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Prefrontal systems in financial processing

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Abstract

Prefrontal systems of the brain are logical regions to study in terms of finances, given their roles in executive functions. Individuals with neurological insults to prefrontal systems often show poor financial management, and healthy individuals consistently show activation of prefrontal systems during financial tasks. This paper reviews studies done in four community samples using self-rating scales of prefrontal system dysfunction. Three studies showed modest but consistent inverse relationships between income and three separate measures of prefrontal system dysfunction, relationships which remained significant after controlling for age, sex, and education. In a fourth study, credit card debt correlated positively to self-ratings of measures of prefrontal system dysfunction, which also remained significant after controlling for age, sex, education, and income. These results are convergent with prior studies, but extend the results into larger community samples, confirming that prefrontal systems play a role in specific aspects of finances including income and credit card use.
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1. Introduction

A biopsychosocial perspective encourages the broadest possible way of understanding a behavior, recognizing that influences exist at multiple levels. As its name implies, this perspective incorporates the influence of biological systems, individual psychological phenomena, and sociocultural forces (Molina, 1983–1984). Much research has been conducted on financial behavior from psychological and sociocultural levels, but an understanding at a neurological level is a

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relatively new undertaking. Towards this end, the field of neuroeconomics is emerging. An understanding of financial behavior that includes neurological influences would clearly improves our understanding of aberrant financial behavior in people with neurological and psychiatric illnesses. Many with such illnesses demonstrate aberrant spending behaviors, requiring them to have assistance or even guardianship (e.g., Bechara et al., 2000). Further, developments in neuroeconomics can add a dimension to understanding normal variations in financial behavior in normal, non-clinical populations.

2. Prefrontal systems and executive functions

Prefrontal systems are logical regions of the brain to study in terms of finances given their known roles in cognition and behavior. Executive functions (such as reasoning, planning and decision-making) are a collection of cognitive abilities that are the most pertinent for adaptive functioning, allowing for behavior that is more goal-oriented, flexible, and autonomous. As such, the measurement of executive functions is of great interest for both clinical assessment and research into multiple relevant behaviors. Prefrontal systems are critical structures that mediate executive functions.

Prefrontal systems consist of prefrontal cortex, the most anterior portions of the frontal lobe (for reviews, see Tekin and Cummings, 2002; Chow, 2000). Prefrontal neurons have projections to nuclei of the striatum (e.g., caudate, nucleus accumbens, globus pallidus), which in turn project to the nuclei of the thalamus. These thalamic nuclei (e.g., anterior and mediodorsal nuclei) project back to prefrontal cortex. These connections form a processing loop that mediates various executive functions. Different aspects of executive functions are mediated by different regions of prefrontal cortex and associated subcortical regions (Tekin and Cummings, 2002). Medial prefrontal regions (including the anterior cingulate) mediate motivational aspects of behavior, such as initiation and persistence (Cohen et al., 1999). Individuals with medial prefrontal dysfunction can show varying degrees of reduced initiation of behaviors, or abulia. The most extreme cases are labeled akinetic mutism, in which there can be a complete lack of initiative, drive and spontaneous behaviors. The dorsolateral prefrontal cortex mediates conceptual reasoning (both verbal and nonverbal), mental flexibility, planning, and working memory (Masterman and Cummings, 1997). Individuals with dorsolateral lesions tend to be concrete, mentally inflexible, and disorganized. The orbitofrontal cortex mediates self-inhibition, social conduct, empathy, and decision-making (Malloy et al., 1993). Individuals with orbitofrontal damage exhibit disinhibition, impulsivity, inappropriate social conduct, a lack of empathy, and poor judgement. These could each play important roles in one's occupational and financial attainment.

3. Financial processing in neurological illnesses

The executive functions mediated by prefrontal systems could play a role in management of finances. This is evident in the financial mismanagement present in many individuals who experience neurological insult to prefrontal systems. Bechara et al. (2000) have shown that individuals with damage to the ventromedial prefrontal cortex make disadvantageous choices on the Iowa Gambling Task. They tend to make shortsighted choices leading to short-term gains, but long-term losses. Individuals with mild cognitive impairment show impairments in conceptual knowledge about finances, cash transactions, bank statement management, bill payment, and overall financial capacity (Griffith et al., 2003). People with frontal lobe lesions perform worse than controls on a financial planning task (Goel et al., 1997). They have difficulties in

organizing and structuring their problems, allocating adequate effort to each phase of problem solving, and generating their own feedback. In effect, they have trouble generalizing, mental set shifting, and exercising judgment about the adequacy and completeness of their plans. Individuals with traumatic brain injury often show reduced autonomy, have difficulty managing their finances, and require increased supervision (Mazaux et al., 1997). These difficulties largely result from impairments of executive functioning. There is also evidence of financial difficulties associated with neurodegenerative dementias. People with frontotemporal dementia develop deficits of executive functioning and behavioral control, typically necessitating a caretaker to assume their financial responsibilities (Mychack et al., 2001; Talerico and Evans, 2001). People with Huntington's disease show poor financial reasoning, making more disadvantageous responses on the Iowa Gambling Task when compared to those with Parkinson's disease (Stout et al., 2001). Further, their performance is related to measures of memory and conceptualization but not disinhibition, suggesting a deficit related more to cognitive dysfunction than to impulsivity or risk taking. A case of Creutzfeldt–Jakob disease was reported who manifested secondary mania, including pressured speech, thought racing, rapid thought shifting, insomnia, and spending sprees which led to credit card debt (Lendvai et al., 1999).

4. Neuroimaging of financial processing

In healthy individuals, several functional neuroimaging studies have been done which illustrate a primary role for prefrontal–subcortical systems in response to monetary reward and punishment. Monetary rewards activate the orbitofrontal cortex (Thut et al., 1997; O'Doherty et al., 2001; Elliott et al., 2000). Knutson et al. (2001a,b) found activation of the ventromedial prefrontal cortex when reward was contrasted against non-reward outcomes. O'Doherty et al. (2001) further showed that the magnitude of orbitofrontal activation correlates with the magnitude of rewards and punishments. The medial prefrontal cortex also responds to monetary rewards. Both increases in cerebral blood flow and electrophysiological activation is observed in the medial prefrontal cortex during both monetary rewards and punishments (Knutson et al., 2000; Gehring and Willoughby, 2002). Furthermore, choices made after losses tended to be riskier and created greater loss-related activity in the medial prefrontal cortex. Subcallosal (or subgenual) regions of the medial prefrontal cortex (Brodmann's area 25) also show activation during monetary reward (Elliott et al., 2000). Monetary decision making created predominantly right-sided activation across multiple prefrontal areas (dorsolateral, orbitofrontal, and anterior cingulate) (Ernst et al., 2002).

Functional neuroimaging shows that striatal and brainstem monoamine structures are also activated in response to financial reward (Elliott et al., 2003). For example, monetary rewards and punishments activate the caudate and putamen (Knutson et al., 2000). The ventral striatum (nucleus accumbens) is activated during the anticipation of monetary rewards, but not during the outcome phase or in response to punishment (Knutson et al., 2001a,b). Ventral striatum activation also is associated with self-ratings of happiness during the task. Elliott et al. (2000) similarly found activation of the ventral striatum during reward but not during punishment. However, Delgado et al. (2000) showed that rewards were associated with activation of the nucleus accumbens, while punishment caused a de-activation.

5. Measurement of prefrontal functions

It can be seen from this brief survey that both functional neuroimaging and clinical studies implicate the prefrontal systems in both cognition and behavior regarding finances. Several meth-

ods exist, however, for assessing the function of prefrontal systems. Functional neuroimaging studies employ direct physiological means of imaging cerebral metabolism or blood flow. These have the advantage of showing the neuroanatomical specificity of the results. They are also a more objective measure, and less susceptible to biases from the subjects and the researchers. However, results may vary from study to study depending on which methodology is used. Subtraction techniques are used, comparing brain activity in one condition to another, and digitally subtracting the results. This can produce varying results depending on which method of subtraction is used. Functional neuroimaging studies also are necessarily limited to measuring brain function in an artificial laboratory setting and using abstract monetary tasks (e.g., winning money for guessing a correct card) whose ecological validity has not been established. Thus, how these results generalize to everyday life is uncertain. A third limitation of functional neuroimaging studies is the very small samples used in each study. Caution must be made in generalizing from small groups of individuals to the general population when there can be a great deal of inter-individual variation in results. Nonetheless, functional neuroimaging studies have consistently shown the relevance of prefrontal systems to financial management, and they have greatly advanced knowledge of the determinants of financial processing. Given these limitations however, it is prudent to corroborate and extend these findings with other methodologies.

Objective neuropsychological tests are objective measures of performance. These tests measure executive functions, which are dependent on the functioning of prefrontal systems. Standardized procedures for administrating and scoring attempt to minimize potential biases, although it would be impossible to eliminate them entirely. These tests are also abstract tasks and of limited ecological validity, so again caution must be exercised in generalizing them to everyday life. Some of these tests must be given in a one-on-one setting, typically in an office or laboratory setting, limiting the practicality of economically obtaining a large sample. One objective measure of executive function is the Cognitive Estimation Test, which requires individuals to engage in a multi-step reasoning process to arrive at an educated guess and has the advantage of being self-administered (Axelrod and Millis, 1994).

Subjective neuropsychological measures are self-rating scales. These are convenient to administer and can be given outside of the laboratory, making larger, more diverse samples feasible. Larger samples allow for greater statistical power and control for demographic influences. They can also inquire about a large range of behaviors and situations that are more applicable to one's everyday life. Their chief disadvantage is in the potential for biases in self-reporting by subjects. Many individuals may tend to underestimate their degree of executive dysfunction. However, several of these instruments have been validated with objective methods including objective neuropsychological tests, functional and structural neuroimaging, and studies of neurologically dysfunctional populations. Several self-rating scales of executive function have been developed and validated, including the Frontal Systems Behavior Scale (FrSBe), the Barratt Impulsiveness Scale (BIS), and the Obsessive–Compulsive Inventory (OCI) (Grace and Malloy, 2001; Foa et al., 2002; Patton et al., 1995).

5.1. Prefrontal systems and personal income

A preliminary investigation was carried to examine the relationship between self-rated executive functions and personal income in a community sample (Spinella et al., 2004a). Participants were recruited by research assistants from the college campus and local community. Participants were 106 non-institutionalized adults (57 males, 49 females) with a mean age of 31.1 years (S.D. = 13.9 years) and a mean of 14.3 years of education (S.D. = 1.9).

The *Barratt Impulsiveness Scale - version 11* (BIS) was administered. The BIS is a 30-item, self-rating scale, which measures three factors: non-planning (orientation towards the present rather than the future, BISnp), motor impulsivity (or acting without thinking, BISm), and attentional impulsivity (e.g., lack of concentration, BISa) (Patton et al., 1995). Representative items include: "I plan tasks carefully" (BISnp, inverted item), "I act on impulse" (BISm), and "I concentrate easily" (BISa, inverted item). Responses on the Barratt Impulsivity Scale have correlated with the white matter microstructure in right prefrontal cortex in people with schizophrenia where less-developed white matter correlated with greater motor impulsivity (Hoptman et al., 2002). Horn et al. (2003) showed that BIS scores relate to prefrontal cortex activity in healthy individuals performing a response inhibition task (go/no-go). BIS scores correlate with objective neuropsychological measures of prefrontal function (go/no-go, antisaccades, and delayed alternation) (Spinella, 2004).

An inverse relationship emerged between income and total impulsiveness, which remained significant after controlling for sex, age and education (see Table 1). The subscale with the most consistent associations was motor impulsivity. Thus, a self-rating measure of executive dysfunction showed modest but predicted inverse correlations with income, even after controlling for demographic influences.

To examine further the relationship between prefrontal system functions and income, a second community sample was obtained of 235 adults from community (129 females, 96 males, 10 unspecified), with a mean age of 28.7 years (S.D. = 11.8) and a mean of 14.4 years of education (S.D. = 1.7) (Spinella et al., 2004a). This sample was administered the Frontal Systems Behavior Scale (FrSBe), a 46-item rating scale developed to assess neurobehavioral traits associated with the function of prefrontal–subcortical system (Grace et al., 1999). The FrSBe has three subscales derived by factor analysis: Apathy (A), Disinhibition (D) and Executive Dysfunction (E), as well as a total score (T). The subscales were designed to measure neurobehavioral syndromes associated with medial prefrontal, orbitofrontal and dorsolateral prefrontal–subcortical systems, respectively (Malloy et al., 1993; Masterman and Cummings, 1997). The validity of the FrSBe has been established by comparisons with prefrontal lesion patients: (1) post-lesion scores are worse than pre-lesion scores, (2) prefrontal lesion patients score worse than healthy controls, and (3) prefrontal lesion patients perform worse than non-prefrontal lesion patients (Grace et al., 1999). Validity has also been established in psychiatric and neurodegenerative dementia populations. FrSBe scores also correlate with objective measures of executive dysfunction (Chiaravalloti and DeLuca, 2003).

Table 1
Correlations between income and scores on the Barratt Impulsiveness Scale (two-tailed significance)

	Bivariate correlation	Partial correlation
NP	−.19*	−.16
M	−.33‡	−.25†
A	−.26†	−.14
Total	−.31‡	−.22*

Partial correlations are controlling for age, sex, and education (d.f. = 101); subscales: non-planning (NP), motor impulsivity (M), attention deficit (A).

* $p \leq .05$.

† $p \leq .01$.

‡ $p \leq .001$.

Table 2
Correlations between scores on the Frontal Systems Behavior Scale and income

	Bivariate correlation	Partial correlation
A	−.10	−.21‡
D	−.27‡	−.17*
E	−.18†	−.19†
T	−.21‡	−.21‡

Partial correlations are controlling for age, sex, and education (d.f. = 209).
* $p \leq .05$.
† $p \leq .01$.
‡ $p \leq .001$.

Income was again inversely associated with overall executive impairment, the FrSBe total score (see Table 2). Among the subscales, income was inversely associated with the Disinhibition and Executive Dysfunction scores but not with the Apathy score. After controlling for age, sex and education, the associations of income with all FrSBe scales were significant. These results corroborate those found with the BIS, using a separate but objectively validated executive function measure. The results for both measures persisted after controlling for demographic variations in individuals from the local community.

A third study was done to further corroborate prior results and extend the findings with other executive function measures (Spinella et al., 2006). This sample consisted of 139 adults from the community (66 males, 71 females, 2 did not specify sex), with a mean age of 33.7 years (S.D. = 14.7) and a mean education of 14.5 years (S.D. = 2.2). This study used the FrSBe, the Obsessive–Compulsive Inventory-Revised (OCI-R), a self-rating measure of obsessive–compulsive symptoms, and the Cognitive Estimation Test (CET).

CET tasks have demonstrated sensitivity to prefrontal dysfunction, as evidenced by performance in people with prefrontal lesions (Shallice and Evans, 1978; Smith and Milner, 1984; Axelrod and Millis, 1994). The Obsessive–Compulsive Inventory-Revised (OCI-R) is an 18-item self-rating scale whose items are concerned with common symptoms of OCD (Foa et al., 2002). It has six subscales, derived by factor analysis (which are listed in Table 3). The OCI-R has been validated and shows sensitivity and specificity in clinical samples. OCD symptoms have been associated with dysfunction in prefrontal–subcortical systems, even in healthy individuals with who show symptoms of subclinical severity (Baxter et al., 1988; Gross-Isseroff et al., 2003; Mataix-Cols et al., 2003).

As can be seen in Table 3, income was associated with the total score on the FrSBe and on all three subscales. Income was also associated with the CET score and with four of the seven scores from the OCI-R. These associations were in the predicted direction, and the majority remained statistically significant after controls for sex, age and education.

5.2. *Prefrontal systems and credit card debt*

Given the consistent results obtained with income and measures of prefrontal function, a fourth study examined other aspects of financial behavior (Spinella et al., 2004b). The use of credit cards for purchases often constitutes a disadvantageous allocation of finances, particularly when used to make purchases one could not otherwise afford. While it is possible to use them advantageously, accumulation of credit card debt is highly disadvantageous (Schor, 1998). This is in contrast to the debt incurred by purchasing a home or automobile, which are generally associated with financial

Table 3
Correlations between income and scale of the Frontal Systems Behavior Scale (FrSBe), Obsessive–Compulsive Inventory-Revised (OCI-R), a self-rating measure of obsessive–compulsive symptoms, and the Cognitive Estimation Test (CET) (two-tailed significance)

	Bivariate correlation	Partial correlation
FrSBe		
A	−.18*	−.10
D	−.34‡	−.18*
E	−.29‡	−.15
T	−.31‡	−.17*
CET Total	−.39‡	−.33‡
OCIR		
Checking	−.17*	−.20*
Hoarding	−.12	−.20*
Neutralizing	−.10	.03
Obsessing	−.30‡	−.22†
Ordering	−.11	−.16
Washing	−.17*	−.10
Total	−.22†	−.21*

Partial correlations are controlling for age, sex, and education (d.f. = 129).
* $p \leq .05$.
† $p \leq .01$.
‡ $p \leq .001$.

stability and responsibility (Drentea and Lavrakas, 2000). The ratio of credit card debt to income is associated with increased anxiety and stress, and poorer health, and credit card debt is associated with overall patterns of self-destructive behavior (Drentea and Lavrakas, 2000; Drentea, 2000; Politano and Lester, 1997).

This study employed 127 adults recruited from the community (69 female, 58 male), with a mean age of 33.0 years (S.D. = 13.3), and a mean of 14.5 years of education (S.D. = 2.1). They were administered the FrSBe and asked about both personal income and credit card debt. Linear regression, removing the influences of age, sex, education and income, showed that the E subscale score predicted credit card debt [$F(6, 133) = 2.03$, $p < .001$; Adjusted $R^2 = .47$]. As anticipated,

Table 4
Linear regression showing the relationship of credit card debt to subscales of the Frontal Systems Behavior Scale

	B	S.E.	Beta
Set 1			
Age	−.02	.01	−.18
Sex	−.27	.12	−.20*
Education	−.02	.06	−.03
Income	.41	.14	.31‡
Set 2			
A	−.03	.03	−.13
D	−.02	.02	−.11
E	.06	.02	.35†

* $p \leq .05$.
† $p \leq .01$.

the relationship was positive, with greater executive impairment associated with greater credit card debt, even after removing the influences of demographic variables and income (see Table 4). The FrSBe E scale addresses functions such as organization, multitasking, sequencing, mental flexibility, benefiting from feedback, and using mental strategies, functions that are associated mainly with the activity of dorsolateral prefrontal cortex circuits. Thus, credit card debt appears to be related to one's ability to mentally track one's finances, and to spend and allocate them strategically. For example, a person with mild dorsolateral prefrontal dysfunction may be less likely to take existing debt and mounting interest into account when deciding to make another purchase with a credit card. This finding is consistent with prior studies mentioned above. Ernst et al. (2002) demonstrated widespread prefrontal activation, including dorsolateral prefrontal activation, during the Iowa Gambling task. People with Huntington's disease show impairments on the Iowa Gambling Task that is related to dorsolateral associated functions (concept formation, memory), and not disinhibition (Stout et al., 2001). People with frontal lobe lesions have difficulty with financial planning due to dorsolateral-associated functions such as organization, conceptualizing, problem solving, and benefiting from feedback (Goel et al., 1997). Thus, the differences between healthy and neurologically impaired individuals may be a matter of degree.

6. Conclusions

The results discussed here constitute consistent evidence that prefrontal systems are involved in executive functions that relate to financial behavior. The results were obtained in separate samples using externally validated neuropsychological measures. While the results with subjective measures (FrSBE, BIS, OCI-R) have limitations inherent in subjective rating scales and thus must be interpreted with caution, the results are consistent with each of the independently developed scales and in the anticipated directions. Further, they are consistent with an objective measure (CET) and consistent with what would be anticipated from clinical and functional neuroimaging studies. Thus, these studies constitute convergent evidence from diverse methodologies, confirming the logical supposition that executive functions, and the prefrontal systems that mediate them, play an important role in financial behavior. Subjective rating scales, when properly developed and validated, comprise an economical but useful complement to other methodologies. These initial results open the way for investigation of the neurobiological bases of many other aspects of financial behavior.

References

Axelrod, B.N., Millis, S.R., 1994. Preliminary standardization of the Cognitive Estimation Test. Assessment 1, 269–274.

Baxter, L.R., Schwartz, J.M., Mazziotta, J.C., Phelps, M.E., Pahl, J.J., Guze, B.H., Fairbanks, L., 1988. Cerebral glucose metabolic rates in nondepressed patients with obsessive–compulsive disorder. American Journal of Psychiatry 145, 1560–1563.

Bechara, A., Tranel, D., Damasio, H., 2000. Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. Brain 123, 2189–2202.

Chiaravalloti, N.D., DeLuca, J., 2003. Assessing the behavioral consequences of multiple sclerosis: an application of the Frontal Systems Behavior Scale (FrSBe). Cognitive & Behavioral Neurology 16, 54–67.

Chow, T.W., 2000. Personality in frontal lobe disorders. Current Psychiatry Reports 2, 446–451.

Cohen, R.A., Kaplan, R.F., Zuffante, P., Moser, D.J., Jenkins, M.A., Salloway, S., Wilkinson, H., 1999. Alteration of intention and self-initiated action associated with bilateral anterior cingulotomy. Journal of Neuropsychiatry and Clinical Neurosciences 11, 444–453.

Delgado, M.R., Nystrom, L.E., Fissell, C., Noll, D.C., Fiez, J.A., 2000. Tracking the hemodynamic responses to reward and punishment in the striatum. Journal of Neurophysiology 84, 3072–3077.

Drentea, P., 2000. Age, debt and anxiety. Journal of Health and Social Behavior 41, 437–450.
Drentea, P., Lavrakas, P.J., 2000. Over the limit: the association among health, race and debt. Social Sciences and Medicine 50 (4), 517–529.
Elliott, R., Friston, K.J., Dolan, R.J., 2000. Dissociable neural responses in human reward systems. Journal of Neuroscience 20, 6159–6165.
Elliott, R., Newman, J.L., Longe, O.A., Deakin, J.F., 2003. Differential response patterns in the striatum and orbitofrontal cortex to financial reward in humans: a parametric functional magnetic resonance imaging study. Journal of Neuroscience 23, 303–307.
Ernst, M., Bolla, K., Mouratidis, M., Contoreggi, C., Matochik, J.A., Kurian, V., Cadet, J.L., Kimes, A.S., London, E.D., 2002. Decision-making in a risk-taking task: a PET study. Neuropsychopharmacology 26, 682–691.
Foa, E.B., Huppert, J.D., Leiberg, S., Langner, R., Kichic, R., Hajcak, G., Salkovskis, P.M., 2002. The Obsessive–Compulsive Inventory: development and validation of a short version. Psychological Assessment 14, 485–495.
Gehring, W.J., Willoughby, A.R., 2002. The medial frontal cortex and the rapid processing of monetary gains and losses. Science 295, 2279–2282.
Goel, V., Grafman, J., Tajik, J., Gana, S., Danto, D., 1997. A study of the performance of patients with frontal lobe lesions in a financial planning task. Brain 120, 1805–1822.
Grace, J., Malloy, P.F., 2001. Frontal Systems Behavior Scale. Psychological Assessment Resources, Lutz, FL.
Grace, J., Stout, J.C., Malloy, P.F., 1999. Assessing frontal behavior syndromes with the Frontal Lobe Personality Scale. Assessment 6, 269–284.
Griffith, H.R., Belue, K., Sicola, A., Krzywanski, S., Zamrini, E., Harrell, L., Marson, D.C., 2003. Impaired financial abilities in mild cognitive impairment: a direct assessment approach. Neurology 60, 449–457.
Gross-Isseroff, R., Hermesh, H., Zohar, J., Weizman, A., 2003. Neuroimaging communality between schizophrenia and obsessive compulsive disorder: a putative basis for schizo-obsessive disorder? World Journal of Biological Psychiatry 4, 129–134.
Hoptman, M.J., Volavka, J., Johnson, G., Weiss, E., Bilder, R.M., Lim, K.O., 2002. Frontal white matter microstructure, aggression, and impulsivity in men with schizophrenia: a preliminary study. Biological Psychiatry 52, 9–14.
Horn, N.R., Dolan, M., Elliott, R., Deakin, J.F., Woodruff, P.W., 2003. Response inhibition and impulsivity: an fMRI study. Neuropsychologia 41, 1959–1966.
Knutson, B., Adams, C.M., Fong, G.W., Hommer, D., 2001a. Anticipation of increasing monetary reward selectively recruits nucleus accumbens. Journal of Neuroscience 21, RC159.
Knutson, B., Fong, G.W., Adams, C.M., Varner, J.L., Hommer, D., 2001b. Dissociation of reward anticipation and outcome with event-related fMRI. Neuroreport 12, 3683–3687.
Knutson, B., Westdorp, A., Kaiser, E., Hommer, D., 2000. FMRI visualization of brain activity during a monetary incentive delay task. Neuroimage 12, 20–27.
Lendvai, I., Saravay, S.M., Steinberg, M.D., 1999. Creutzfeldt–Jakob disease presenting as secondary mania. Psychosomatics: Journal of Consultation Liaison Psychiatry 40, 524–525.
Malloy, P.F., Bihrle, A., Duffy, J., Cimino, C., 1993. The orbitomedial frontal syndrome. Archives of Clinical Neuropsychology 8, 185–201.
Masterman, D.L., Cummings, J.L., 1997. Frontal–subcortical circuits: the anatomic basis of executive, social and motivated behaviors. Journal of Psychopharmacology 11, 107–114.
Mataix-Cols, D., Cullen, S., Lange, K., Zelaya, F., Andrew, C., Amaro, E., Brammer, M.J., Williams, S.C., Speckens, A., Phillips, M.L., 2003. Neural correlates of anxiety associated with obsessive–compulsive symptom dimensions in normal volunteers. Biological Psychiatry 53, 482–493.
Mazaux, J.M., Masson, F., Levin, H.S., Alaoui, P., Maurette, P., Barat, M., 1997. Long-term neuropsychological outcome and loss of social autonomy after traumatic brain injury. Archives of Physical Medicine and Rehabilitation 78, 1316–1320.
Molina, J.A., 1983–1984. Understanding the biopsychosocial model. International Journal of Psychiatry and Medicine 13, 29–36.
Mychack, P., Kramer, J.H., Boone, K.B., Miller, B.L., 2001. The influence of right frontotemporal dysfunction on social behavior in frontotemporal dementia. Neurology 56 (11 Suppl. 4), S11–S15.
O'Doherty, J., Kringelbach, M.L., Rolls, E.T., Hornak, J., Andrews, C., 2001. Abstract reward and punishment representations in the human orbitofrontal cortex. Nature Neuroscience 4, 95–102.
Patton, J.H., Stanford, M.S., Barratt, E.S., 1995. Factor structure of the Barratt impulsiveness scale. Journal of Clinical Psychology 51, 768–774.
Politano, J., Lester, D., 1997. Self-destructiveness and credit card debt. Psychological Reports 81, 634.

Schor, J.B., 1998. The Overspent American: Upscaling, Downshifting, and the New Consumerism. Basic Books, New York.
Shallice, T., Evans, M.E., 1978. The involvement of the frontal lobes in cognitive estimation. Cortex 14, 294–303.
Smith, M.L., Milner, B., 1984. Differential effects of frontal-lobe lesions on cognitive estimation and spatial memory. Neuropsychologia 22, 697–705.
Spinella, M., 2004. Neurobehavioral correlates of impulsivity. International Journal of Neuroscience 114, 95–104.
Spinella, M., Yang, B., Lester, D., 2004a. Income and prefrontal system dysfunction: a preliminary study in neuroeconomics. Journal of Interdisciplinary Economics 15, 217–223.
Spinella, M., Yang, B., Lester, D., 2004b. Prefrontal system dysfunction and credit card debt. International Journal of Neuroscience 114, 1323–1332.
Spinella, M., Lester, D., Yang, B., 2006. Prefrontal cortex dysfunction and income. Psychological Reports 98, 37–38.
Stout, J.C., Rodawalt, W.C., Siemers, E.R., 2001. Risky decision making in Huntington's disease. Journal of the International Neuropsychological Society 7, 92–101.
Talerico, K.A., Evans, L.K., 2001. Responding to safety issues in frontotemporal dementias. Neurology 56 (11 Suppl. 4), S52–S55.
Tekin, S., Cummings, J.L., 2002. Frontal–subcortical neuronal circuits and clinical neuropsychiatry: an update. Journal of Psychosomatic Research 53, 647–654.
Thut, G., Schultz, W., Roelcke, U., Nienhusmeier, M., Missimer, J., Maguire, R.P., Leenders, K.L., 1997. Activation of the human brain by monetary reward. Neuroreport 8, 1225–1228.