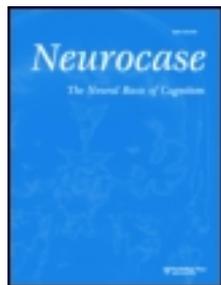


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Financial errors in dementia: Testing a neuroeconomic conceptual framework

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Financial errors by patients with dementia can have devastating personal and family consequences. We developed and evaluated a neuroeconomic conceptual framework for understanding financial errors across different dementia syndromes, using a systematic, retrospective, blinded chart review of demographically-balanced cohorts of patients with Alzheimer's disease (AD, n=100) and behavioral variant frontotemporal dementia (bvFTD, n=50). Reviewers recorded specific reports of financial errors according to a conceptual framework identifying patient cognitive and affective characteristics, and contextual influences, conferring susceptibility to each error. Specific financial errors were reported for 49% of AD and 70% of bvFTD patients ($p = 0.012$). AD patients were more likely than bvFTD patients to make amnesic errors ($p < 0.001$), while bvFTD patients were more likely to spend excessively ($p = 0.004$) and to exhibit other behaviors consistent with diminished sensitivity to losses and other negative outcomes ($p < 0.001$). Exploratory factor analysis identified a social/affective vulnerability factor associated with errors in bvFTD, and a cognitive vulnerability factor associated with errors in AD. Our findings highlight the frequency and functional importance of financial errors as symptoms of AD and bvFTD. A conceptual model derived from neuroeconomic literature identifies factors that influence vulnerability to different types of financial error in different dementia syndromes, with implications for early diagnosis and subsequent risk prevention.

Keywords: Alzheimer's disease; Frontotemporal dementia; Neuroeconomics; Decision-making; Financial capacity; Instrumental activities of daily living; Affect; Fraud; Financial abuse.

Existing measures of financial management in dementia identify patients who no longer have the capacity to manage their financial affairs independently (Hebert, Carrier, & Bilodeau, 1988; Lawton & Brody, 1969; Martin et al., 2008; Pfeffer, Kurosaki, Harrah, Chance, & Filos, 1982). Conceptually, financial incapacity represents an advanced stage of functional impairment, often when dementia is established and financial errors have

already been made. Many patients present for evaluation at an earlier stage, when they have concerns about their financial management or have made one or two financial errors, yet still manage their finances independently. Biological therapies for dementia that are currently in development are anticipated to slow disease progression without preventing disease onset, which would leave a larger population of patients in such intermediate stages

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of functional impairment (Brookmeyer, Johnson, Ziegler-Graham, & Arrighi, 2007).

Closer study of real-world financial errors in dementia would have implications for early diagnosis and management. Financial mismanagement is often the earliest indicator of cognitive decline (Pérès et al., 2008; Triebel et al., 2009), and different dementia syndromes target specific neural systems that may be reflected in susceptibility to different types of error (e.g., amnesic errors in Alzheimer's disease versus impulsive decisions in frontotemporal dementia). Also, if risks for different types of error in different syndromes can be established, clinicians will be better-equipped to counsel patients and families to avoid situations that place them at greatest risk (Widera, Steenpass, Marson, & Sudore, 2011).

Neuroeconomics is an emerging interdisciplinary field that combines the analytic power of economic models with methods from cognitive neuroscience, yielding new insights into the neural bases of decision-making and financial judgment (Glimcher & Ristichini, 2004; Loewenstein, Rick, & Cohen, 2008; Zak, 2004). We applied these insights to develop a conceptual framework for understanding financial errors in patients with neurodegenerative disease. We then tested this framework's clinical relevance in a blinded chart review of financial errors in patients with Alzheimer's disease and behavioral variant frontotemporal dementia.

METHODS

Conceptual framework of financial errors in dementia

Financial management is a multidimensional activity that involves myriad cognitive and affective resources (Marson et al., 2000), and is strongly influenced by one's social milieu and life circumstances. In developing a framework for susceptibility to financial errors in dementia, we drew upon an existing neuroeconomic literature documenting neural and cognitive components of financial decision-making and management. This model was also informed by well-known alterations in cognitive and affective function in different dementia syndromes, and by our clinical experience in evaluating financial errors made by patients with dementia. (Figure 1).

This framework accounts for contextual influences as well as individual patient characteristics that predispose patients to make financial errors.

Individual patient cognitive characteristics include disease-related impairment in domains of "fluid" intelligence such as memory, calculation, and executive function, as well as premorbidly-acquired "crystallized" intelligence in the form of stored financial conceptual knowledge and experience (Agarwal, Driscoll, Gabaix, & Laibson, 2009).

Neuroeconomic research also highlights the importance of affective factors in financial decision-making (Coricelli et al., 2005; Knutson & Greer, 2008; Loewenstein, Weber, Hsee, & Welch, 2001; Samanez-Larkin, Kuhnen, Yoo, & Knutson, 2010; Sokol-Hessner, 2009); these may have particular relevance in dementia given the recognized neuropsychiatric manifestations of different dementia syndromes (Cummings et al., 1994; Levy, Miller, Cummings, Fairbanks, & Craig, 1996). Applying prospect theory, the most established empirical account of decision-making under risk (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992), we have distinguished between disease-related alterations in affective responses to anticipated gains and to anticipated losses. Exaggerated affective responses to gains and blunted responses to losses (or other negative consequences) would predispose patients to errors such as overspending, risky investments, and criminality; while diminished responses to gains and exaggerated responses to losses would predispose patients to conservative decisions (which may or may not be appropriate), and also to anxiety and paranoia about financial matters.

Individual patient cognitive and affective characteristics interact with contextual influences. For instance, patients with dementia are less able to critically evaluate telemarketing, e-mail, and personal solicitations. At the same time, if fraud perpetrators target the cognitively impaired, then patients may be at increased risk for receiving such solicitations in the first place (Smith, 2000; Templeton & Kirkman, 2007). Meanwhile, other demographic characteristics may determine whether the opportunity arises for a patient to make a certain kind of error. Some patients, such as wives in some patriarchal cultures, have never had responsibility for investments or checking, and so would be at less risk for errors in these tasks. Other errors arise in the context of financial issues specific to a stage of life (Nielsen & Mather, 2011); for instance, middle-aged patients may be more likely than elderly patients to make errors in purchasing real estate. Finally, some patients' families may act preemptively to limit patients' financial independence and diminish the likelihood of

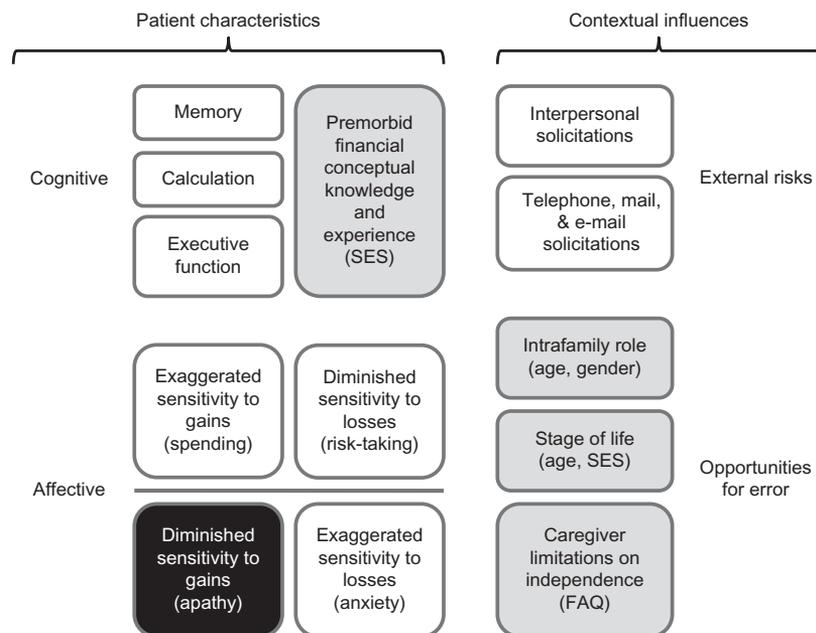


Figure 1. Neuroeconomic conceptual framework for susceptibility to financial errors in dementia. White boxes represent domains explicitly addressed in this chart review. Gray boxes represent variables controlled between AD and bvFTD patients in our demographic matching algorithm (using years of education as a proxy for socioeconomic status, SES) or measured at the time of patient evaluation (in the case of the Functional Activities Questionnaire, FAQ). Diminished sensitivity to gains is represented in black because we did not attempt to account for this characteristic in this chart review; while we believe that such diminished sensitivity is pathological in many patients, available data did not allow us to distinguish pathological cases from other cases in which conservative decision-making reflects a reasonable response to diminished cognitive ability.

subsequent financial errors, but this depends greatly on the social and family support available to the patient.

SUBJECTS

We applied this conceptual framework to a retrospective chart review of patients with Alzheimer's disease (AD) and behavioral variant frontotemporal dementia (bvFTD) seen at our tertiary memory disorders center. Given the interaction of patient characteristics and contextual influences, which are affected by demographic variables such as age, gender, and socioeconomic status, we selected samples of patients that were balanced for these characteristics. We began by identifying 50 patients diagnosed with bvFTD at our center according to established research criteria (Neary et al., 1998) between 2007 and 2012; to limit heterogeneity we excluded patients with predominantly right temporal atrophy (as opposed to frontal atrophy) given the unique cognitive and neuropsychiatric manifestations of this subtype (Chan et al., 2009).

We then selected 100 patients diagnosed with AD at our center between 2007 and 2012, matched in a two-to-one fashion with the bvFTD cohort by age at initial presentation to our center, gender, and years of education (as a surrogate for socioeconomic status). AD patients met established research criteria for probable AD (McKhann et al., 1984) and had a predicted neuropathology of Alzheimer's disease; to limit heterogeneity we also restricted this cohort to patients with a classical amnesic and/or dysexecutive initial presentation, excluding patients with a predominantly behavioral, language, or visuospatial syndrome at onset. The resulting cohorts were demographically well-balanced both in their means and also their distributions (Table 1). The greater proportion of men in both cohorts reflects the greater preponderance of male patients affected in bvFTD.

During their evaluations, patients underwent several cognitive and functional evaluations, including the Functional Activities Questionnaire (FAQ; Pfeffer et al., 1982), an informant-based measure of patient independence. Three items on the FAQ assess independence in financial behaviors such as

TABLE 1
Demographic characteristics of AD and bvFTD patients

Characteristic	AD (n = 100)	bvFTD (n = 50)	p
Age at initial presentation (y)	60.6 ± 6.5	58.9 ± 6.1	0.13
Male gender (%)	72%	72%	1.00
Education (y)	15.1 ± 3.0	15.0 ± 3.6	0.96
Number of visits available for review	2.1 ± 1.4	1.8 ± 1.1	0.17

Values are means ± standard deviation. Variables are compared across cohorts using unpaired *t*-tests with unequal variance.

paying bills, assembling tax documents, and making purchases; these items are scored on a scale ranging from 0 (normal) to 3 (dependent). Initial FAQ data were available for all 50 patients with bvFTD; these data were available for 35 patients with AD and were estimated from chart review for another 41 patients with AD. Financial independence items were combined into a subtotal; there was a trend towards greater initial financial independence in the AD group than the bvFTD group (5.82 vs. 6.62 out of 9, $p = 0.11$).

Assessment of history of financial errors

Clinical reports and research visit summaries for the selected subjects were reviewed, with the reviewer (W.C.) blinded to the final diagnosis. Any mention of financial impairment (even if not detailed) was recorded, and specific examples of financial error and other aberrant financial behaviors were categorized as detailed below. We restricted our analysis to behaviors involving the disposition of money, property or assets; other behaviors, even with predictably negative financial consequences (e.g., insulting one's boss and losing one's job) were not included.

For each specific error described in the chart, the reviewer attempted to categorize the primary domain influencing the patient's susceptibility to that error, according to the conceptual framework described. In some cases, two joint domains were identified. Memory, calculation, and executive errors were conceptualized as errors in which the patient made a correct decision (e.g., to pay a bill), but failed to correctly carry out that decision due to a cognitive failure (e.g., forgetting that the bill had already been paid and paying it again, miscalculating the amount due, or failing to carry out a sequence of steps to pay it).

Affective contributions were conceptualized as contributors to poor financial decisions. Excessive spending might either reflect exaggerated sensitivity to gains (i.e., possessing some desired object) or diminished sensitivity to losses (i.e., the monetary cost of the object) (Knutson & Greer, 2008); however, available chart data did not allow us to distinguish these possibilities, so all cases of excessive spending were grouped together. Other cases of diminished sensitivity to negative consequences were also recorded, such as risky investments, shoplifting, and taking out multiple loans when already overextended. We also recorded examples of increased sensitivity to losses, often in the form of paranoia about theft or hiding valuables. We did not attempt to record errors reflecting diminished sensitivity to gains, which in theory would produce apathy and the failure to exploit available financial opportunities. While such failures likely are pathological in some patients, data available from chart review could not distinguish between pathological cases and other cases in which conservative decision-making reflects a reasonable response to diminished cognitive ability.

We also recorded errors that resulted from a failure to critically assess solicitations and other proposals, which were also conceptualized as contributors to poor financial decisions. Vulnerability to interpersonal solicitations and to solicitations in less personal formats (such as telemarketing or e-mail) were recorded separately. Charitable giving (whether to organizations or to panhandlers) was coded as an error if disorganized (e.g., for one patient who continued to donate when being unable to meet his own expenses, or another patient who later was not able to identify the charities to which he had donated) or if inconsistent with premorbid behavior.

To measure interrater reliability for the application of our conceptual framework to financial errors uncovered in chart review, a subset of 20% of charts (19 patients with AD, 11 patients with bvFTD) were independently reviewed and coded by a second reviewer (D.W.).

Statistical analyses

Differences in recorded financial impairments and in recorded errors were compared across groups using unmatched *t*-tests with unequal variance, and a kappa statistic was calculated as a measure of interrater reliability of our chart review method.

We then used exploratory factor analysis to investigate underlying relationships among the measured subtypes of error. Reviewers' judgments about error subtypes were then retabulated according to the factors uncovered in our exploratory analysis, yielding a revised kappa statistic.

Standard protocol approvals, registrations, and patient consents

Given the retrospective nature of our chart review, a waiver of consent for participation in research was granted by the Committee on Human Research at UCSF.

RESULTS

Prevalence and timing of financial impairments

Financial impairments (of any type) were commonly reported, and in many cases were early indicators of cognitive decline. 72% of AD and 84% of bvFTD charts included some report of financial impairment, $p = 0.09$. In 16% of AD cases and 30% of bvFTD cases, the financial impairment was either the first indicator of cognitive decline or was observed concurrently with the first indicator of decline, $p = 0.07$; and in 34% of AD cases and 48% of bvFTD cases, the financial impairment was noted within the first two years of illness, $p = 0.11$. In all cases, there was a trend towards greater impairment in bvFTD, but no comparison was statistically significant.

Differences in susceptibility to errors in AD and bvFTD

Our conceptual framework revealed significant between-group differences in susceptibility to financial errors in AD and bvFTD (Tables 2 & 3). Specific reported financial errors were less prevalent in AD (49%) than in bvFTD (70%). Categorizing errors according to our conceptual framework, AD patients were more likely to make amnesic errors (26%) than were bvFTD patients (4%). Meanwhile, bvFTD patients were more likely to spend excessively (6% in AD vs. 34% in bvFTD) and to otherwise exhibit diminished sensitivity to losses (0% in AD vs. 36% in bvFTD). There was a trend towards increased sensitivity to losses in AD as

TABLE 2
Prevalence of reported financial errors in AD and bvFTD

	AD (<i>n</i> = 100)	bvFTD (<i>n</i> = 50)	<i>p</i>
All reported financial errors	49 (49%)	35 (70%)	0.01*
Memory	26 (26%)	2 (4%)	<0.001*
Calculation	6 (6%)	1 (2%)	0.20
Executive function	8 (8%)	3 (6%)	0.65
Excessive spending	7 (7%)	17 (34%)	0.004*
Decreased sensitivity to losses	0 (0%)	18 (36%)	<0.001*
Increased sensitivity to losses	9 (9%)	3 (6%)	0.50
Interpersonal solicitation	5 (5%)	8 (16%)	0.06
Telephone/mail/e-mail solicitation	2 (2%)	5 (10%)	0.08

Prevalence of reported errors is compared across cohorts using unpaired *t*-tests with unequal variance. Prevalence rates of error subtypes do not sum to the total error prevalence because many patients made multiple documented errors of different subtypes, while some other errors could not be categorized. Within the subtypes given by our conceptual framework, asterisks represent significant findings after Bonferroni correction for multiple comparisons ($p < 0.00625$).

compared to bvFTD (9% vs. 6%). Of note, two of the three bvFTD patients with behaviors suggesting exaggerated sensitivity to losses also had excessive spending, whereas excessive spending and diminished sensitivity to losses were observed in none of the nine AD patients with such behaviors. Thus, these behaviors in AD may represent a “pure” syndrome of exaggerated sensitivity to losses, while these behaviors in bvFTD may instead be merely a component of a broader affective dysregulation with regard to financial matters.

Seven errors recorded in AD charts and 10 errors recorded in bvFTD charts could not be categorized according to our conceptual framework. In many cases, the description in the chart was too sparse for more detailed analysis—e.g., one patient who “has made a number of bad decisions with respect to finances.” In other cases, the nature of the errors was not recoverable because the patients' decisions had not been monitored by family members, and the patients could not explain what they had done. Hoarding behaviors (3% of AD and 18% of bvFTD charts, $p = 0.012$) in many cases could not be categorized as they could either represent exaggerated sensitivity to losses (e.g., being unable to throw away things that might prove useful later), or diminished sensitivity to losses (e.g., collecting

TABLE 3
Representative financial errors documented in patient charts

Memory	“[The patient’s wife] stated he would forget to pay bills or pay bills twice.” (AD)
Calculation	“In 2006 they received a check back from New York State for \$1189 in reimbursement from taxes. . . he could not figure out how much they owed in taxes that year and simply sent a check.” (AD)
Executive function	“[S]he started putting her checks and bills in the wrong envelopes.” (AD)
Excessive spending	“At baseline, she was quite thrifty and was a successful small business owner. In 2002, she began to be compulsively shopping and she spent a great amount of money on a motor home, two new cars, and in remodeling of the backyard area of her home.” (bvFTD)
Decreased sensitivity to losses	“He became more aggressive with his investment decisions, and several of his investments lost value in the range of hundreds of thousands of dollars.” (bvFTD)
Increased sensitivity to losses	“Increasing obsessive behavior about jewelry and money, suspicious about it being money, constantly asking to see it, count it, and be assured that it is around. She often becomes quite anxious and tearful thinking it is missing or someone has taken it. She has begun hiding it.” (AD)
Interpersonal solicitation	“He began giving money out to strangers and was lured into a bogus gambling scheme conceived by his barber. The two of them traveled to Las Vegas at considerable expense on two occasions.” (bvFTD)
Telephone/mail/e-mail solicitation	“[The patient] started investing massively in lottery tickets, wiring money abroad and falling for scams found in her junk mail or magazines. She reached the credit limit on most of her credit cards and apparently lost tens of thousands of dollars this way.” (bvFTD)

Quotations are verbatim.

items without regard to their cost or the costs of storing them).

Interrater reliability for two reviewers independently reviewing errors using this framework yielded a kappa = 0.59, indicating moderate agreement.

Exploratory factor analysis

An exploratory factor analysis was performed using the measured error subtypes, limiting the interpretation to variables with loadings of 0.30 and above (Table 4). This yielded a two-factor solution, with Factor 1 representing social/affective vulnerability

and Factor 2 representing cognitive vulnerability to errors. Reviewers’ assessments of patient charts were retabulated to reflect these factors; errors reflecting Factor 1 were less common in AD than in bvFTD (12% vs. 58%, $p < 0.001$), while errors reflecting Factor 2 were more common in AD than in bvFTD (29% vs. 6%, $p < 0.001$). We hypothesized that some cases of interrater disagreement within the original coding schema may have been due to ambiguity between two subtypes reflecting a common factor. Retabulating reviewers’ assessments according to these factors yielded a kappa = 0.73, indicating substantial agreement.

DISCUSSION

Financial errors are common in AD and bvFTD, and the cognitive, affective and contextual factors influencing susceptibility to these errors are different in the two diseases. A neuroeconomic conceptual framework identified subtypes of financial errors that were strongly associated with AD and other subtypes that were strongly associated with bvFTD. Amnesic financial errors were common in AD; while bvFTD patients were susceptible to excessive spending and other behaviors suggestive of diminished affective sensitivity to losses and other negative consequences, including theft, shoplifting, risky investments, and overuse of credit. More broadly, financial errors in AD reflected a cognitive vulnerability factor, while financial errors

TABLE 4

Factor loadings of measured subtypes of financial errors

	<i>Factor 1: Social/affective vulnerability</i>	<i>Factor 2: Cognitive vulnerability</i>
Excessive spending	0.463	−0.029
Telephone/mail/e-mail solicitation	0.438	−0.004
Decreased sensitivity to losses	0.415	−0.229
Interpersonal solicitation	0.381	0.131
Calculation	0.145	0.373
Memory	−0.196	0.316
Variance explained by each factor	0.784	0.309

Loadings for variables found to load on each factor are represented in bold type.

in bvFTD reflected a social and affective vulnerability factor. Social/affective rather than cognitive deficits conferred greater risk for financial errors, as is suggested by prospect theory.

Our chart review was limited by its retrospective design, and on clinicians' reliance upon caregiver report in compiling the clinical histories that were used in our chart review. Both of these limitations would likely lead to systematic underestimates of the prevalence of financial errors. Also, while our study supports a role for individual cognitive and affective characteristics in vulnerability to financial errors, we did not have concurrent measurements of cognitive and affective parameters at the time that patients made errors (in some cases, years prior to the initial clinical evaluation). These limitations reflect a common clinical scenario, in which a patient presents for a cognitive evaluation and the clinician must ascertain the clinical significance of a reported financial error (or alternatively, the absence of reported errors).

To exclude confounding effects of age, gender, and socioeconomic status, we used a bvFTD cohort as a reference sample and selected an AD cohort that was matched for these variables. The resulting AD cohort is not demographically representative of AD patients as a whole; in particular, this cohort is younger and predominantly male. Differences in clinical presentation have been observed between patients with early-onset and late-onset AD (Balasa et al., 2011). Therefore, care should be taken in generalizing our results to all patients with AD. Both cohorts were also of high educational attainment, and the financial problems encountered by our patients may not reflect those encountered by patients with less education or of lower socioeconomic status.

Because our data depend on the quality of clinicians' notes, we cannot exclude the possibility of systematic bias in documentation of errors between diagnostic categories. Also, because we restricted our analysis to patients evaluated in the past five years, only a small subset of patients has an autopsy-confirmed neurodegenerative disease diagnosis: one patient in the AD cohort and 15 patients in the bvFTD cohort (of whom nine had concomitant motor neuron disease). All 16 patients were correctly diagnosed premortem, suggesting high clinical diagnostic accuracy in our center. Seven patients in the AD cohort and 12 patients in the bvFTD cohort have undergone PET imaging with the amyloid-binding agent Pittsburgh Compound B (PiB). All seven scans in AD patients

were independently evaluated as PiB-positive, and all 12 scans in bvFTD patients were evaluated as PiB-negative.

Future work will extend the application of our proposed neuroeconomic framework to prospective studies of financial decision-making in dementia and mild cognitive impairment, as well as in normal aging. Further characterization of susceptibility to different kinds of financial errors in different dementia syndromes may aid in early diagnosis, and may also aid clinicians in advising patients and family members to avoid situations that place them at greatest risk for errors, fraud, and abuse.

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