Neuroscience and Ultimate Causation in Accounting Research

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What is human nature? It is not the genes, which prescribe it, or culture, its ultimate product. Rather, human nature is something else for which we have only begun to find ready expression. It is the epigenetic rules, the hereditary regularities of mental development that bias cultural evolution in one direction as opposed to another, and thus connect the genes to culture... The search for human nature can be viewed as the archaeology of epigenetic rules. It is destined to be a vital part of future interdisciplinary work.
—E. O. Wilson

I. INTRODUCTION

The brain of homo sapiens is the result of natural selection over millions of years (Darwin 1871, 83–99; Allman 2000). The human brain is the source of adaptive behaviors that have allowed us to survive in varying climates across the planet; the brain lies at the core of what it means to be human, and likely what has produced tools, art, and music (Wilson 1999). It also may be the ultimate source of tools used to create accounting artifacts and reports (Dickhaut, Basu, McCabe, and Waymire 2010).

Implicit in an evolutionary story of accounting origins is a link between evolved features of the human brain and the accounting measurement rules that emerge from market interactions (Dickhaut 2009). Evolution is a long-term process that requires that we consider both proximate and ultimate causation. For example, a powerful proximate force affecting the demand for accounting is debt contracting, where lenders use accounting data to monitor lending agreements (Watts and Zimmerman 1985). The ultimate causal role of accounting may stem from its being necessary for the success of societies with market economies based on exchange and division of labor (Smith 1776/1976; Basu and Waymire 2006; Soll 2014).

Attacking the bigger issue of ultimate causation in accounting requires that we gather direct evidence on how accounting alters decision-making within the brain. While there is an extensive experimental literature on how investors use accounting information (Libby, Bloomfield, and Nelson 2002; Bonner 2008), this work has had no direct access to actions within the brain that drive
behavior. Recent technological innovations now used widely by neuroscientists offer an opportunity to get a more direct look at what occurs in the brain while economic decisions are being made. The studies by Barton, Berns, and Brooks (2014; hereafter BBB) and Farrell, Goh, and White (2014; hereafter FGW) that accompany this essay are the first such studies in accounting of which I am aware.

These studies examine fundamental accounting issues using functional MRI (fMRI) scanning methods. The BBB paper links stock market pricing of earnings news to reward processing in the brain. This paper is a type of "event study" that explores directly how brain behavior reflects aggregate market behavior. FGW’s paper addresses the managerial accounting issue of how compensation plan design influences investment choice. The study’s unique contribution is to investigate how the brain balances emotional factors (System 1) and economic factors (System 2) in making decisions. Both of these studies address issues that have long been of interest to accounting researchers (e.g., Ball and Brown 1968; Chow and Haddad 1991).

These papers raise the question of whether neuroscience studies in accounting are a one-off event versus offering the potential to break major new ground in understanding accounting. After describing the contributions of these two "NeuroAccounting" studies, I will offer some observations about why I believe this research has potentially large upside potential (see, also, Birnberg and Ganguly [2012] for a similar view of this research).

II. CONTRIBUTIONS OF THE BBB AND FGW PAPERS TO ACCOUNTING KNOWLEDGE

Barton, Berns, and Brooks (2014)

Accounting scholars have long recognized accounting earnings as a measure of economic value that is useful to common stock investors. Ball and Brown (1968) empirically evaluated two prior claims made by normative accounting theorists that (1) financial statements prepared under existing reporting rules are meaningless, and (2) radical changes in the nature of financial statement information are necessary to produce useful information (Ball and Brown 2014, 3). The evidence provided by Ball and Brown (1968) called into question the validity of the claims made by normative theorists, at least with respect to the first issue of earnings usefulness (Ball and Brown 2014, 15–16).

One limitation of stock price studies is that they provide evidence of correlation, but not causation. Ball and Brown (1968) and the numerous studies that followed can at best establish a contemporaneous association between public earnings disclosure and stock price movements—see Lev (1989) for review. Such studies cannot establish that a metric like earnings leads to changes in how investors view a firm’s equity value, where the changes presumably generate stock price adjustments reflecting aggregate market belief revision. Several studies have investigated the impact of earnings and other accounting data on individual investor judgments (Libby et al. 2002, 783–789), but such studies can only provide indirect evidence on how the human brain is affected by earnings numbers. The Barton et al. (2014) paper provides more direct evidence.

The first challenge faced by BBB is to specify hypotheses about how an earnings announcement will lead to measurable physiological activity within the brain. BBB’s first hypothesis is that the brain will view accounting earnings as a secondary “reward” where greater amounts of earnings will be viewed as “good” or “pleasurable.” The idea is that an earnings

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1 An earlier paper examining similar issues from the standpoint of security analysts is Horngren (1955, 576), who concluded that analysts regard the income statement as “the most important reflector of operations of the firm.”

2 A “primary” reward is one that directly relates to an organism’s survival—e.g., food or sexual activity (Murray et al. 2011). A secondary reward is something like money or status that allows an individual to acquire greater primary rewards (Zink, Pagnoni, Martin-Skurski, Chappelow, and Berns 2004).
announcements lead to neuronal activity in brain areas such as the ventral striatum that are known to be involved in reward processing (Haber 2011). Their second hypothesis is that ventral striatum activity precedes actions that are associated with market consequences. Thus, the extent of ventral striatum activity associated with an earnings announcement will be positively correlated with measures of market activity such as trading volume.

BBB’s experiment involves a multi-stage process where subjects prepare an earnings forecast for each of 60 actual firms, choose either a long or short position for each firm’s common stock, and observe the actual earnings and stock price changes for the companies. The final stage of the experiment occurs in the scanner, where the subject’s brain is scanned using fMRI technology every two seconds while observing earnings and returns.

Each trial faced by the subject in the scanner involved three distinct events. The first was a reminder of the subject’s earnings forecast and equity position chosen in the pre-scanner phase, the second event was the revelation of the actual earnings surprise for that specific trial, and the third was the revelation of the actual stock return for that trial, which determined the financial payoff to the subject. The brain image data collected by BBB were intended to identify neuronal firing in the ventral striatum at the time of these three events.

BBB’s findings establish a clear association between earnings news and concurrent activity in the ventral striatum that is consistent with empirical findings that date back nearly 50 years. First, they demonstrate that the intensity of reactions in the ventral striatum is generally increasing in response to earnings forecast errors measured relative to the analyst consensus. This finding parallels early work on the information content of the sign and magnitude of earnings news (Ball and Brown 1968; Beaver, Clarke, and Wright 1979). Second, they show that striatal reaction is more pronounced for bad earnings news than good earnings news. This parallels long-known empirical regularities suggesting an asymmetric relation between earnings and common stock returns (e.g., Mendenhall and Nichols 1988; Basu 1997) and is also consistent with Prospect Theory (Kahneman and Tversky 1979). Finally, BBB also document that striatal behavior correlates positively with stock price changes and trading volume at the time that actual earnings are revealed to subjects, which is consistent with early work on trading volume and earnings news (Beaver 1968; Patell 1976).

The Barton et al. (2014) paper is important because it empirically establishes a deeper scientific connection between earnings, the main output from the accounting process, and physiological responses reflected in investor processing of rewards that likely has roots in the biological evolution of the brain. I view this as the best evidence available suggesting that accounting earnings measures a fundamental economic construct.

Farrell, Goh, and White (2014)

Experimental researchers began exploring how human decisions were influenced by accounting information in the 1960s, and numerous studies relating accounting information to

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3 The ventral striatum is not the only brain area where rewards are processed. Instead, the ventral striatum is more likely one important component of multiple parts of the brain that are “connected” through neurons in processing rewards (Camara, Rodriguez-Fornells, and Munte 2009).

4 The brain image data in a typical fMRI study are subject to substantial adjustment to make the data interpretable. The overall effect of these data adjustments is to obtain measures of brain activity that correspond generally to what can be thought of as a “difference-in-differences” design, where observed brain responses to experimental stimuli are benchmarked against brain activity during a control period. Both the Barton et al. (2014) and the Farrell et al. (2014) studies have this feature.

5 Other neuroscience studies have found evidence that other brain regions respond more strongly to negative information than positive information (e.g., Knutson, Adams, Fong, and Hommer 2001; Tom, Fox, Trespel, and Poldrack 2007).
individual decisions were published in the 1970s. For example, Swieringa and Weick (1982) list 113 experimental articles published in Accounting, Organizations and Society, The Accounting Review, and Journal of Accounting Research during 1970–1981. This research remains an important part of the accounting research literature (Bonner 2008).

Some of this research explores how accounting numbers and compensation contracts influence managers’ investment decisions (Chow and Haddad 1991). Other studies investigate how a manager trades off economic and emotional factors in making investment decisions (Kida, Moreno, and Smith 2001; Moreno, Kida, and Smith 2002). The idea behind these studies is that emotional factors might be weighed excessively to the detriment of shareholders. The FGW paper fits squarely within this literature and makes its contribution by using fMRI technology to see inside the “black box” of the brain while investment decisions are made.

FGW’s main hypothesis is that the impact of affect on investment decisions will vary when a performance-based contract is used rather than a fixed wage contract. The key constructs here are “System 1” and “System 2,” which represent complementary dual processes within the brain, as described by Kahneman (2011). System 1 is a more heuristic-based decision process that is rapid, intuitive, and may not even be explicitly recognized by the decision-maker. System 2 is more deliberative and consciously overrides System 1 when the costs of poor decisions are salient or larger.

FGW’s main hypothesis is that managers’ affect for some proposers will lead to a greater reliance on System 1 processing, but that System 2 would be more likely to override System 1 when performance-based compensation is used. The test of this hypothesis involves an experiment where a subject is provided a series of vignettes describing specific positive and negative personality characteristics of several individuals who will propose specific investment opportunities. The subject acting as a division manager responsible for making investment decisions then chooses between two risky investment proposals. The subject faces a series of trials where the investment choice is first made under a fixed compensation contract and then under a performance-based contract tied to realized earnings.

Subjects’ brains were scanned while observing outcomes from their investment choices under six different sets of experimental conditions based on compensation (fixed wage or performance-based) and affect (positive, neutral, or negative). Unlike BBB, where the main hypothesis focused on a specific brain region (ventral striatum), the tests in FGW are based on analyses of several brain regions. This approach is necessary since System 1 and System 2 processing are distributed across multiple regions within the brain.

FGW document that regions associated with System 1 processing (e.g., insula, superior medial frontal/anterior cingulate) respond more to affective choices under both types of contracts. Also, System 2 regions (e.g., regions in the frontal lobe known to perform an “executive” function in the brain) responded more to affective choices under a performance-based contract than under a fixed wage contract. Finally, additional evidence indicates that the actual choices made by subjects, in both the scanner experiment and in a second behavioral experiment, confirm that subjects make

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6 The first experimental work in accounting dates to the early 1960s; Birnberg and Nath (1967) provide a review of this early work.
7 Of course, reliance on emotional factors can be desirable in many circumstances. For instance, persons who lack the ability to express emotions can be unable to carry on the day-to-day business of everyday living—see, e.g., the case of Phineas Gage, who suffered major personality changes after having survived an accident where an iron rod was driven through his skull in 1848 (Damasio 1994). Darwin (1871) theorizes that human emotions like fear and disgust were shaped by natural selection and, thus, can be of adaptive value. FGW recognize such effects in their footnote 3.
8 Stanovich and West (2000, 658) introduced the terms “System 1” and “System 2” to describe ideas that had previously received considerable attention from psychologists.
more economically desirable choices in affective scenarios when compensation is determined by a performance-based contract.

The big takeaway from the FGW paper is that accounting information, when used to determine compensation, changes behavior and has multiple direct correlates in contemporaneous brain activity. This is important because it suggests a link between the brain and benefits from accounting, as suggested by the earliest writers on double-entry accounting. For example, as quoted by Carruthers and Espeland (1991, 36), Pacioli (1494/1924, 1) notes:

The present treatise will serve all their needs with regard to accounts and recording, and for this reason only do I insert it. I therefore intend to give sufficient rules to enable them to keep all their accounts and books in an orderly manner . . . The third and last thing necessary is that all one’s affairs be arranged in good order so that one may get, without loss of time, all the particulars as to the debit and also the credit of all of them, as business does not deal with anything else. This is very useful, because it would be impossible to conduct business without due order of recording, for without rest, merchants would always be in great mental trouble.

III. CAN NEUROSCIENCE HELP US IDENTIFY ULTIMATE CAUSATION FOR ACCOUNTING?

Merriam-Webster’s defines the noun for “cause” to include “something that brings about an effect or result.” Causation can be either proximate or ultimate, both of which can help explain the occurrence of past events, allow for prediction of future events, and lead to accurate interpretation of “goal-directed” phenomena related to the events (Mayr 1961, 1,501). Pinker (2002, 54) notes:

A proximate cause of behavior is a mechanism that pushes behavior buttons in real time, such as the hunger and lust that impel people to eat and have sex. An ultimate cause is the adaptive rationale that led the proximate cause to evolve, such as the need for nutrition and reproduction that gave us the drives of hunger and lust. The distinction between proximate and ultimate causation is indispensable in understanding ourselves because it determines the answer to every question of the form “Why did that person act as he did?” (emphasis in the original)

The quote at the start of this essay suggests that ultimate causation for human behavior arises from “epigenetic rules,” which Wilson (1999, 210) defines as:

innate operations in the sensory system and brain . . . They predispose individuals to view the world in a particular innate way and automatically to make certain choices as opposed to others . . . We avoid mating with a sibling, speak in grammatically coherent sentences, smile at friends, and when alone fear strangers in first encounters. Typically emotion-driven, epigenetic rules in all categories of behavior direct the individual toward those relatively quick and accurate responses most likely to ensure survival and reproduction.

In a prior paper, co-authors and I speculated that ultimate causation for many longstanding accounting principles may lie in fundamental human behaviors that likely result from epigenetic rules (Dickhaut et al. 2010, 227–231). These behaviors are reflected in norms that are common

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9 Turkheimer (2000) describes research on behavior genetics as having three laws, the first of which is “All human behavioral traits are heritable.”
across human societies and human moral codes of behavior: (1) fair dealing, (2) trust-based reputations tied to reciprocity, and (3) altruistic punishment to sanction offenders.¹⁰

That paper speculated that accounting principles emerged as part of a broad institutional structure to support beneficial reciprocal exchange. How might this be manifested in practices that we see today? Consider the case of debt contracting, which is seen as a major determinant of conservative accounting practices (Watts 2003). Under this view, debt contracting is a proximate cause for conservatism. At the same time, contracting for mutually advantageous exchange could be an ultimate cause of conservative accounting, since “contract formation is more than a cultural universal. It is a human trait as characteristic of our species as language and abstract thought, having been constructed from both instinct and high intelligence” (Wilson 1999, 186).

The idea that accounting is tied to fundamental human behavior suggests that moral and legal codes will sanction those who fail to repay debts, and base such decisions on records of past transactions created by accountants (Basu and Waymire 2006, 221–223). This also suggests that such effects may feed back to favor accounting practices that promote better self-control to avoid behaviors that could endanger an individual’s reputation for trustworthiness in exchange. Schelling (1984, 83–87) describes such internal conflicts as being addressed in part by “social arrangements” that encourage behaviors that are in the individual’s long-term interests, but are personally difficult to implement. Accounting is a social institution that can encourage appropriate behavior consistent with human moral codes (Aho 2006; Soll 2014).

To illustrate, consider an accounting phenomenon that is ubiquitous, yet rarely recognized by financial statement users. Suppose that a retailer takes out a 12-month loan to finance the acquisition of inventory that will collateralize the loan. The retailer will record a payable for this loan and the lending bank will similarly record a receivable. At subsequent dates, the bank’s receivable will be shown net of an allowance for credit losses due to possible default by the borrower. Such will not be the case for the borrower; it seems self-evident that a borrower would not record such a reserve because future potential lenders would avoid any borrower whose financial statements indicated he considered loan default to be an ex ante strategic decision. How then does one explain the asymmetric treatment of reserves for credit gains versus losses that dates back several hundred years to a time when financial statements were generally not publicly disclosed?

One potential hypothesis is that the asymmetric treatment of reserves for receivables and payables has moral underpinnings, where a business owner seeking to protect a reputation for honest conduct might view asset and liability reserves as fundamentally different in character. This is consistent with words offered in the early accounting text of Bennedetto Cotrugli (1458) when he suggested, as quoted by Carruthers and Espeland (1991, 44):

> We shall turn to the practice of [keeping] records. These not only preserve and keep in memory [all] transaction, but they are also a means to avoid many litigations, quarrels and scandals... Mercantile records are the means to remember all that a man does, and from whom he must have, and to whom he must give, and the costs of wares, and the profits, and the losses, and every transaction on which the merchant is all dependent. And it should be noted that knowing how to keep good and orderly records teaches one to draw contracts, how to do business, and how to obtain a profit. And undoubtedly, a merchant must not rely upon memory, for such reliance has caused many persons to err.

¹⁰ Reciprocity and reciprocal exchange are included in the list of human universals as compiled by Brown (1991)—see, also, Pinker (2002, 54–58, 435–439). Human universals “consist of those features of culture, society, language, behavior, and mind that, so far as the record has been examined, are found among all peoples known to ethnography and history” (Brown 2004, 47).
To this point, my discussion has emphasized that accounting is rooted in moral conduct. Its foundations encourage ethical behavior, with presumed benefits arising from accounting’s ability to generate trust in, and increase gains from, economic exchange. Stated differently, good morals promote economic efficiency (Arrow 1972; McCloskey 2007). Future research should explore these links more rigorously and neuroscience methods will likely play an important role in this research effort. Accordingly, I will close this essay by offering a few suggestions concerning where this research might be particularly helpful. Birnberg and Ganguly (2012, 7–9) provide several additional suggestions for useful future NeuroAccounting research.

One area concerns the extent to which accounting information actually promotes an intent to trust. Rilling and Sanfey (2011, 28–29) review research in social neuroscience, which includes research on individuals’ willingness to trust a partner in social exchange and others’ willingness to reciprocate trust. This research implicates several brain areas associated with such activity using trust game and Prisoner’s Dilemma experiments. Given the longstanding view that “better” accounting and auditing enhances investor trust, these experiments could prove valuable in helping us understand when this is the case. Similar experiments could be run using experimental manipulations for how feedback information is provided to subjects in ways that resemble accounting information, such as quantitative information on rewards, where biases resembling conservatism are built into the information system or more precise hard information is provided.

A related area for research would involve exploring whether and how accounting information affects fraudulent behavior. Recent research suggests that individuals with certain psychological profiles are more likely to commit fraud—e.g., Majors (2014) documents that individuals with Dark Triad-type personalities are more likely to manipulate information. Other research links some of these personality types with different activation patterns in the brain while playing games involving a social cognition task (Bereczkei et al. 2013). Possible extensions to this research would include investigating (1) how accounting professionals score on these kinds of measures, and (2) whether priming for accounting ethics has any impact on how these individuals behave in such experiments.

More generally, the effect of accounting education on neuronal connectivity could be a fruitful area for research. It has long been known that different areas of the brain are connected with neurons; neurons also are characterized by plasticity, where neuronal connections can grow stronger as a result of training and experience (Doidge 2007). Extensive research has documented such effects to be present among professional musicians (Munte, Altenmüller, and Jancke 2002). While researchers may be many years away from documenting similar effects for accountants’ brains, this research suggests that accountants may have chosen their profession because their brains are genetically well suited to performing such tasks. In addition, accounting education and practice may further develop these abilities. If so, then accounting’s epigenetic basis might be discoverable.

REFERENCES

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