAT = Wide Range Achievement Test-3rd edition Reading subscale; PEG-D = Grooved Pegboard dominant hand; PEG-ND = Grooved Pegboard nondominant hand; WMS-R-LMI = Wechsler Memory Scale (Revised) Logical Memory I subtest; WMS-R-LMII = Wechsler Memory Scale (Revised) Logical Memory II subtest; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; CATS = Category Test; UFOV = Useful Field of View.
X indicates included in multiple regression equation.

Table 14

Hierarchical Stepwise Multiple Regression Analysis, Controlling for Education and Race, Between the Everyday Problems Test Total Score and Neuropsychological Tests (Combined Groups)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.13	2.15	.03			
Race	.03	.53	.60	.45	.21	.19
Step 2						
TMT-B	-.45	-5.95	.01	.68	.46	.45
Step 3						
SILS-VOC	.4	6.14	.01	.77	.60	.58
Step 4						
UFOV composite	-.15	-2.14	.04	.79	.63	.61
Step 5						
TMT-A	.21	3.01	.01	.81	.65	.63
Step 6						
PEG-ND	-.18	-2.53	.01	.82	.67	.64

Note. Reported beta after all variables in equation. Constant = 16.28. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; PEG-ND = Grooved Pegboard nondominant hand; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; UFOV = Useful Field of View.

Table 15

Hierarchical Stepwise Multiple Regression Analysis, Controlling for Education and Race, Between the Everyday Problems Test Food Preparation Subtest and Neuropsychological Tests (Combined Groups)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.00	.04	.97			
Race	-.10	-1.26	.21	.20	.04	.02
Step 2						
TMT-B	-.30	-3.49	.01	.50	.25	.23
Step 3						
PEG-D	-.34	-4.04	.01	.58	.33	.31
Step 4						
WRAT	.28	3.19	.01	.62	.39	.36

Note. Reported beta after all variables in equation. Constant = 3.30. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; PEG-ND = Grooved Pegboard nondominant hand; TMT-B = Trail Making Test Part B; WRAT = Wide Range Achievement Test-3rd edition Reading subtest.

Table 16

Hierarchical Stepwise Multiple Regression Analysis, Controlling for Education and Race, Between the Everyday Problems Test Phone Use Subscale and Neuropsychological Tests (Combined Groups)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.15	1.8	.07			
Race	.01	-.10	.92	.38	.15	.13
Step 2						
SILS-VOC	.36	4.27	.01	.56	.31	.29
Step 3						
TMT-B	-.43	-4.58	.01	.62	.39	.37
Step 4						
TMT-A	.22	2.44	.02	.65	.42	.40

Note. Reported beta after all variables in equation. Constant = -1.24. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B.

Table 17

Hierarchical Stepwise Multiple Regression Analysis, Controlling for Education and Race, Between the Everyday Problems Test Financial Subscale and Neuropsychological Tests (Combined Groups)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.31	4.0	.01			
Race	.22	2.8	.01	.52	.27	.26
Step 2						
SILS-AB	.25	2.8	.01	.60	.36	.34
Step 3						
CATS	-.17	-2.0	.05	.62	.38	.36

Note. Reported beta after all variables in equation. Constant = 1.68. SILS-AB = Shipley Institute of Living Scale Abstraction subscale; CATS = Category Test.

Table 18

Hierarchical Stepwise Multiple Regression Analysis, Controlling for Education and Race, Between the Everyday Problems Test Transportation Subscale and Neuropsychological Tests (Combined Groups)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.16	2.05	.04			
Race	-.06	-.75	.46	.39	.15	.14
Step 2						
SILS-VOC	.42	5.23	.01	.58	.34	.32
Step 3						
TMT-B	-.37	-4.91	.01	.68	.46	.44

Note. Reported beta after all variables in equation. Constant = 0.84. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; TMT-B = Trail Making Test Part B.

Table 19

Hierarchical Stepwise Multiple Regression Analysis, Controlling for Education and Race, Between the Everyday Problems Test Medication Subscale and Neuropsychological Tests (Combined Groups)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.08	.88	.38			
Race	.18	2.19	.03	.37	.13	.12
Step 2						
TMT-B	-.34	-4.12	.01	.51	.26	.24
Step 3						
SILS-VOC	.42	3.63	.01	.56	.31	.28
Step 4						
WRAT	-.25	-2.16	.03	.58	.34	.31

Note. Reported beta after all variables in equation. Constant = 4.80. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; TMT-B = Trail Making Test Part B; WRAT = Wide Range Achievement Test-3rd edition Reading subtest.

Table 20

Hierarchical Stepwise Multiple Regression Analysis, Controlling for Education and Race, Between the Everyday Problems Test Shopping Subscale and Neuropsychological Tests (Combined Groups)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.07	.76	.45			
Race	.13	1.49	.14	.34	.12	.10
Step 2						
PEG-ND	-.28	-2.98	.01	.50	.25	.23
Step 3						
SILS-VOC	.26	2.89	.01	.56	.31	.28
Step 4						
UFOV composite score	-.20	-2.07	.04	.58	.34	.31

Note. Reported beta after all variables in equation. Constant = 3.78. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; PEG-ND = Grooved Pegboard nondominant hand; UFOV = Useful Field of View.

Table 21

Hierarchical Stepwise Multiple Regression Analysis, Controlling for Education and Race, Between the Everyday Problems Test Household Chores Subscale and Neuropsychological Tests (Combined Groups)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	-.09	-1.09	.28			
Race	-.02	-.26	.79	.24	.06	.04
Step 2						
SILS-AB	.33	3.57	.01	.53	.28	.26
Step 3						
SILS-VOC	.31	3.37	.01	.58	.34	.32
Step 4						
UFOV composite score	-.23	-2.76	.01	.62	.39	.36

Note. Reported beta after all variables in equation. Constant = 1.23. SILS-AB = Shipley Institute of Living Scale Abstraction subscale; SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; UFOV = Useful Field of View.

Table 22

Summary of Hierarchical Multiple Regression Analysis with Everyday Problems Test Scores as the Dependent Measure; Education and Race Entered on the First step, Cognitive Tests Predictive of the IADL Domain Entered on the Second Step, and Heart Catheterization Data Stepwise Entry on the Third Step

	Everyday Problems Test - Scores							
Variable	Total Score	Food Prep	Phone Use	Fin-ance	Trans-porta-tion	Med-ica-tion	Shop ping	House Chores
Heart Cath Data								
MUGA LVEF								
RAM								
PAS								
PAD								
PAM								
MAP								
PCWP				X				
Cardiac Output								
Cardiac Index								
SVR								
PVR								
Comorbid Dis								
N. of Medications								

Note. MUGA LVEF = multiple gated acquistion of images left ventricular ejection fraction; RAM = right atrial mean pressure; PAS = pulmonary arterial systolic pressure; PAD = pulmonary arterial diastolic pressure; PAM = pulmonary arterial mean pressure; MAP = mean arterial pressure; PCWP = Pulmonary capilary wedge pressure; SVR = systemic vascular resistance; PVR = pulmonary vascular resistance; Dis = disorders.
X indicates included in multiple regression equation.

Table 23

Hierarchical Stepwise Multiple Regression Analysis Between the Everyday Problems Test Total Score and Cardiac Function Measures Controlling for Education, Race, SILS-VOC, TMT-B, PEG-ND, UFOV Composite Score, and TMT-A (Only Transplant Candidates)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.09	1.16	.25			
Race	.06	.68	.50			
UFOV composite score	-.12	-1.41	.16			
SILS-VOC	.43	5.30	.01			
TMT-B	-.51	-5.46	.01			
PEG-D	-.18	-1.82	.07			
TMT-A	.15	1.53	.13	.82	.67	.63

Note. Reported beta after all variables in equation. Constant = 14.9. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; PEG-ND = Grooved Pegboard nondominant hand; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; UFOV = Useful Field of View.

Table 24

Hierarchical Stepwise Multiple Regression Analysis Between the Everyday Problems Test Food Preparation Score and Cardiac Function Measures Controlling for Education, Race, TMT-B, PEG-D, and WRAT (Only Transplant Candidates)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	-.03	-.35	.73			
Race	-.01	-.01	.99			
WRAT	.22	2.26	.03			
PEG-D	-.37	-3.79	.01			
TMT-B	-.41	-4.18	.01	.69	.48	.44

Note. Reported beta after all variables in equation. Constant = 3.90. TMT-B = Trail Making Test Part B; PEG-D = Grooved Pegboard dominant hand; WRAT = Wide Range Achievement Test-3rd edition Reading subtest.

Table 25

Hierarchical Stepwise Multiple Regression Analysis Between the Everyday Problems Test Phone Subscale and Cardiac Function Measures Controlling for Education, Race, and Neuropsychological Tests (Only Transplant Candidates)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.12	1.19	.24			
Race	.05	.49	.63			
SILS-VOC	.34	3.17	.01			
TMT-A	.14	1.11	.27			
TMT-B	.45	-3.61	.01	.55	.31	.27

Note. Reported beta after all variables in equation. Constant = -1.42. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; TMT-A = Trail Making Test - Part A; TMT-B = Trail Making Test-Part B.

Table 26

Hierarchical Stepwise Multiple Regression Analysis Between the Everyday Problems Test Financial Subscale and Cardiac Function Measures Controlling for Education, Race, and Neuropsychological Tests (Only Transplant Candidates)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.27	2.74	.01			
Race	.21	2.03	.05			
SILS-AB	.32	2.76	.01			
CATS	-.20	-1.90	.06	.58	.34	.30
Step 2						
PCWP	.23	-2.26	.03	.62	.38	.34

Note. Reported beta after all variables in equation. Constant = .59. SILS-AB = Shipley Institute of Living Scale Abstraction subscale; CATS = Category Test; PCWP = Pulmonary Capillary Wedge Pressure.

Table 27

Hierarchical Stepwise Multiple Regression Analysis Between the Everyday Problems Test Transportation Subscale and Cardiac Function Measures Controlling for Education, Race, and Neuropsychological Tests (Only Transplant Candidates)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.09	1.00	.32			
Race	-.06	-.62	.54			
SILS-VOC	.45	4.60	.01			
TMT-B	-.42	-4.53	.01	.67	.44	.41

Note. Reported beta after all variables in equation. Constant = 1.03. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; TMT-B = Trail Making Test Part B.

Table 28

Hierarchical Stepwise Multiple Regression Analysis Between the Everyday Problems Test Medication Subscale and Cardiac Function Measures Controlling for Education, Race, and Neuropsycholigical Tests (Only Transplant Candidates)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.08	.81	.42			
Race	.25	2.52	.01			
SILS-VOC	.41	3.42	.01			
TMT-B	-.41	-4.42	.01			
WRAT	-.30	-2.60	.01	.66	.44	.40

Note. Reported beta after all variables in equation. Constant = 5.42. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; TMT-B = Trail Making Test Part B; WRAT = Wide Range Achievement Test-3rd edition Reading subtest.

Table 29

Hierarchical Stepwise Multiple Regression Analysis Between the Everyday Problems Test Shopping Subscale and Cardiac Function Measures Controlling for Education, Race, and Neuropsychological Tests (Only Transplant Candidates)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	.01	.10	.92			
Race	.08	.75	.46			
PEG-ND	-.32	-2.63	.01			
SILS-VOC	.36	3.30	.01			
UFOV composite score	-.17	-1.44	.16	.59	.35	.30

Note. Reported beta after all variables in equation. Constant = 3.03. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; PEG-ND = Grooved Pegboard nondominant hand; UFOV = Useful Field of View.

Table 30

Hierarchical Stepwise Multiple Regression Analysis Between the Everyday Problems Test Household Subscale and Cardiac Function Measures Controlling for Education, Race, and Neuropsychological Tests (Only Transplant Candidates)

Variable	Beta	t	p	R	R^2	Adj. R^2
Step 1						
Education	-.10	-.95	.35			
Race	.04	.41	.68			
SILS-VOC	.25	2.27	.03			
SILS-AB	.36	3.28	.01			
UFOV composite score	-.23	-2.21	.03	.61	.37	.33

Note. Reported beta after all variables in equation. Constant = 1.02. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; SILS-AB = Shipley Institute of Living Scale Abstraction subscale; UFOV = Useful Field of View.

Table 31

Summary of Hierarchical Multiple Regression Analysis with Everyday Problems Test Scores as the Dependent Measure: Education and Race Entered on the First Step, Heart Catheterization Data Stepwise Entry on the Second Step, and Cognitive Tests Stepwise Entry on the Third Step

	Everyday Problems Test - Scores							
Variable	Total Score	Food Prep	Phone Use	Fin-ance	Trans-porta-tion	Med-ica-tion	Shop-ping	House Chores
Catheterization data								
MUGA LVEF								X
RAM								
PAS								
PAD								
PAM								
MAP								
PCWP								
Cardiac Output								
Cardiac Index								
SVR							X	
PVR								
Comorbid diseases								
N. of Medications								
Cognitive Tests								
SILS-VOC	X		X	X	X	X	X	X
SILS-AB	X	X		X	X			X
WRAT						X		
PEG-D	X	X						
PEG-ND							X	
WMS-R-LMI								
WMS-R-LMII								
TMT-A								
TMT-B	X	X	X	X	X	X		
CATS								
UFOV composite							X	X

Note. MUGA LVEF = multiple gated acquistion of images left ventricular ejection fraction; RAM = right atrial mean pressure; PAS = pulmonary arterial systolic pressure; PAD = pulmonary arterial diastolic pressure; PAM = pulmonary arterial mean pressure; MAP = mean arterial pressure; PCWP = Pulmonary capilary wedge pressure; SVR = Systemic vascular resistance; PVR = pulmonary vascular resistance. SILS-VOC = Shipley Institute of Living Scale Vocabulary subscale; SILS-AB = Shipley Institute of Living Scale Abstraction subscale; WRAT = Wide Range Achievement Test-3rd edition Reading subscale; PEG-D = Grooved Pegboard dominant hand; PEG-ND = Grooved Pegboard nondominant hand; WMS-R-LMI = Wechsler Memory Scale (Revised) Logical Memory I subtest; WMS-R-LMII = Wechsler Memory Scale (Revised) Logical Memory II subtest; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; CATS = Category Test; UFOV = Useful Field of View.
X indicates included in multiple regression equation.

Table 32

Short Category Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

Category Test	Sensitivity	Specificity	PPP	NPP
EPT Food	.50	.65	.36	.77
EPT Telephone	.41	.62	.41	.62
EPT Financial	.61	.70	.43	.83
EPT Transportation	.50	.68	.50	.68
EPT Medication	.61	.68	.39	.84
EPT Shopping	.57	.65	.27	.87
EPT Housekeeping	.51	.67	.41	.75

Note. One standard deviation impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 33

Short Category Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

Category Test	Sensitivity	Specificity	PPP	NPP
EPT Food	.03	.98	.33	.72
EPT Telephone	.05	.99	.67	.62
EPT Financial	.10	1.0	1.0	.75
EPT Transportation	.02	.97	.33	.61
EPT Medication	.07	.99	.67	.76
EPT Shopping	.05	.98	.33	.82
EPT Housekeeping	.03	.97	.33	.69

Note. Two standard deviations impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 34

SILS Vocabulary Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

SILS Vocabulary Test	Sensitivity	Specificity	PPP	NPP
EPT Food	.25	.95	.67	.76
EPT Telephone	.18	.94	.67	.64
EPT Financial	.19	.93	.50	.75
EPT Transportation	.23	.97	.83	.66
EPT Medication	.21	.93	.50	.78
EPT Shopping	.29	.94	.50	.85
EPT Housekeeping	.23	.95	.67	.73

Note. One standard deviation impairment on the cognitive measure. SILS = Shipley Institute of Living Scale; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 35

SILS Vocabulary Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

SILS-Vocabulary Test	Sensitivity	Specificity	PPP	NPP
EPT Food	.06	.99	.67	.73
EPT Telephone	.05	.99	.67	.62
EPT Financial	.03	.98	.33	.73
EPT Transportation	.07	1.00	1.00	.63
EPT Medication	.07	.99	.67	.76
EPT Shopping	.05	.98	.33	.82
EPT Housekeeping	.09	1.00	1.00	.71

Note. Two standard deviations impairment on the cognitive measure. SILS = Shipley Institute of Living Scale; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 36

SILS Abstraction Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

SILS Abstraction Test	Sensitivity	Specificity	PPP	NPP
EPT Food	.19	.98	.75	.75
EPT Telephone	.14	.97	.75	.64
EPT Financial	.16	.96	.63	.75
EPT Transportation	.18	1.00	1.00	.66
EPT Medication	.21	.98	.75	.79
EPT Shopping	.24	.97	.63	.85
EPT Housekeeping	.20	.99	.88	.73

Note. One standard deviation impairment on the cognitive measure. SILS = Shipley Institute of Living Scale; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 37

SILS Abstraction Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

SILS Abstraction Test	Sensitivity	Specificity	PPP	NPP
EPT Food	0	1.0	0	.72
EPT Telephone	0	1.0	0	.61
EPT Financial	0	1.0	0	.73
EPT Transportation	0	1.0	0	.61
EPT Medication	0	1.0	0	.75
EPT Shopping	0	1.0	0	.81
EPT Housekeeping	0	1.0	0	.69

Note. Two standard deviations impairment on the cognitive measure. SILS = Shipley Institute of Living Scale; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 38

<u>WRAT Reading Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation</u>

WRAT-Reading Test	Sensitivity	Specificity	PPP	NPP
EPT Food	.28	.93	.60	.77
EPT Telephone	.18	.90	.53	.63
EPT Financial	.26	.92	.53	.77
EPT Transportation	.25	.94	.73	.66
EPT Medication	.18	.88	.33	.77
EPT Shopping	.29	.90	.40	.85
EPT Housekeeping	.20	.90	.47	.71

Note. One standard deviation impairment on the cognitive measure. WRAT = Wide Range Achievement Test-3rd edition; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 39

<u>WRAT Reading Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations</u>

WRAT-Reading Test	Sensitivity	Specificity	PPP	NPP
EPT Food	0	1.0	0	.72
EPT Telephone	0	1.0	0	.61
EPT Financial	0	1.0	0	.73
EPT Transportation	0	1.0	0	.61
EPT Medication	0	1.0	0	.75
EPT Shopping	0	1.0	0	.81
EPT Housekeeping	0	1.0	0	.69

Note. Two standard deviations impairment on the cognitive measure. WRAT = Wide Range Achievement Test -3rd edition; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 40

Grooved Pegboard Dominant Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

Grooved Pegboard Dominant	Sensitivity	Specificity	PPP	NPP
EPT Food	.39	.86	.52	.79
EPT Telephone	.28	.84	.52	.65
EPT Financial	.23	.80	.30	.73
EPT Transportation	.25	.82	.48	.63
EPT Medication	.29	.82	.35	.78
EPT Shopping	.33	.82	.30	.84
EPT Housekeeping	.35	.86	.52	.75

Note. One standard deviation impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 41

Grooved Pegboard Dominant Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

Grooved Pegboard Dominant	Sensitivity	Specificity	PPP	NPP
EPT Food	.32	.96	.77	.79
EPT Telephone	.16	.91	.54	.64
EPT Financial	.16	.90	.39	.74
EPT Transportation	.16	.91	.54	.63
EPT Medication	.14	.89	.31	.76
EPT Shopping	.24	.91	.39	.84
EPT Housekeeping	.29	.96	.77	.76

Note. Two standard deviations impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 42

Grooved Pegboard Nondominant Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

Grooved Pegboard Nondominant	Sensitivity	Specificity	PPP	NPP
EPT Food	.47	.80	.47	.80
EPT Telephone	.41	.81	.57	.68
EPT Financial	.36	.76	.37	.75
EPT Transportation	.37	.79	.53	.66
EPT Medication	.46	.79	.43	.81
EPT Shopping	.45	.76	.30	.86
EPT Housekeeping	.38	.77	.40	.75

Note. One standard deviation impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 43

Grooved Pegboard Nondominant Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

Grooved Pegboard Nondominant	Sensitivity	Specificity	PPP	NPP
EPT Food	.20	.96	.67	.76
EPT Telephone	.14	.96	.67	.64
EPT Financial	.13	.94	.44	.73
EPT Transportation	.16	.97	.79	.64
EPT Medication	.11	.93	.33	.75
EPT Shopping	.25	.96	.56	.85
EPT Housekeeping	.16	.95	.56	.73

Note. Two standard deviations impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 44

Weschler Memory Scale (Revised) Logical Memory I Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

WMS-R-LMI	Sensitivity	Specificity	PPP	NPP
EPT Food	.16	.88	.33	.72
EPT Telephone	.16	.88	.47	.62
EPT Financial	.26	.92	.53	.77
EPT Transportation	.21	.91	.60	.64
EPT Medication	.29	.92	.53	.80
EPT Shopping	.24	.89	.33	.84
EPT Housekeeping	.17	.89	.40	.70

Note. One standard deviations impairment on the cognitive measure WMS-R-LMI = Weschler Memory Scale (Revised) Logical Memory I; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 45

Weschler Memory Scale (Revised) Logical Memory I Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

WMS-R-LMI	Sensitivity	Specificity	PPP	NPP
EPT Food	0	1.0	0	.72
EPT Telephone	0	1.0	0	.61
EPT Financial	0	1.0	0	.73
EPT Transportation	0	1.0	0	.61
EPT Medication	0	1.0	0	.75
EPT Shopping	0	1.0	0	.81
EPT Housekeeping	0	1.0	0	.69

Note. Two standard deviation impairment on the cognitive measure WMS-R-LMI = Weschler Logical Memory Scale (Revised) Logical Memory I; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 46

Weschler Memory Scale (Revised) Logical Memory II Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

WMS-R-LMII	Sensitivity	Specificity	PPP	NPP
EPT Food	.28	.85	.43	.75
EPT Telephone	.23	.84	.48	.63
EPT Financial	.32	.87	.48	.77
EPT Transportation	.27	.87	.57	.65
EPT Medication	.36	.87	.48	.80
EPT Shopping	.24	.83	.24	.83
EPT Housekeeping	.20	.82	.33	.70

Note.One standard deviations impairment on the cognitive measure WMS-R-LMII = Weschler Logical Memory Scale (Revised) Logical Memory II; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 47

Weschler Memory Scale (Revised) Logical Memory II Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

WMS-R-LM-II	Sensitivity	Specificity	PPP	NPP
EPT Food	0	1.0	0	.72
EPT Telephone	0	1.0	0	.61
EPT Financial	0	1.0	0	.73
EPT Transportation	0	1.0	0	.61
EPT Medication	0	1.0	0	.75
EPT Shopping	0	1.0	0	.81
EPT Housekeeping	0	1.0	0	.69

Note. Two standard deviations impairment on the cognitive measure WMS-R-LM-II = Weschler Logical Memory Scale (Revised) Logical Memory II; EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 48

Trail Making Test Part A Test's Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

Trail Making Test Part A	Sensitivity	Specificity	PPP	NPP
EPT Food	.31	.80	.39	.74
EPT Telephone	.27	.79	.46	.63
EPT Financial	.29	.79	.35	.74
EPT Transportation	.34	.84	.58	.66
EPT Medication	.27	.79	.46	.63
EPT Shopping	.29	.78	.23	.83
EPT Housekeeping	.26	.78	.35	.70

Note. One standard deviation impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 49

Trail Making Test Part A Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

Trail Making Test Part A	Sensitivity	Specificity	PPP	NPP
EPT Food	.16	.91	.42	.73
EPT Telephone	.09	.88	.33	.60
EPT Financial	.13	.90	.33	.73
EPT Transportation	.14	.91	.50	.62
EPT Medication	.11	.89	.25	.75
EPT Shopping	.19	.91	.33	.83
EPT Housekeeping	.11	.90	.33	.69

Note. Two standard deviations impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 50

Trail Making Test Part B Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at One Standard Deviation

Trail Making Test Part B	Sensitivity	Specificity	PPP	NPP
EPT Food	.50	.89	.64	.82
EPT Telephone	.34	.85	.60	.67
EPT Financial	.48	.88	.60	.82
EPT Transportation	.43	.91	.76	.71
EPT Medication	.43	.85	.48	.82
EPT Shopping	.48	.84	.40	.87
EPT Housekeeping	.37	.84	.52	.76

Note. One standard deviation impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 51

Trail Making Test Part B Positive Predictive Power, Negative Predictive Power, Sensitivity, and Specificity of Impaired Everyday Problems Test Functioning at Two Standard Deviations

Trail Making Test Part B	Sensitivity	Specificit y	PPP	NPP
EPT Food	.31	.96	.77	.78
EPT Telephone	.23	.96	.77	.66
EPT Financial	.29	.95	.69	.78
EPT Transportation	.27	.99	.92	.68
EPT Medication	.29	.94	.62	.80
EPT Shopping	.48	.97	.77	.89
EPT Housekeeping	.26	.95	.69	.74

Note. Two standard deviations impairment on the cognitive measure. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power.

Table 52

Summary of Neuropsychological Tests with the Highest Sensitivity, Specificity, Positive Predictive Power and Negative Predictive Power for Each Everyday Problems Test Subscale

	Sensitivity	Specificity	PPP	NPP
EPT Food	TMT-B, CATS	SILS-AB	SILS-AB	TMT-part B
EPT Telephone	CATS, PEGS-ND	SILS-AB	SILS-AB	PEGS-ND
EPT Financial	CATS	SILS-AB	SILS-AB	CATS
EPT Transportation	CATS	SILS-AB	SILS-AB	TMT-B
EPT Medication	CATS	SILS-AB	SILS-AB	CATS
EPT Shopping	CATS	SILS-AB	SILS-AB	TMT-B, CATS
EPT Housekeeping	CATS	SILS-AB	SILS-AB	TMT-B

Note. One standard deviation impairment on the neuropsychological test. EPT = Everyday Problems Test; PPP = positive predictive power; NPP = negative predictive power. SILS-ABST = Shipley Institute of Living Scale Abstraction subtest; CATS = Short Category Test; TMT-B = Trail Making Test Part B. PEGS-ND = Grooved Pegboard nondominant hand.

DISCUSSION

As in previous studies (Putzke et al., 1997a), heart transplant candidates displayed impaired performance on neuropsychological tests assessing psychomotor speed, mental flexibility, and abstract reasoning, compared to an age- and education-matched control group. The heart transplant group also scored significantly lower on both subtests of a measure assessing intellectual functioning (i.e., SILS), and thus, the heart transplant group had a significantly lowered the estimated IQ as compared to controls. Decreased performance on the Abstraction subtest of the SILS was expected, and a similar finding was reported in a recent case control study that matched heart transplant candidates case for case with controls on age, education, race, and gender (Putzke et al., in press). The significant group difference on the SILS Vocabulary subtest, however, was not expected since vocabulary skills tend to be relatively resistant to medical illness and are highly correlated with general intellectual ability (Lezak, 1995). Indeed, vocabulary ability is often used in equations estimating premorbid IQ (Zachary, 1986). It should be noted, however, that another estimate of long-standing verbal ability (i.e., WRAT Reading subtest) was not significantly different between groups.

The heart transplant group also showed significant bilateral slowing in fine motor-speed and dexterity compared to controls. Impaired motor performance raises the compelling argument that poor performance on timed neuropsychological tests among heart transplant candidates may be mediated by poor motor functioning. Although poor motor functioning may have contributed, in part, to the decreased performance among the heart transplant candidates on a test of psychomotor speed and mental flexibility (TMT-B), no differences were found on a simpler task of attention and concentration, and psychomotor speed (TMT-A). Moreover, speeded motor functioning is not required on the SILS Abstraction subtest, which was impaired in the transplant group. Unexpectedly, group differences were not found on another test of reasoning and working memory (i.e., Short Category Test).

Instrumental Activities of Daily Living Functioning

Although several studies have examined self-reported functional and quality of life measures among lung (Caine, Sharples, Dennis, Higenbottam, & Wallwork, 1996; Gross, Savik, Bolman, & Hertz, 1995; Manzetti, Hoffman, Sereika, Sciurba, & Griffith, 1994; Ramsey, Patrick, Lewis, Albert, & Raghu, 1995; TenVergert et al., 1998), heart (Caine et al., 1996; Dracup, Walden, Stevenson, & Brecht, 1992; Grady et al., 1995; Walsh, Charlesworth, Andrews, Hawkins, & Cowley, 1997), liver (Dickson et al., 1997; Price et al., 1995), renal (Kiebert, van Oosterhout, Lemkes, van Bronswijk, & Gooszen, 1994; Kiebert, van Oosterhout, van Bronswijk, Lemkes, & Gooszen, 1994), and bone marrow (Andrykowski et al., 1995; Haberman, Bush, Young, & Sullivan, 1993; Molassiotis, Boughton, Burgoyne, & van den Akker, 1995; Wettergren, Langius, Bjorkholm, & Bjorvell, 1997; Wingard, Curbow, Baker, & Piantadosi, 1991) transplant patients, only one study has examined IADL functioning using a performance-based IADL criterion (Putzke, et al., 1999). The use of performance-based IADL measures is particularly important since transplant candidates tend to minimize problems on self-report measures (Putzke et al., 1997b; Putzke, Williams, & Boll, 1998; Putzke et al., 1999a; Williams et al., 1997). Putzke et al. (1999c) examined IADL performance using the EPT in a subsample of heart transplant and controls from the current study as well as a group of patients with cardiac disease not undergoing evaluation for transplantation. Both heart transplant and cardiac disease groups performed significantly worse on the EPT, suggesting patients with cardiac disease may experience a diminished capacity to perform IADL tasks. Education and race were found to be significant demographic predictors of EPT performance; however, other potential important cognitive and physical health predictor variables were not examined.

Consistent with previous findings (Putzke et al., in press), the EPT total score was significantly lower among the heart transplant group compared to controls. Specific comparisons within each IADL domain indicated that the heart transplant candidates scored significantly lower on the EPT Food Preparation, Transportation, Shopping and Housekeeping subscales. These findings are likely conservative estimates of probable IADL impairment since the EPT does not involve significant motor engagement. That is, for those IADL tasks that involve both high cognitive and motor demand (e.g., household chores, shopping), it seems reasonable to assume that performance capacity may be even further compromised secondary to fatigue, poor motivation, and shortness of breath than that seen on a paper and pencil IADL task. This assumption is only speculative since in-home performance of IADL task may benefit from substantial cuing and repetition priming. Interestingly, a group difference was not found on the Medication subscale, suggesting the transplant group's ability to follow a complex medical regimen may be intact. However, analysis of the EPT Medication subscale suggested a negatively skewed distribution, raising the concern of possible ceiling effects that may have minimized power.

Neuropsychological Performance and Instrumental Activities of Daily Living Capacity

This was the first study to examine the predictive validity of demographic, neuropsychological, and cardiac function measures to IADL capacity among heart transplant candidates using a performance-based IADL criterion. Partial correlational analyses, controlling for education and race, showed mild to moderate correlations (rs = .25 to .51) between the neuropsychological test variables and the EPT subscales. Cognitive tasks assessing fine motor speed and dexterity (PEG-D, PEG-ND), long-standing verbal ability (SILS-VOC), reading ability (WRAT), psychomotor speed and mental flexibility (TMT-B), abstract thinking and problem solving (SILS-AB, CATS) were the most consistently related to IADL functioning. Multiple regression analyses, controlling for education and race, showed that measures of fine motor speed and dexterity (PEG-ND), attention and concentration, and psychomotor speed (TMT-A), long standing verbal ability (SILS-VOC), abstract thinking and mental flexibility (TMT-B, SILS-AB) were the most important independent predictors of overall IADL capacity (i.e., EPT total score). The individual domains of IADL functioning (i.e., EPT subscales) were most consistently predicted by the combination of three neuropsychological tests assessing long-standing verbal ability (SILS-VOC), psychomotor speed and mental flexibility (TMT-B), and abstract thinking and problem solving (SILS-AB). The Selective Attention subtest of the UFOV was also an important predictor on three of the seven IADL subtests, but was not a significant predictor of the EPT total score. In each regression equation, decreased neuropsychological functioning was associated with decreased performance on the EPT.

In contrast to previous studies (Goldstein et al., 1992; McCue, Rogers, & Goldstein, 1990; Nadler et ai., 1995), memory functioning was found to be largely unrelated to IADL capacity. Several factors may be related to this apparent discrepancy. The first is related to a limitation of previous studies. More specifically, one study included only memory measures as predictor variables (Goldstein et al., 1992), which leaves unclear whether memory served as a proxy variable for other areas of neuropsychological deficits that may be related to IADL capacity (Richardson et al., 1995). Second, unlike performance-based IADL tasks that involve memory for a brief instruction set, the paper and pencil format of the EPT visually displays all the information necessary for a correct response for each item on one page. This format may limit the influence of memory functioning. Relatedly, since the paper and pencil format of the EPT involves minimal motor engagement, the predictive validity of speeded motor tasks (i.e., PEG-D) to IADL capacity may also have been limited. Third, the verbal memory task used in the current study (WMS-R Logical Memory) employs a story format that provides a rich set of contextual cues that may facilitate encoding and retrieval as compared to verbal list learning tasks that are more dependent on spontaneous encoding and retrieval strategies (e.g., associative memory strategies). Indeed, a case-control study of groups matched on age, education, gender, and race found no differences between heart transplant candidates and controls on the WMS-R Logical Memory subtest (Putzke et al., in press). The use of a verbal list learning task that may be more sensitive to subtle cognitive decline might have had a greater predictive power to identify compromised IADL functioning. Finally, the neuropsychological battery used did not include a visuo-spatial memory and processing task, which has been shown to be an important neuropsychological domain related to IADL functioning (Richardson et al., 1995). Practical constraints (e.g., administration time) of the clinical services limited the scope of the neuropsychological domains assessed.

Cardiac Function and Instrumental Activities of Daily Living Capacity

A comprehensive model of IADL functioning includes not only cognitive predictors, but also physical health indicators (Willis, 1996c; Willis & Schaie, 1993). Indeed, several studies have shown a significant relationship between self-reported cardiac disease markers (e.g., angina pectoris, number of cardiac medications) and self-reported IADL functioning (Hlatky et al., 1986; Neill et al., 1985; Nelson et al., 1991; Pinsky et al., 1990; Stewart et al., 1989; Willis & Marsiske, 1991). Thus, a secondary aim of the current study was to explore the incremental predictive validity of measures of cardiac function to IADL capacity. In general, cardiac function data failed to incrementally predict IADL capacity after education, race, and cognitive predictors were controlled. Moreover, cardiac function measures failed to predict IADL performance even when entered into the regression model on the second step, before the neuropsychological test variables.

Several important factors may have limited the predictive validity of cardiac function measures to IADL performance. Most importantly, the EPT does not involve significant motor engagement. That is, a paper and pencil problem-solving task was used to assessed IADL tasks with a high motor load. Since subjects did not have to actually perform the high motor demand tasks, the influence of increased fatigue, motivation, and shortness of breath secondary to poor cardiac function may have been minimized. It should be noted, however, that non-load-dependent cardiac measures, which tend to be the most consistently correlated to neuropsychological functioning, did not significantly predict IADL capacity, even when entered into the regression model before the neuropsych-ological test variables. Second, since all patient participants had end-stage heart disease, the relationship between measures of cardiac function and IADL capacity may also have been attenuated secondary to a restricted range of function on the cardiac measures. Ideally, the relationship between cardiac function and IADL performance would include three groups: normal controls, patients with cardiac disease not being considered for transplantation because cardiac function is too high, and patients with end-stage cardiac disease. Thus, assuming a linear relationship exits between measures of cardiac function and IADL ability, the correlations found in the current study may have been lowered by a restriction in range. Since homoeostatic regulatory mechanisms serve to maintain cerebral and cardiac perfusion in mild to moderate cardiovascular disease at the expense of other organs and muscular beds (Saxena & Schoemaker, 1993), the assumption of a linear relationship between cardiac function and IADL performance across the entire range of cardiac function (i.e., disease state to normal) may be reasonable for IADL tasks with a high motor load. Fatigue, poor motivation, and shortness of breath may be the mechanisms related to reduced capacity on high motor-demand IADLs secondary to impaired cardiac function. This hypothesis is unclear, however, since the relationship between cardiac function, exercise tolerance, and fatigue is far from perfect (Coats, 1997). Another factor possibly minimizing the relationship between cardiac function and IADL capacity is the fact that cardiac catheterization data was collected within 20 days of completing the EPT. In contrast, the EPT and cognitive tests were administered on the same day. The increased time between completion of the catheterization and EPT may have increased the variability of the cardiac function data (Pai & Shah, 1995), potentially limiting predictive power.

Limitations

There are some other limitations of the current study to consider. First, as mentioned earlier, the neuropsychological battery employed did not include a verbal list learning or a visuo-spatial memory task. Impaired verbal list learning has been consistently demonstrated in heart transplant candidates (Augustine et al., 1994; Hecker et al., 1989; Nussbaum et al., 1995; Putzke et al., 1997a; Riether et al., 1992; Roman et al., 1997). Visuo-spatial processing and memory among heart transplant candidates have been mixed, with some studies showing performance within normal limits (Roman et al., 1997; Strauss et al., 1992) and others reporting mild to moderate deficits (Bornstein et al., 1995; Schall et al., 1989). More importantly, a visuo-spatial processing measure was the strongest predictor of IADL capacity in a large study of dementia and elderly participants (Richardson et al., 1995). Thus, the predictive validity of visuo-spatial memory and verbal list learning measures to EPT capacity among heart transplant candidates is unknown. Second, IADL tasks are generally considered to be in the early stage of development. Two issues are particularly salient to the current study. One issue is that the EPT does not fully capture spontaneous initiation or sequencing of behaviors that may be problematic in the patient's daily life. Thus, the extent to which EPT performance can be generalized to in-home daily living may be limited. Relatedly, environmental (e.g., mechanical aids, social support) factors may compensate for poor IADL functioning. Thus, even if a patient demostrated impaired IADL function, other compensatory support mechanisms may minimize concerns of the patient's ability to independently manage a complex medical regimen. Another issue is that the EPT does not capture the motor component involved in many IADL tasks, possibly limiting the influence of fatigue, poor motivation or arousal, and shortness of breath secondary to reduced cardiac function. However, the extent to which physical ability should be included in IADL ability is debatable, as many in the field generally are moving toward a definition of IADL capacity with increased emphasis on cognitive functioning (see cognitive competency conceptualization, (Willis, 1991; 1996a; 1996b; 1996c; Willis & Schaie, 1993).

Future Directions

There are two areas of continued research needed: One area is more general to the IADL assessment enterprise, and the other is more specifically related to IADL functioning among heart transplant candidates. First, development of well validated instruments of IADL functioning that address some of the limitations of the current measures are needed to improve clinical judgement of IADL capacity. Similar to other instruments, IADL test development will encounter an ongoing tension between conflicting concerns of efficiency, cost, reliability, response burden, and external validity. Continued development will be particularly important as the U.S. population continues to age. The combination of a psychometrically sound IADL and neuropsychological tests will be important tools to establish standards of competency and to identify patient strengths and weakness for targeted intervention efforts. With regard to heart transplant candidates, prospective studies with appropriate controls are needed to determine the predictive validity of IADL capacity to transplant outcome broadly defined (e.g., rejection episodes, infection episodes, health care utilization). Establishing IADL predictors to posttransplant functioning will help clinicians make informed pretransplant decisions with regards to targeted intervention efforts for those at increased risk of poor post transplant outcome.

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APPENDIX

POWER ANALYSIS

A power analysis was conducted using the Borenstein, M. & Cohen, J. (1988) Statistical Power Computer Program to determine the likelihood of finding a statistically significant correlation coefficient between cognitive tests and ADL capacity if it was actually present. The number of subjects needed for a range of correlation coefficients at the .8 power level were generated assuming a two-tail Alpha level of .05 (see table below). The most conservative estimate was chosen (n = 84).

Correlation coefficient	n
.6	19
.5	28
.4	46
.3	84

Borenstein, M. & Cohen, J. (1988). Statistical Power Analysis: A Computer Program. Hillsdale, NJ: Lawrence Elrbaum.

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Activities of Daily Living in Heart Transplant Candidates

I certify that I have read this document and examined the student regarding its content. In my opinion, this dissertation conforms to acceptable standards of scholarly presentation and is adequate in scope and quality, and the attainments of this student are such that _he may be recommended for the degree of Doctor of Philosophy.

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IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6"

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