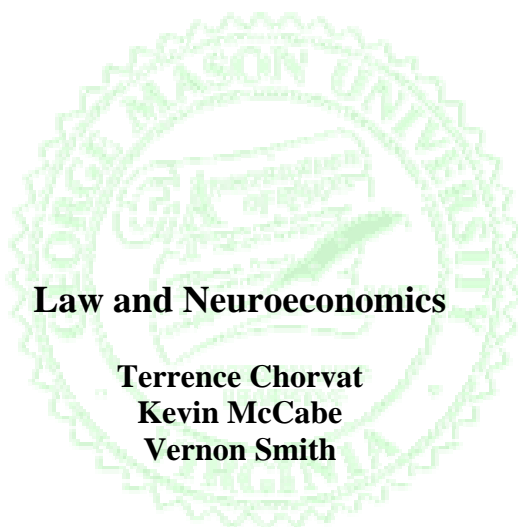


# **George Mason University SCHOOL of LAW**



**Law and Neuroeconomics**

**Terrence Chorvat  
Kevin McCabe  
Vernon Smith**

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**LAW AND ECONOMICS WORKING PAPER SERIES**

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# Law and Neuroeconomics

Terrence Chorvat<sup>\*</sup>, Kevin McCabe<sup>\*\*</sup> and Vernon Smith<sup>\*\*\*</sup>

*As legal scholarship has come to rely more on economic analysis, the foundational questions of economics have become important questions for legal analysis as well. One of the key foundational elements of modern economics is the assumption of the rational utility maximizing individual. While this assumption has often been questioned, until recently, it was not possible to actually examine the brain mechanisms that individuals use to process the economic problems they face. As a result of the increasing abilities to explore the brain as individuals engage in economic activity, this article calls for a new approach to the study of law which incorporates the findings from the emerging area of neuroeconomics. We call this approach law and neuroeconomics. We argue that this research can help us understand what is occurring in the brains of the individuals and knowledge gained thereby can greatly aid both in understanding the process of creation and development of law as well as its effects on human behavior. The article discusses this research and begins the analysis of applying these findings the study of law.*

## I. INTRODUCTION

Perhaps the most significant development in the study of law in the later half of the twentieth century was the application of social sciences to legal problems; Langdell's notions of law as autonomous study have long since been eroded.<sup>1</sup> The necessity of this application is obvious. Laws are made by humans<sup>2</sup> and hence the study of human

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<sup>1</sup> For a discussion of Christopher Columbus Langdell's notions of legal education see Roger Gordon, *Legal Education and Practice: The Case for (and Against) Harvard*, 93 Mich. L. Rev. 1231, 1245–1260 (1995) Law scholarship is no more merely determining what a particular case means, but also analyzing what is the optimal doctrine from a particular perspective. For a discussion of the change in the application of economics to law see William Landes, *The Empirical Side of Law and Economics*, 70 U Chi. L. Rev. 167 (2003)

<sup>2</sup> While many who follow schools of thought such as the natural law tradition may argue that law derives from objective universal principles. It is clear though that actual laws we have are created by humans. Arguable exceptions include Islamic Law, the laws found in Leviticus etc. These legal systems are beyond the scope of this article.

behavior is clearly pertinent to the study of law.<sup>3</sup> Economics, which is the study of how individuals and society choose to allocate scarce resources to satisfy their wants, clearly should have implications for understanding legal problems.<sup>4</sup> The study of human behavior can tell us a great deal about how humans will react to rules and one hopes it will allow us to generate better rules. Some commentators have argued that a key problem with the application of economics to legal problems has been the seemingly unreasonability of the assumptions of modern economics.<sup>5</sup> They argue that the assumptions that humans always follow their rational self-interest or that preferences can necessarily be stated in a coherent way are incorrect and therefore the conclusions that follow from them are questionable.<sup>6</sup> One of the most fertile areas of current research in human decision making is attempting to determine the degree to which these assumptions are reasonable. Such research will ultimately allow us to build economic models on more solid foundations.

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<sup>3</sup> Even to understand how doctrines should be applied one needs to understand how rules are interpreted by humans, not by computers, and this is related to the underdetermination of meaning of a particular phrase because no phrase is self-defining.

<sup>4</sup> See generally, Richard Posner, *The Economic Analysis of the Law* (Aspen Law & Business, 5th ed 1998)

<sup>5</sup> Milton Friedman, *Essays in Positive Economics* 16–23 (Chicago, 1953), argues the unreasonability of the assumptions of a model is not as important as the empirical value of the predictions. For a discussion of this point see Thomas Ulen, *Rational Choice in Law and Economics*, in Boudewijn Boukert and Geert de Geest eds, *Encyclopedia of Law and Economics* 790 (Edward Elgar, 2000).

<sup>6</sup> Ulen, *Rational Choice in Law and Economics* (cited in note 5). For a discussion of the major alternative to these neoclassical assumptions and the application of this to the law see Cass Sunstein ed, *Behavioral Law and Economics* (Cambridge, 2000). Many of the problems with traditional expected utility maximizing models stem from the fact that it is essentially impossible for individuals to actually make the choices we do based on an optimization calculation. Consider how many calculations would be necessary to decide what to buy in a typical American grocery store. The level of computational fluency would be beyond essentially everyone. Therefore, we must be using different rules to determine our behavior than these models predict. While these models may generally yield the correct outcome, if the processes are different it is entirely possible that they do not always yield the same result (that is, they may not be mathematically isomorphic).

Almost all approaches to the study of law involve some assumptions about the nature of human behavior and reasoning. Law and Economics is a discipline which attempts to apply the insights from economics to the study of law. Historically, the practice of this discipline has largely been the application of price theory to legal situations.<sup>7</sup> More recently, game theory has begun to be applied in some very areas, yielding some useful results.<sup>8</sup> In addition, other disciplines such as behavioral economics and its cousin behavioral finance have also begun to be applied to legal problems, yielding conclusions which are often at odds with traditional law and economics scholarship.<sup>9</sup>

The most recent approach to the study of economic problems to emerge is the discipline of neuroeconomics. Neuroeconomics attempts to study behavior by studying the neural mechanisms most responsible for behavior.<sup>10</sup> This article calls for incorporating the insights from neuroeconomics into legal studies. We refer to this enterprise as law and neuroeconomics. The goal which is intended to be achieved from this study is not merely the arcane knowledge that a particular perception occurs in a particular region of the brain, but rather an understanding of the brain mechanisms used by individuals as they address economic problems and how these mechanisms affect behavior. From this inquiry, we can hope to understand the nature of the limits of law to alter behavior, how the alterations that can be achieved can be accomplished more

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<sup>7</sup> For example, the economics discussed in Posner's book is almost entirely applications of price theory. See generally Posner, *The Economic Analysis of the Law* (cited in note 4).

<sup>8</sup> Douglas Baird et al, *Game Theory and the Law* (Harvard, 1994).

<sup>9</sup> Sunstein, *Behavioral Law and Economics* (cited in note 6).

<sup>10</sup> See Kevin McCabe, *Neuroeconomics*, in Lynn Nadel et al eds, *The Encyclopedia of Cognitive Science* (Nature Publishing Group, 2003).

effectively, and perhaps more importantly the nature of what it means for a law to be optimal.

Part II of the article discusses the current state of law and economics scholarship at fairly high level of generality. It discusses the nature of modern economic thought and how it has affected legal scholarship through the subdiscipline of law and economics. It discusses how traditional law and economics scholarship, behavioral law and economics as well as other economic approaches to law have both had a significant impact on legal scholarship. Part III discusses some of the research in the new discipline of neuroeconomics, which is most relevant to legal scholarship. In particular, it addresses the findings that relate to trust and reciprocity, the relationship between the value of a reward and uncertainty of receiving it, and the effects of addiction. Part IV discusses the ways in which neuroeconomics is likely to have a significant impact on the law and economic analysis. It examines the potential application of neuroeconomics to four major areas of the law: contract law, property law, business associations, and the study of juries.

The field of neuroeconomics is only just emerging.<sup>11</sup> The results from this inquiry are still to be determined. However, even the preliminary research findings are interesting both because they shed new light on earlier conclusions from other schools of economics and because they give us a glimpse of the promise of this method. The impact on law and economics scholarship from neuroeconomics is likely to be enormous. The intent of this article is to give a brief overview of what the research has already accomplished and where it is likely to go in the near future.

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<sup>11</sup> The first major book discussing this discipline is Paul Glimcher, *Decisions, Uncertainty, and the Brain: The Science of Neuroeconomics* (MIT, 2003).

## II. LAW AND ECONOMICS SCHOLARSHIP

### A. Traditional Law and Economics Scholarship

Law and economics scholarship has gone from being a small but interesting method of understanding specific legal problems such as antitrust law to becoming one of the most prevalent forms of analysis of legal problems.<sup>12</sup> This discipline has sought to bring the insights of economics into the understanding of legal problems. There is scarcely a single area of legal scholarship which is untouched by law and economics. It has significantly affected disciplines from contract law<sup>13</sup> to tax law<sup>14</sup> to legal history<sup>15</sup> and family law.<sup>16</sup>

Traditional law and economics scholarship is almost entirely based on what is generally referred to as neoclassical economics.<sup>17</sup> This school derives its conclusions from certain assumptions about human behavior such as consistent preferences and rational behavior.<sup>18</sup> These assumptions and conclusions are generally stated in mathematical terms in order to insure rigor and to reduce potential ambiguity of result.

The area of neoclassical economics most commonly invoked by scholars of traditional

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<sup>12</sup> Richard Posner's *Economic Analysis of Law* is one the most cited works in history. A lexis search turned up over 1,000 citations to it. See a discussion in Landes, 70 U Chi L Rev 167 (cited in note 1) about his experiences on being hired at the University of Chicago Law School. For other popular books discussing law and economics, see Robert Cooter and Thomas Ulen, *Law and Economics* (Addison-Wesley, 4th ed 2003) and Mitchell Polinsky, *Introduction to Law and Economics* (Little Brown, 1989).

<sup>13</sup> See Richard Craswell and Alan Schwartz eds, *Foundations of Contract Law* (Oxford, 1980)

<sup>14</sup> See Henry J. Aaron eds, *The Economics of Taxation* (Brookings Institution, 1980)

<sup>15</sup> See, e.g., David Bernstein, *The Law and Economics of Post Civil War Restrictions on Interstate Migrations by Africans-Americans*, 74 Tex L Rev 781 (1998).

<sup>16</sup> See, e.g., Margaret Brinig and Frank Buckley, *The Market for Deadbeats*, 25 J Leg Stud 207 (1996).

<sup>17</sup> David Friedman, even defines economics as the study of rational behavior which is almost certainly too restrictive. David Friedman, *Price Theory: An Intermediate Text* 293 (Southwestern, 1996).

<sup>18</sup> Hal Varian, *Microeconomic Analysis* ch 7 & ch 8 (Norton, 3d ed 1992) (discussing these assumptions).

law and economic is price theory. This particular approach examines questions involving the behavior of utility maximizing individuals and profit-maximizing firms.<sup>19</sup> From these assumptions, price theory derives conclusions about how economic actors will behave if the price of a good, service, or behavior increases. Because this form of analysis is generally quite mathematically rigorous, the conclusions of any particular model are dependent on the assumptions made. The most famous and most generally applicable conclusion of price theory is that own price demand curves slope downward.<sup>20</sup>

Just as neoclassical economics has helped to explicate human behavior to a significant degree, traditional law and economics scholarship has been able to aid the analysis of an enormous number of the legal problems in a fairly parsimonious way. The success of this school of thought is undeniable. One of the most prominent conclusions of much of the law and economics literature seems to be that interference in the market needs some type of special justification.<sup>21</sup> While clearly not all who practice traditional law and economics come to these conclusions,<sup>22</sup> this is clearly the view of many who do.

Law and economics has been so successful that even some of the more advanced areas of neoclassical economics, such as game theory, have begun to be applied to legal

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<sup>19</sup> Id.

<sup>20</sup> Eugene Silberberg, *The Structure of Economics: A Mathematical Approach* 323–329 (McGraw-Hill, 1992). However, this can also be derived from irrational actors. Gary S. Becker, *Irrational Behavior and Economic Theory*, 70 *J. of Pol. Economy* 1 (1962). For a discussion of when even this law might be violated see Rod Garratt, *Indivisibilities, Inferior Goods and Giffen Goods*, 30 *Can. J Econ.* 246 (1997).

<sup>21</sup> Posner, *The Economic Analysis of the Law* (cited in note 4) at 568. This is to some extent derived from the first and second fundamental theorems of welfare economics. See Varian, *Microeconomic Analysis* at 325–29 (cited in note 18).

<sup>22</sup> For example, see Andrew Schotter, *Free Market Economics: A Critical Appraisal* (2<sup>nd</sup> ed. Basil Blackwell 1990).

issues.<sup>23</sup> The subdiscipline of game theory and the law is beginning to attract a fair number of adherents.<sup>24</sup> However, the seeming hyper-rationality of game theory has not yet received quite the same degree of acclaim in the legal academy as price theory.<sup>25</sup>

## **B. New Approaches: Behavioral Economics and Experimental Economics**

Both standard neoclassical economics and traditional law and economics have been challenged by behavioral economics and the behavioral law and economics literature which derives from it. Behavioral economics has called into question some of the assumptions upon which neoclassical economics is based and attempts to replace them with what are viewed as more realistic assumptions about human behavior. In particular, behavioral economics is based on the results of experiments where individuals have not in general exhibited rational utility maximizing behavior. These experiments generally involve asking individuals questions about how they would react to a particular situation.<sup>26</sup> The results of these experiments have often been used to argue against some of the conclusions of standard neoclassical economics such as the abilities of markets to function well.<sup>27</sup> Many of these experiments have been quite controversial.<sup>28</sup> Some

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<sup>23</sup> If one defines neoclassical economics as the Walrasian general equilibrium model (as Herbert Gintis does), then there are some points at which a game theoretic approach and a neoclassical approach disagree, see Herbert Gintis, *Game Theory Evolving* (Princeton, 1999) at 43–46. Indeed, some economists are attempting to derive a general equilibrium theory which is more consistent with game theory. See J. Geanakoplos and H.M. Polemarchakis, *Existence, Regularity and Constrained Suboptimality of Competitive Allocations When the Asset Market is Incomplete*, in G. Debreu, ed, *General Equilibrium Theory* (Edward Elgar, 1996).

<sup>24</sup> Baird, *Game Theory and the Law* (cited in note 8).

<sup>25</sup> Posner, *The Economic Analysis of the Law* (cited in note 4).

<sup>26</sup> Daniel Kahneman et al, *Experimental Tests of the Endowment Effect and the Coase Theorem*, 98 J of Pol Econ 1325 (1990)

<sup>27</sup> See, e.g., Donald Langevoort, *Organized Illusions: A Behavioral Theory of Why Corporations Mislead Stock Market Investors (and Cause other Social Harms)*, in Sunstein, *Behavioral Law and Economics* (cited in note 6). See also, Robert Shiller, *Irrational Exuberance* (Princeton, 2000).



commentators argue that these findings do not apply to real market situations.<sup>29</sup> Such critics point out that the findings are very sensitive to the particular experimental techniques and it is questionable to what degree these conditions exemplify those one would find in real economic situations.<sup>30</sup>

As mentioned above, behavioral economics relies on studies of actual human behavior in experiments. These studies often show that individuals behave quite differently than predicted by neo-classical models, particularly with regard to thinking about risk and uncertainty<sup>31</sup> and how to discount for future value.<sup>32</sup> <sup>33</sup> Among the most prominent theories that have emerged from behavioral economics are prospect theory, hindsight bias, optimism bias, and the effects of framing.<sup>34</sup> The extent to which individuals exhibit each of these behaviors is the subject of a fair amount of debate. To a significant degree, each of these behaviors is related to the others. For example, under

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<sup>28</sup> One of the first experimental results to challenge the neoclassical synthesis was the research done by Richard Thaler on the endowment effect. See Daniel Kahneman, Jack Knetsch and Richard Thaler, *Anomalies: The Endowment Effect, Loss Aversion, and the Status Quo Bias*, 5 J of Econ Perspectives 193 (1991). However, recently there has been some research challenging the robustness of these results. See Charles Plott and Kathryn Zeiler, *The Willingness to Pay/Willingness to Accept Gap, the "Endowment Effect" and Experimental Procedures for Eliciting Valuation*, Caltech Social Science Working Paper # 1732 (April 2003). (e-mail and get cites)

<sup>29</sup> Ulen, *Rational Choice in Law and Economics* (cited in note 5).

<sup>30</sup> Id. For an example of this sensitivity see Elizabeth Hoffman, Kevin McCabe, Keith Shacat and Vernon Smith *Preferences, Property Rights and Anonymity in Bargaining Games*, 7 Games and Economic Behavior 346 (1994).

<sup>31</sup> See Daniel Kahneman and Amos Tversky, *Choices Values and Frames*, in Daniel Kahneman and Amos Tversky eds, *Choices Values and Frames* (Cambridge, 1998)

<sup>32</sup> Discounting future benefits relative to current benefits often does exhibit dynamically consistency. See Id.

<sup>33</sup> Colin Camerer et al, *Neuroeconomics: How Neuroscience Can Inform Economics*, Caltech Social Science Working Paper (Feb. 2003).

<sup>34</sup> See generally Sunstein, *Behavioral Law and Economics* (cited in note 6).

prospect theory, while individuals still behave as utility maximizers, as they do under neoclassical models, the utility function is quite a bit more complicated than traditional expected utility maximization.<sup>35</sup> Under this theory, individuals are not trying to maximize wealth, but improvements to wealth, and the individuals are risk averse as to gains and risk preferring as to losses.<sup>36</sup> In addition, the way in which the question is framed can significantly affect the way that subjects will answer. While many aspects of the theory were described much earlier in ways that are compatible with most of the assumptions of neoclassical economics,<sup>37</sup> prospect theory is a behavioral theory as opposed to a neoclassical theory, in fact because it also adds this element of framing to the analysis.<sup>38</sup>

Both behavioral economics and behavioral law and economics are also gaining adherents in the academy.<sup>39</sup> Behavioral law and economics has also become very influential in legal scholarship. Many new articles are written each year applying these ideas to new areas of the law.<sup>40</sup> The degree to which individuals actually behave either as neoclassical actors or as “behavioral” actors can have a significant impact on our

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<sup>35</sup> Camerer, *supra* note 33.

<sup>36</sup> Kahneman and Tversky, *Choices Values and Frames* (cited in note 30).

<sup>37</sup> Actually this theory was to some degree discussed much earlier by Milton Friedman and Leonard James Savage and Harry Markowitz. This analysis essentially created some rather like prospect theory. See Milton Friedman and L.J. Savage, *The Utility Analysis of Choices Involving Risk*, 56 J Pol Econ 279 (1948), and Harry Markowitz, *The Utility of Wealth* 60 J Pol Econ 151 (1952).

<sup>38</sup> Posner, *The Economic Analysis of the Law* (cited in note 4), and Christine Jolls et al, *A Behavioral Approach to Law and Economics*, in Sunstein, *Behavioral Law and Economics* (cited in note 6).

<sup>39</sup> Kahneman and Tversky are now also among the most cited authors in law reviews.

<sup>40</sup> For example see the articles that were presented in the Symposium entitled *Empirical Legal Realism: A New Social Scientific Assessment of Law and Human Behavior* published in 97 Northwestern U. L. Rev. (Spring 2003).

expectations of how they will behave under different legal regimes. Therefore, which of these two schools of thought more accurately represents human behavior is important for legal scholarship.

Another area of research which has altered our picture of human decision-making is experimental economics. While the methods used by experimental economics and behavioral economics may superficially appear the same in that both place emphasis on the way humans behave in experiments, experimental economics examines economic problems from a different perspective than behavioral economics. Behavioral economics focuses on the reasoning process of individual actors. Experimental economics focuses more on the ways in which individuals interact in exchange situations, rather than on particular reasoning problems.<sup>41</sup> Experimental economics focuses on actual economic activities as opposed to the particular assumptions of the neoclassical model.

Experimental economics has produced some particularly striking findings. For example, game theory would predict that cooperative behavior should breakdown in games with finite periods.<sup>42</sup> However, when actual experiments are conducted they do not find this except in the most extreme experiments.<sup>43</sup> The experiments show that individuals are both more cooperative and trusting than predicted by game theory. These

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<sup>41</sup> This methodology is more in line with the behavioral analysis of researchers such as Gerd Gigerenzer who argue that one cannot simply look at a particular reasoning method in isolation. By examining how people behave in simple (and sometimes complex) economic behavior, if there are offsetting misconceptions which operate to generate optimal behavior it is likely to show up in experimental economic studies rather than in behavioral studies. Gerd Gigerenzer and Reinhard Selten *Rethinking Rationality*, in Gerd Gigerenzer and Reinhard Selten, *Bounded Rationality: The Adaptive Toolbox* (MIT, 2001).

<sup>42</sup> Varian, *Microeconomic Analysis* at 325–29 (cited in note 18).

<sup>43</sup> Elizabeth Hoffman, Kevin McCabe and Vernon Smith, *Behavioral Foundations of Reciprocity: Experimental Economics and Evolutionary Psychology*, 36 *Economic Inquiry* 335 (1998).

experiments show that where trust will lead to more favorable outcomes, people tend to trust at a much higher level than if all are operating based on traditional game theory.<sup>44</sup>

One can analogize the difference between experimental economics and behavioral economics to the difference between psychology and economics.<sup>45</sup> Behavioral economics focuses on individual rationality,<sup>46</sup> whereas experimental economics examines how individuals interact in somewhat simplified economic situations.<sup>47</sup> Behavioral economics therefore tends to be a little closer to psychology in its approach, while experimental economics tends to have more similarity with standard economic analysis, and it that it studies how individuals react in economic settings. One of the key insights from experimental economics, and which separates it from behavioral economics, is the notion that the behavior of individuals in a group may not simply be reductionistically determinable from individual behavior, but will also involve interactions between persons wholly absent from individual single-person behavior which is primarily the subject of behavioral economics.

Of course some in the legal academy are skeptical of either or all schools of economic thought.<sup>48</sup> This is particularly true because they seem to have assumptions

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<sup>44</sup> Id. In order to account for this behavior, Kevin McCabe and Vernon Smith have proposed a model which they refer to as goodwill accounting in which individuals account for the reciprocity shown them. Kevin McCabe and Vernon Smith, *Goodwill Accounting and Process of Exchange in Bounded Rationality: The Adaptive Toolbox* (MIT, 2001)

<sup>45</sup> Evidence for this is found in the fact that both Amos Tversky and Daniel Kahneman both were trained as psychologists not economists.

<sup>46</sup> This is one of the key foundations of price theory and game theory.

<sup>47</sup> The difference between psychology and economics can be analogized to the difference between the study of atomic structure, which is branch of physics and chemistry which the study of how molecules form and how they interact. In some sense chemistry is derivative of physics, but at this point we cannot simply derive the behavior of people when they interact from their behavior when they are reacting alone.

<sup>48</sup> Ulen, *Rational Choice in Law and Economics* (cited in note 5).

about the behavior of people which contradict each other. What is needed is a more solid foundation from which to base our theories of human behavior.

### **III. Neuroeconomics**

The different schools of economics largely disagree about the basic assumptions about how individuals behave. Neoclassical economics seems to assume we are almost ruthlessly rational. Behavioral economics assumes we have systematic reasoning mistakes and the mistakes have important consequences. Therefore, a natural area of focus of research should be the cognitive processes individuals use to perceive different economic and legal situations. Directing our study to what is occurring in the brains of individuals as they make decisions can help us to decide to what degree each of the schools is correct and it can also aid us in developing new theories of economic behavior.

#### **1. Description of the Research and Its Methodologies**

Neuroeconomics<sup>49</sup> is the study of how the embodied brain interacts with its external environment to produce economic behavior. This can be extended to the study of how groups of minds interact to produce economic behavior. Technology has now advanced to the point where we can begin to study directly the brain mechanisms that individuals are using to perform different activities.<sup>50</sup> In general, the science of human behavior and how the brain creates this behavior is known as cognitive neuroscience.<sup>51</sup>

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<sup>49</sup> In 1996, this term was invented by one the authors (McCabe) in coming up with the name for a course on neurology and economics. One could also apply to term to method in which the brain allocates its own scarce resources and that in some sense that is what this studying the economics of the brain, and the effect this has on behavior.

<sup>50</sup> See Camerer, *supra* note 33

<sup>51</sup> Michael Gazzaniga et al, *Cognitive Neuroscience: The Biology of the Mind* 138–39(Norton, 2002).

The cognitive neuroscience research relating to human social behavior and human decision making has particular relevance to neuroeconomics.<sup>52</sup>

Studies of the brain and its effects on behavior have been conducted for quite some time. Amongst the earliest neurological research were studies of patients with brain lesions.<sup>53</sup> While there has been a great wealth of information derived from these studies, the clarity of the information obtained is less obvious. If after a patient incurs brain damage, and they can no longer perform a particular function that they could have before, this does not necessarily mean that this region of the brain was where that function “resided”. There are various functions that might be required to perform an action: recording sensation, processing responses, binding it with other information etc. It is not clear exactly which of these functions was impaired by the damage.<sup>54</sup> However, these types of studies did indicate that there appears to be some localization of functions of the brain.<sup>55</sup>

In recent years, technology has advanced to the point where we can begin to examine brains *in vivo* as they perform functions. Early technological advances such as electroencephalography (EEG) allowed us to study the electrical activity occurring at or near the skull of individuals engaged in cognitive behavior.<sup>56</sup> The temporal resolution of this method is quite good, however, the spatial resolution leaves much to be desired for

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<sup>52</sup> For a review of these findings as of March 2003 see Ralph Adolphs, *Cognitive Neuroscience of Human Social Behavior*, 4 Nature Reviews–Neuroscience 165 (March 2003).

<sup>53</sup> The case of Phineas Gage is described in Malcolm Macmillan, *An Odd Kind of Fame* (MIT, 2002)

<sup>54</sup> This criticism was voiced as early as the nineteenth century. See Gazzaniga p.4 (cited note 51)

<sup>55</sup> One of the most famous examples of this is Paul Broca’s research which showed that certain parts of language processing appear to be fairly localized in the temporal lobe. Gazzaniga (cited note 51)

<sup>56</sup> Camerer, *supra* note 33.

an in depth understanding of the neural mechanism involved in behavior.<sup>57</sup> A significant leap forward in spatial resolution occurred with advent of the use of positron emission tomography (commonly known as PET scans).<sup>58</sup> A further leap forward in spatial resolution relative to PET scans occurred with the use of functional magnetic resonance imaging or fMRI.<sup>59</sup> Both methods detect changes in metabolism or blood flow in the brain while the subject is engaged in cognitive tasks. Because of this, fMRI is becoming the method of choice for neuroeconomic studies.

The spatial resolution is superior with fMRI, with current scanners able to resolve volumetric area of 3mm<sup>3</sup> and there is the potential to have even greater degrees of resolution as more powerful magnets become available.<sup>60</sup> Because fMRI does not involve the injection of radioactive tracers as required for PET scans, the same individual can be tested repeatedly, either in a single session or even multiple sessions. This permits the observation of many more data points which can allow for more advanced statistical analysis.<sup>61</sup> Temporal resolution is also much better with fMRI. In PET scans, the subject

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<sup>57</sup> Camerer. Supra note 33. Generally, this method only allows us to gather information about the electrical activity in the cortex. Electrical signals from the interior brain regions are not currently able to be detected by this method. In addition, even within the cortex, its ability to localize the activity is somewhat limited. Gazzinga p. 129-132.

<sup>58</sup> Camerer et al., supra note 33. In PET scans, the subject's blood is injected with a radioactive tracer which indicates where the blood is flowing. By determining where the radioactive decay occurs (in this case the interactions detected is the interaction between positrons and electrons) one can determine to what parts of the brain blood was flowing at higher rates. See Marcus Raichle, *Visualizing the Mind* in Antonio Damasio, *The Scientific American Book of the Mind* (Lyons Press, 1999).

<sup>59</sup> This is based on chemistry discovered by Linus Pauling that the amount of oxygen carried by hemoglobin changes the degree to which it disturbs a magnetic field. The signal is known as blood oxygen level dependent or BOLD it is used for most brain imaging studies. Gazzaniga et al, *Cognitive Neuroscience* at 138-39 (cited in note 51).

<sup>60</sup> Id.

<sup>61</sup> See for example J. Xiong, PT Fox, JH Gao, *Directly Mapping Magnetic Field Effects of Neuronal Activity by Magnetic Resonance Imaging*, 20 Hum Brain Mapp 41 (2003), they were able to get spatial resolutions of 3 mm but temporal resolutions of 100 msec. in the visual, motor and premotor cortices. The

must be continuously engaged in a given experimental task for at least 40 seconds, in order to be able to get useful results.<sup>62</sup> One particular type of fMRI, called event-related fMRI, can be used to study changes in the brain that occur over 1-2 seconds.<sup>63</sup> Because of this short-time period, experimenters can relate the effects to specific events more readily with fMRI. However, even these timescales are longer than researchers would find ideal because it is normally thought that responses in the brain occur in time scales of approximately .01-.1 of a second.<sup>64</sup> These methods then are giving us results in times that are one to two orders of magnitude longer than required for that level of precision. However, the technology continues to improve.

One of the more interesting recent technological advances is that of hyperscanning. This involves comparing the brain activity of two or more subjects who are engaged in an economic transaction with each other. This allows us to compare the allocation of computation not only within a single individual, but also among groups of individuals.<sup>65</sup>

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temporal resolution is often better than that obtained from traditional fMRI by a factor of 10 or more. They are able to obtain better temporal resolution by imaging the actual neuronal activity rather than the associated blood response which might take longer. This technique, which is known as magnetic source magnetic resonance imaging. This is related to magnetoencephalography (MEG) which is the detection of small magnetic fields which are generated by neuronal activity.

<sup>62</sup> Gazzinga at 139 (cited in note 50).

<sup>63</sup> Id at 142–43.

<sup>64</sup> Camerer, at note 33

<sup>65</sup> See P. Read Montague et al., *HyperScanning: Simultaneous fMRI During Linked Social Interactions*, 16 *Neuroimage* 1159 (2002) for a discussion of hyperscanning and the technological advantages it brings. See also [www.hnk.bcm.tcm.edu/hyperScan.html](http://www.hnk.bcm.tcm.edu/hyperScan.html) for a description of hyperscanning.



Another new technology which is gaining popularity is transcranial magnetic stimulation.<sup>66</sup> This involves stimulating a region of the brain by use of magnets which are outside of the patient. Because magnetic force can act at a distance, actual contact with the head of the subject is unnecessary. This technology has been used to create “artificial” lesions by over-stimulating parts of the brain, and observing what changes in functions occur. There are problems with this method, in that it is not clear how much the effects observed are related to the actual processing that occurred within the region stimulated or as a response by other areas of the brain to the changes from the function in the stimulated area.<sup>67</sup> In addition, this research is subject to many of the same problems as lesion studies.

In many ways, neuroeconomics is where psychology and economics meet. This research allows to us observe what is happening within individuals as they engage in economic behavior. Researchers can now both observe how the individual reacts to particular stimuli while also noting how that individual actually behaves. This methodology therefore joins both behavioral economics with its focus on individual reasoning with experimental economics with its focus on interactive behavior.

## **2. Experimental Results**

There have been a number of studies using neuroimaging technology to examine how people perceive economic problems. One needs to stress that the full implications of this work is only beginning to be understood. However, the preliminary results are quite

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<sup>66</sup> For a discussion of this see Vincent Walsh & Alvaro Pascual-Leone, *Transcranial Magnetic Stimulation: A Neurochronometrics of Mind*, (MIT, 2003).

<sup>67</sup> That is, if we stimulate area A and this stimulation of A also effects area B, then we cannot be certain that the effects we observe are from the stimulation of A itself, or from the secondary effects on area B. An additional problem with this method is that there may some increase in the incidence of epilepsy from its use. Camerer et al., supra note 33.

interesting. The investigations so far have been focused on a few rather specific areas such as trust and reciprocity, the nature of rewards in both certain and uncertain contexts and how these situations affect behavior. One of the most prominent findings to emerge from these studies is the heterogeneity of perception and reasoning. To some extent, heterogeneity of brain structure is obvious. Left and right handedness is clearly a difference in the way brains are organized.<sup>68</sup> Of course the notion that individuals behave in a heterogeneous manner is apparent from both observing every day life as well as from experimental research.<sup>69</sup> Neuroimaging studies have shown that individuals will often use different parts of the brain for the same or similar problems and that the use of different neural mechanisms is correlated with different behavior. This indicates that what we might initially think are similar situations are likely to be perceived differently.

It is generally possible to place various types of cognitive processing into specific areas of the brain. However, each single process is implemented by a flexible set of structures, and a single structure can participate in several processes.<sup>70</sup> This makes it quite difficult to place a particular behavior in a particular area with certainty. Even with these constraints, one consistent finding in human cognition studies is that emotion is tied to social behavior.<sup>71</sup> Humans are surprisingly adept at detecting changes in human facial

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<sup>68</sup> Gazzaniga et al, *Cognitive Neuroscience* (cited in note 51).

<sup>69</sup> Colin Camerer, *Individual Decision Making* in *Handbook of Experimental Economics* (Kagel and Roth eds., Princeton, 1995).

<sup>70</sup> Adolphs, *Cognitive Neuroscience of Human Social Behavior* (cited in note 51).

<sup>71</sup> See generally Adolphs, *Cognitive Neuroscience of Human Social Behavior* (cited in note 51). Adolphs argues that it might be that the ability to represent other's minds distinguishes humans and perhaps apes from all other animals.

expressions and what those imply about emotional state.<sup>72</sup> It appears then that emotions and social behavior appear to be related in the neural mechanisms they activate.

Neuroeconomic studies show that the way in which we process information can have a significant impact on the opportunities we perceive and how we evaluate them. If we can determine how a particular individual processes information, we can go a long way to predicting how that individual will behave. Some of the studies have verified some of the key conclusion of earlier schools of economics, some have challenged their conclusions.<sup>73</sup> This section discusses three area of most important areas of current neuroeconomic research : Trust and reciprocity, risk and ambiguity, and addiction.

#### **a. Trust and Reciprocity**

Among the most interesting neuroeconomic research already conducted relates to trust and reciprocity. As discussed earlier in connection with experimental economics, a key conclusion of many studies in experimental economics is that individuals often cooperate more often than game theory would predict.<sup>74</sup> In addition, these studies show that individuals who cooperate actually do better in total than they would do if they were

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<sup>72</sup> See J. Liu, A Harris, and N. Kanwisher *Stages of Processing in Face Perception: An MEG Study*, 5 Nature Neuroscience 910 (2002) This study found that human brains can categorize faces in a relatively short period (around 100 ms.), this was slightly shorter than period that it took to identify a person in the photograph (about 170 ms.).

<sup>73</sup> Studies on the ways in which monkeys operate indicate that relative values are important which concerning the absolute values. L. Tremblay and W. Schultz, *Relative Reward Preference in Primate Orbitofrontal Cortex*, 398 Nature 704 (1999). For an analysis of Neuroeconomics see Vernon Smith, *Experimental Methods in (Neuro)Economics*, in Lynn Nadel et al eds, *The Encyclopedia of Cognitive Science* (publ, 2003). Studies of non-economic phenomena, such as the placebo effect have also yielded interesting results.

<sup>74</sup> Kevin McCabe et al, *A Functional Imaging Study of Cooperation in Two Personal Reciprocal Exchange*, 98 Proc. Nat'l Acc, Sci. 1373 (2000)

completely self-interested individuals.<sup>75</sup> Many people expect that others will opt for co-operative solutions, even when the other actors may have to make a choice against self-interest.<sup>76</sup> Importantly, those people who assume co-operation by others are generally correct. Subjects who act co-operatively often achieve higher gains than would be predicted in standard game theory. However, there is also a substantial percentage of the population which does not trust and does not reward trust.<sup>77</sup>

Given this heterogeneity, a natural question is what can neuroimaging tell us about the differences between cooperators and non-cooperators? By examining the difference between the two, we can see what mechanisms of the brain are differentially used by those who trust and behave reciprocally versus those who defect and how perceptions of the two types may be different.<sup>78</sup> An experiment was conducted in which subjects engaged in various cooperation games. As an example of these experiments, in the trust game, the first player decided between choosing option one which gave both players a payoff of 45 tokens<sup>79</sup> and option two which gave second player a choice between giving the first player a payoff of 180 tokens and the second player a payoff of 225 tokens, or alternatively giving the first player a zero payoff and the second player would keep all 405 tokens. The first player would choose option two if he or she trusted

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<sup>75</sup> Herbert Gintis, *Game Theory Evolving: A Problem-Centered Introduction to Modeling Strategic Interaction* (Princeton, 1999) . an example discussed in the book is the centipede game which is essentially an extended version of the trust game.

<sup>76</sup> As argued in Gintis this may be evolutionary advantageous. Id.

<sup>77</sup> Id.

<sup>78</sup> Perception here is meant as high-level or mid-level cognition, not literally visual processing, or other low-level of cognition etc.

<sup>79</sup> This payoff involved receiving tokens which at the end of the experiment were exchanged for money.

that player two would reciprocate and give player one the 180 tokens. In order to trust the second player, the first must believe the second will cooperate against his self-interest. Subjects sometimes would deal with a computer and sometimes another human. In each case, this was disclosed to the subject. In addition, the computer's strategy (a 75% probability of choosing the [180, 225] payoff<sup>80</sup> and 25% probability of choosing the [0, 405] payoff) was disclosed to the subjects. The experiment was conducted while the subject's brain was being scanned by an the fMRI machine. The neuroimage of the subject in the 1.5 seconds before the decision was reported and compared between subjects. Of the twelve subjects, 7 were classified as cooperators and 5 as non-cooperators.

The neuroimages of the subjects showed that cooperators and non-cooperators have different patterns of brain activity. Cooperators had a common pattern on BOLD<sup>81</sup> activation. The areas activated are commonly associated with calculation, visual recognition and social situations. This suggests that cooperation requires individuals to use mechanisms in the brain which allow them to focus on mutual gains and that allows inhibition of immediate gains to allow for co-operative decisions.<sup>82</sup> One of the key areas of difference between cooperators and non-cooperators was in the activation of

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<sup>80</sup> In this payoff, 180 relates the payoff to the first decision maker, 225 the payoff for the second decision maker.

<sup>81</sup> This stands for blood oxygen level dependent. That is, this method detects that areas that have an increase in oxygen uptake through increased blood flow.

<sup>82</sup> The areas activated when the subject was co-operating included Brodmann areas 17, 18, also area in the parietal lobe, Brodmann area 7 the place in primate vision pathway that helps to place things. Also the middle frontal gyrus and the frontal pole, Brodmann area 9 and 10. Half the subjects in the experiment consistently attempted to cooperate. The non-cooperators showed no difference between working with a computer and human.

Brodmann's area 8.<sup>83</sup> This area is commonly associated with visualization and social situations. Cooperators had more activity in this region than non-cooperators.

Interestingly, the brain activity of non-cooperators resembled the brain activity of those who are simply playing against a computer. This evidence tells us that there are likely fundamental differences in the ways in which the two groups perceived the trust problem facing them (at least in this game). These subjects did not seem to merely place a different level or value on cooperation or even seem to simply make different guesses about what others are doing but it seems to merely assume all would exclusively follow rational self-interest. That is, the neuroimaging evidence tends to indicate that they were using a different mechanism to either perceive the problem and/or analyze it, rather than merely placing different weights on the various outcomes.

In addition, neuroeconomic research is now helping to shed light on what has been one of the most interesting controversies in behavioral and experimental economics: the behavior of subjects in the ultimatum game. This game is one in which the first player is given a sum of money and told to determine how much to send to the second player. The second player can decide whether to accept the offer or reject the offer. If the second player rejects the offer then neither player gets any money. Under standard game theory, the subgame perfect strategy for the second player is to accept any offer greater than zero and the first player will know this and therefore offer very little. When this experiment is actually conducted, this is not what occurs. In the first versions of the game tested, the first players offered substantially more than zero (often between 40-50%)

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<sup>83</sup> Korbinian Brodmann analyzed the cellular structure of the cortex and described it as being composed of 52 separate regions. Later research has shown that these regions are often correlated with different functions performed by the brain. Gazzaniga et al, *Cognitive Neuroscience* at 5 (cited in note 51).

and they were almost always accepted.<sup>84</sup> However, by changing the structure of the game, these results can be altered. For example if players compete to be the first player, the amounts offered decrease without significant increase in rejections. An experiment was conducted in which the standard ultimatum game was conducted while images are obtained of the brains of the subjects. Subjects whose brains were imaged while they were presented with an unfair offer showed greater activity in the bilateral anterior insula.<sup>85</sup> Those with the strongest activation of the anterior insula rejected a higher proportion of the unfair offers.<sup>86</sup>

In many ways these results are consistent with the arguments of economists such as Douglass North and Friedrich Hayek.<sup>87</sup> For example, Hayek and the others argued that impersonal bargaining, such as occurs in financial markets, is different than personal bargaining as may happen within a family.<sup>88</sup> This impersonal bargaining may be required in many situations where individuals do not have time to develop personal relationships with all of those with whom they transact business. But that this distinction is inherent in human behavior, and attempts to cause people to treat impersonal situations

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<sup>84</sup> This described in Elizabeth Hoffman, Kevin McCabe, and Vernon Smith, *Behavioral Foundations of Reciprocity: Experimental Economics and Evolutionary Psychology*, 36 *Econ. Inquiry* 335 (1998). This game has also been the subject of games in different cultures. See Joseph Heinrich et al. *In Search of Homo Economicus: Behavioral Experiments in Fifteen Small Scale Societies*, 91 *Am. Econ. Rev.* 74 (2001)

<sup>85</sup> The insula is commonly viewed as influential in experiences related to disgust, such as bad smells. Colin Camerer, *Strategizing in the Brain*, 300 *Science* 1673 (2003). See Sanfey et al., *The Neural Basis of Economic Decision-Making in the Ultimatum Game* 300 *Science* 1755 (2003), for the experimental results.

<sup>86</sup> In addition, the anterior cingulate cortex (ACC) a brain region that detects cognitive conflict also showed greater activity during this unfair offer, which some have argued that this suggests this area meditates the conflict between earnings money and feeling bad from the offer.

<sup>87</sup> See for example, Douglass North, *Institutions, Institutional Change, and Economic Performance* (Cambridge, 1990).

<sup>88</sup> See generally Friedrich A. Hayek, *The Fatal Conceit: The Errors of Socialism* (Chicago, 1989) at 18.

as personal bargains are doomed to failure.<sup>89</sup> Based on these arguments, many economists of the so-called Austrian school of economics argue that markets are best method to integrate the information held by individuals in impersonal bargaining situations.<sup>90</sup>

## **b. Risk and Ambiguity**

As discussed earlier, in connection with behavioral economics, one of the areas of conflict between neoclassical economics and behavioral economics is the way in which individuals perceive risk and uncertainty.<sup>91</sup> One study looked at the ways in which individuals perceive risky gains, risky losses and ambiguity in both losses and gains.<sup>92</sup> To understand the results of this study, we need to first distinguish between risk and ambiguity. Under risk, the likelihoods of the various alternative outcomes are fully known. Under ambiguity, the likelihoods are unknown. In this experiment, subjects were asked to choose from which urn they would prefer to select balls. They were given higher rewards if the balls of particular colors were drawn.<sup>93</sup> In one urn, the contents of the urn were disclosed to the subject, meaning they could calculate the probability of drawing a particular color. The subjects did not know the contents of the other urn. These choice activities were conducted while brain activity was measured with PET

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<sup>89</sup> Hayek, *supra note 88*.

<sup>90</sup> Vernon Smith, *Constructivist and Ecological Rationality in Economics: Nobel Prize Lecture 2002*, published in 93 Am. Econ. Rev. 465 (2003).

<sup>91</sup> For a discussion of the difference between ambiguity and risk and for arguments that ambiguity aversion can be placed into a neoclassical framework, see Terrence Chovrat, *Ambiguity and Income Taxation*, 23 Cardozo L Rev 635 (2002)

<sup>92</sup> Kip Smith et al, *Neuronal Substrates for Choice under Ambiguity, Risk, Gains and Losses*, 48 Management Science 77 (2002).

<sup>93</sup> This is the classic Ellsberg urn situation, for a discussion see Chovrat, 23 Cardozo L Rev 635 (cited in note 88).



scans.<sup>94</sup> This study reveals that the brains of these subjects did not behave according to a prevalent assumption of economics, the independence of the evaluations of payoffs and outcomes.<sup>95</sup> With respect to risky choices, they behaved in accordance the basic notion of prospect theory that individuals appear to be risk-averse for gains and risk preferring for losses.<sup>96</sup> On the other hand, subjects were always ambiguity averse.<sup>97</sup> The neurological evidence gives some clues as to why this might be the case. Risky gains activated an area in the ventromedial prefrontal cortex and risky losses stimulated area in the dorsomedial prefrontal cortex. Ambiguously risky gains and losses differentially activated the ventromedial prefrontal cortex. The ventromedial area is generally viewed as highly connected with emotional response,<sup>98</sup> whereas the dorsomedial area is connected more with higher cognitive functions, and is often thought to be involved in more calculative processing.

Other prominent studies of the impact of types of reward on cognitive mechanisms include an experiment that examined how introducing additional choices affects the pattern of brain activity.<sup>99</sup> In this experiment, they examined how the introduction of a certain choice affected the choice between two lotteries. They found

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<sup>94</sup> Smith, 48 *Management Science* 77 (cited in note 87).

<sup>95</sup> Varian, *Microeconomic Analysis* at 173–174 (cited in note 18).

<sup>96</sup> Smith, 48 *Management Science* 77 (cited in note 87).

<sup>97</sup> The ventromedial cortex is connected with subcortical regions such as the insula and the amygdala which are generally thought to be associated with emotional reactions. For a discussion of the prevalence of ambiguity versus risk see Chorvat, 23 *Cardozo L Rev* 635 (cited in note 88).

<sup>98</sup> For a discussion of this see Terrence Chorvat, *Perception and Income: The Behavioral Economics of the Realization Doctrine*, 36 *Conn L Rev* 75 (2003).

<sup>99</sup> John Dickhaut et al, *The Impact of the Certainty Context on the Process of Choice*, 100 *PNAS* 3536 (2003).

that while it did not affect the actual choices made, it did affect quite dramatically the response time and the brain activation. The authors of the study argue that these results suggest that the introduction of a certain choice can affect the way the other two choices are viewed.

Research on the effect of monetary rewards as compared to other types of rewards has shown that the areas activated by financial rewards overlap extensively with the areas activated by primary rewards like food.<sup>100</sup> Interestingly, this study shows that the amygdala, striatum and dopaminergic midbrain neurons responded to rewards regardless of the level of rewards given, but the premotor cortex showed a linear response to the rewards.<sup>101</sup> This raises the possibility that the level of responses or utility of a reward may not be linear in some situations, but it may approximate a linear response in other situations.<sup>102</sup>

Another interesting result was found when a research team investigated the effects of expectancy on utility. They found that utility is lower for the same reward if an alternatively higher reward was possible.<sup>103</sup> This suggests that some types of framing effects actually do occur.

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<sup>100</sup> Rebecca Elliot et al, *Differential Response Patterns in The Striatum and Orbitofrontal Cortex to Financial Reward in Humans: A Parametric Functional Magnetic Resonance Imaging Study*, 23 J Neuro Sci 303 (2003).

<sup>101</sup> These areas are all related to reward processing. There is an extensive literature (see Breiter et al. cited in note 103) that relates these brain regions to rewards and expectation of reward. This may have an effect on contract damages, one needs to think of the harm one is doing another in expectation damages.

<sup>102</sup> For small rewards, the total activation of the brain is not proportional to the stimulus, but as a higher percentage of the total stimulus is in the premotor cortex, the total stimulus becomes closer to linear.

<sup>103</sup> Hans Breiter et al. *Functional Imaging of Neural Responses to Expectancy and Experience of Monetary Gains and Losses* 30 Neuron 619 (2001).

### c. Addiction studies.

A key discovery of neuroeconomic research is that individuals who have addictions actually have higher rates of discount even for items to which they are not addicted.<sup>104</sup> This implies that addiction alters the decision process generally, not merely a particular decision. However, when the addiction is ended the discount rate returns to what it was before the addiction.<sup>105</sup> Therefore, the different rates of discount might to some degree be explained by neurological/chemical features such as addiction.<sup>106</sup>

## IV. IMPLICATIONS FOR THE LAW

Understanding how human brains process information can facilitate the building of economic and legal institutions that better serve as extensions of our ability to enter into social exchange. It may help us both to structure institutions which aid in reciprocal or trusting behavior, and productively deal with risk and ambiguity.<sup>107</sup> The above findings show that individuals have different ways of perceiving and reacting to the same stimuli. Knowing the mechanisms used to process stimuli can help us to predict the actions taken by individuals, and thereby help us structure rules to encourage optimal behavior.

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<sup>104</sup> Steven J. Grant, *Impaired Decision-Making in Substance Abusers: Brain Imaging and Cognitive Models*. (NIDA Working Paper, 2002). A higher rate of discount means that future gains have to larger in order to result in savings and future directed behavior. That is,  $1/(1+r)^n$  is a decreasing function in  $r$ . See also, Stephano Corradin and Fredrico Perali, *Dynamic Analysis of Addiction: Impatience and Heterogeneity* (Working Paper 2002).

<sup>105</sup> Id.

<sup>106</sup> This research ties into the hot/cold reasoning and that addiction can be thought of as continually increasing the “heat” of the reasoning process. George Lowenstein, *Out of Control: Visceral Influences on Behavior*, 65 *Organizational Behavior & Human Decision Process* 272 (1996).

<sup>107</sup> Chorvat, *supra* note 72.

This section discusses four areas to which the findings of neuroeconomics can be applied. Of course, this research is very preliminary and conclusions based on it must be taken with caution. The four areas discussed are contract law, property law, the laws of business association and the study of juries. For each of these areas, the section will examine the basics of the traditional law and economic analysis, the behavioral critique, and how neuroeconomics research, both current and future, could impact the analysis.

### **A. Contract Theory.**

The law and economic scholarship in the area of contract law has largely been focused on the improvement of economic efficiency by increasing investment through enforceable promises. Of course, commercial activity could exist in a world without contract law, because it could be based on reputational effects.<sup>108</sup> However, because of informational asymmetries such markets may break down, or remain relatively limited.<sup>109</sup> It may be more optimal for all to create an ability to make promises that will be enforced, thereby reducing the scope of opportunistic behavior. This allows both promisor to induce desired behavior by a promisee, and the promisee to induce desired behavior by the promisor. This theory helps to explain the development of much of contract law. For example, it can help to explain the notion of consideration, which requires that both parties to the contract have to perform some beneficial action to the other party to the agreement to be enforceable.<sup>110</sup> The standard analysis shows the efficiency of many

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<sup>108</sup> Posner, *The Economic Analysis of the Law* (cited in note 4).

<sup>109</sup> George Akerlof, *The Market for Lemons: Quality, Uncertainty and The Market Mechanism* 84 *Quar J of Econ* 488 (1970) See also Douglas North.

<sup>110</sup> Posner, *The Economic Analysis of the Law* (cited in note 4).

common contract rules, because they encourage resources to be used in the most productive behavior, enforce promises that lead to productive behavior.

The behavioral economics account of contract law agrees with much of this description, but is skeptical of some the applications of the theory. Many authors have discussed how the endowment effect and the status quo bias can have effects on the negotiation of contract terms.<sup>111</sup> This scholarship focuses on the notion that because of cognitive limitations, individuals and other economic actors are not likely to behave efficiently from either an individual or societal perspective.<sup>112</sup> This might give society an incentive to limit freedom of contract to the extent individuals cannot behave optimally on their own.<sup>113</sup>

As discussed in Part II, the neuroeconomic evidence shows that perception and analysis is heterogeneous in the population, which implies that some individuals are more likely to behave more according to standard game theory predictions<sup>114</sup> and others may have a greater tendency to cooperate more.<sup>115</sup> This heterogeneity of responses might be used to argue in favor of different methods of interpreting contracts depending on the context in which the agreement is reached. For example, if the persons involved are members of a group which one could denominate a high-trust society, a greater degree of

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<sup>111</sup> Russell Korobkin, *The Status Quo Bias and Contract Default Rules* 83 Cornell L Rev 608 (1998), and also Russell Korobkin, *Inertia and Perception in Contract Negotiation: The Psychological Power of Default Rules and Form Terms*, 51 Vand L Rev 1583 (1998)

<sup>112</sup> Jeffrey Rachlinski *A Positive Psychological Theory of Judgment in Hindsight*, in Sunstein, *Behavioral Law and Economics* (cited in note 6).

<sup>113</sup> Ulen, *Rational Choice in Law and Economics* (cited in note 5).

<sup>114</sup> McCabe et al. *supra* note 74.

<sup>115</sup> *Id.*

ambiguity in a contract may still result in a reasonable understanding. In such cases, some of the results from behavioral economics (such as not really understanding an agreement and yet assenting to it) may be the result of rational time allocation.<sup>116</sup> In other situations, where the parties are more skeptical of the cooperating behavior of the other party, the actors may behave more like game theory would predict. In such a lower trust situation, greater specificity may be required.<sup>117</sup> The optimal rules might therefore be different for different type of contracts.<sup>118</sup> Neuroeconomic research could help to inform us about how these relationships are perceived and how this affects behavior.

One focus of neuroeconomic research should be to understand what type of legal rules would foster higher-trust relationships. Such relationships tend to be less costly because they are cheaper to both the participants and society.<sup>119</sup> Of course, we need to be mindful of Hayek's point that it is difficult, if not impossible, to generally turn impersonal contacts into personal ones, so that we should not expect a perfect ability to accomplish this. However, to the extent that legal rules can on the margin attempt to foster trust rather than distrust, this should be the focus of drafters of laws.<sup>120</sup>

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<sup>116</sup> Herbert Simon, *Models of Bounded Rationality* (MIT, 1984)

<sup>117</sup> In *Texaco, Inc. v. Pennzoil, Inc.*, 729 S.W. 2d 768 (1987) the litigants disagreed over whether there was a valid contract. Joseph Jamail, the lawyer for Texaco argued that in Texas, a handshake formed a contract. The jury agreed and held there was a valid contract.

<sup>118</sup> In addition, if the contract calls for performance on different time scales, we may want this to be reflected in the enforceability and interpretation of the contract. For example, Alan Schwartz and Robert Scott argue that at least as to sophisticated individuals, traditional contract law (which one can argue is based on ideas similar to classical game theory) should be applied. They intentionally do not argue that these same arguments apply to all contracts. Alan Schwartz and Robert Scott, *Contract Theory and the Limits of Contract Law*, 113 Yale L J 541 (2003).

<sup>119</sup> Of course, to the extent the implicit contract may involve high-trust groups, but also involve socially detrimental behavior, such as mafia agreements, they should not be enforced.

<sup>120</sup> Iris Bohnet, Bruno Frey and Steffen Huck *More Order with Less Law: On Contract Enforcement, Trust and Crowding Out*, 95 Am. Pol. Sci. Rev. 131 (2001)

Another area of interest will be the relationship between notions of the perception of risk and ambiguity and the indefiniteness of contracts.<sup>121</sup> The neuroeconomic research concerning how we perceive ambiguous risks may help us to understand how such uncertainties can be allocated optimally.<sup>122</sup> The optimal allocation of ambiguity can impact our interpretation of contracts, as well as notions such as the doctrine of mutual mistake.

## **B. Property Law**

Traditional law and economic analysis uses relatively simple utility functions for which wealth and other forms of property enter the argument directly.<sup>123</sup> Traditional law and economic analysis makes the same assumptions that that neo-classical economics makes such as the more of a good, the higher the utility and that the value of the good is generally relatively stable over time.<sup>124</sup> These assumptions are not overly restrictive because even within this paradigm, there is still a great deal of freedom for creating models.<sup>125</sup>

One of the standard results in the law and economics of property is the Coase Theorem which implies that if transactions costs are kept low enough, it does not matter

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<sup>121</sup> For an discussion of the economic impact of ambiguity, see *Ambiguity Aversion and Incompleteness of Contractual Form* 88 Am. Econ. Rev. 1207 (1998).

<sup>122</sup> For example see Larry Epstein, *Sharing Ambiguity* 91 Am Econ Rev. 45 (2001).

<sup>123</sup> The can be described as  $U(p, \dots)$  where  $p$  is the property. More generally, property is simply a form of wealth and so the utility function may only be indirectly a function of property such as  $U(W(p, \dots))$ . The other elements of the argument might be items such as leisure time, and other pleasurable activities.

<sup>124</sup> This is more formally known as the principle of non-satiation. See Varian, *Microeconomic Analysis* at 96 (cited in note 18). This stability assumption does not necessarily apply to financial assets.

<sup>125</sup> The precise nature of the utility function, the cost function, profit function etc, and what other elements comprise the arguments of the objective function, determine the behavior of the person at issue. By altering the relationship between these, you can essentially rationalize any behavior which does not violate the weak axiom of revealed preference.

if property rights are not initially awarded to the most efficient user of the property, because the property will still end up in the hands of most efficient user.<sup>126</sup> One lesson from the Coase theorem might be that we should attempt to keep transactions costs low, rather than trying to find the most efficient party, which may be more difficult.<sup>127</sup> Of course, even under the Coase theorem, if either transactions costs are high or if we are concerned about distributional effects, then the predictions of the theorem are less valuable.

The behavioral law and economic analysis looks at these questions differently. It takes the standard neoclassical analysis as its base, but it adds ideas such as the endowment effect, and other types of framing effects. If we apply an endowment effect analysis to these situations, the value of a piece of property to an individual increases as soon as the individual is actually given the property. That is, before a person is given a mug he might value it at \$2, but after receiving it, he values it at \$4.<sup>128</sup> From this perspective, the Coase theorem may not hold anymore. If simply the receipt of property will increase its value to the recipient, the original allocation becomes important. The party who would have derived more value from it,<sup>129</sup> might not value it enough to acquire

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<sup>126</sup> Ronald Coase, *The Problem of Social Cost* 3 J L & Econ 1 (1960).

<sup>127</sup> This is related to literature on the economics of institutions. For an example see Armen Alchian and Harold Demsetz, *Production, Information Costs and Economics Organization*, 62 Am Econ Rev 777 (1972).

<sup>128</sup> There is some evidence that the endowment effect maybe due to the quite complicated phenomena. Plott and Zeiler, *The Willingness to Pay/Willingness to Accept Gap* (cited in note 27).

<sup>129</sup> Daniel Kahneman et al, *Experimental Test of the Endowment Effect and the Coase Theorem*, in Sunstein, *Behavioral Law and Economics* (cited in note 6). The idea here can be illustrated by way of an example. If there are two individuals who could be awarded the good, A and B and before the good is awarded they value it \$10 and \$12, respectively and after \$17 and \$19 respectively. So that while B always values the asset more, if we mistakenly give it to A, A will never sell it to B, even though transactions costs are zero. In some sense this has the effect of having very large transactions costs. However, these transactions costs are built-in to humans, rather than merely the institutions we have.



it from the person who in fact received, so that even if transactions costs are zero, it is possible that property can be awarded inefficiently.<sup>130</sup>

Neuroeconomics can help us to understand how individuals actually view property and how that the perception of property affects behavior. The heterogeneity already observed indicates that people not only place different values on the same piece of property (as neoclassical analysis would predict) or that the value may change depending upon circumstances (as behavioral economics assumes), but also that the way in which the notion of ownership is processed by different people may be quite different. Some may view it as a resource to be shared, and others may view it entirely in a non-cooperative way.<sup>131</sup> In addition, it appears that either view is to some degree context dependent.<sup>132</sup> Understanding this may help to explain the anomalies analyzed under behavioral economics and help to provide a solution to one of the greatest problems of behavioral economics as viewed by its critics: its need for a central theory from which one can deduce the particular behaviors observed.<sup>133</sup>

### **C. Business Associations**

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<sup>130</sup> To determine the efficiency of any allocation, one needs to have some notion of a social welfare function, and this somehow related to addition of the welfare of all the members of the society. For example one could use a Samuelson-Bergson Social Welfare function. See A. Bergson, *A Reformulation of Certain Aspects of Welfare Economics*, 68 *Quar J Of Econ* 233 (1938).

<sup>131</sup> See the distinction between actors in the Trust game and the ultimatum games describes at Part III.2.a, *infra*.

<sup>132</sup> See Hoffman et al, (cited at 30, above)

<sup>133</sup> Behavioral economics is sometimes referred to by its critics as the anomalies literature. Eugene Fama, *Efficient Capital Markets II*, 46 *J Fin* 1575 (1991).

In many ways, the laws regarding business organizations are subset of contract rules.<sup>134</sup> Many of the same issues that apply to the analysis of contracts apply to the study of business organizations (e.g., questions such as what individuals are trying to optimize<sup>135</sup> and what methods do they use to accomplish this). The standard analysis of why particular entities are chosen to conduct business is based on the Jensen-Meckling hypothesis that agency costs in the environment is the key factor in making this decision.<sup>136</sup> The agents will choose a corporate form if the business requires formal structure with separation of ownership and management.<sup>137</sup> If flexibility is needed and the owners essentially need to be the managers, a partnership will be chosen.<sup>138</sup>

The behavioral economics accounts agree with these descriptions but introduce cognitive biases such as over-confidence into the analysis and conclude that individuals may choose the wrong entity because they do not realistically evaluate the prospects.<sup>139</sup> This might lead us to think we should limit the ability of individuals to choose particular forms of entities to particular kinds of businesses, and also to place significant restrictions on the internal rules of the structures they do choose.

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<sup>134</sup> The notion of firm as nexus of contracts, is now a standard of the literature. Michael Jensen and William Meckling, *Theory of the Firm: Managerial Behavioral, Agency Costs, and Ownership Structure*, 3 J Fin Econ 305 (1976).

<sup>135</sup> It might not be clear if they are maximizing profit, minimizing cost, satisficing or using some other method to decide what course of action to select.

<sup>136</sup> See also Alchian and Demsetz, *Am Econ Rev* 1972 (cited in note 119).

<sup>137</sup> Michael Jensen and William Meckling, *Theory of the Firm: Managerial Behavioral, Agency Costs, and Ownership Structure*, 3 J Fin Econ 305 (1976).

<sup>138</sup> Id

<sup>139</sup> Joseph Bankman, *The Structure of Silicon Valley Startups*, 41 UCLA L Rev 1734 (1994) and Victor Fleischer, *The Rational Exuberance of Structuring Venture Capital Start-ups*, *Tax L Rev* (forthcoming 2004). Limited liability is no longer much of a concern because limited liability companies can be taxed as partnership, but have limited liability like corporations. Bankman indicates that the government may be profiting from this, because entrepreneurs do not make sufficient use of tax losses.

One application of neuroeconomics to these transactions again relates heterogeneity of behavior to this analysis. Different groups may have different levels of trust embedded in them and so not only is the choice of entity related to the business environment, but also to the particular relations between the owner-mangers. Hence the degree of trust will influence the choice of entity. If different individuals, families and cultures have different levels of trust, this may help explain the choice of entities etc., not just the business environment. In order to understand the selection of entity as well as the particular agreements they reach, one has to understand the interaction between individuals who co-operate and those who defect, and the understanding between those individuals who may have better information than other individuals.<sup>140</sup> Different firm structures have different methods of allocating risks, uncertainties and rewards. The research indicates that ambiguity aversion and risk aversion are not perfectly correlated.<sup>141</sup> Therefore, the ways in which this allocation is made will likely matter. How parties decide to allocate calculable risk may not be the same as how they would likely to allocate ambiguous risks. Significant research is being conducted on the relationship between differential ambiguity aversion and the ownership of entrepreneurship firm versus being an employee.<sup>142</sup> The literature on risk, uncertainty (or ambiguity) have all assumed particular models of how individuals perceive and behave

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<sup>140</sup> Certain types of people, known as high Machs (after Machiavellian), are generally do not reciprocate when it is not in their interest. The reverse or low Machs. reciprocate when it is not in their interest. Anna Gunthordotir, et al., *Using the Machiavellian Instrument to Predict Trustworthiness in a Bargaining Game* 23 J. Econ. Psychology 49 (2002).

<sup>141</sup> See for example, Paul Shoemaker, *Choices Involving Uncertain Probabilities: Tests of Generalized Utility Models* 16 J. Econ. Behav. Org. 295 (1991).

<sup>142</sup> For example, see Luca Rigotti, Matthew Ryan, Rhema Vaithiarathan, *Tolerance of Ambiguity and Entrepreneurial Innovation* (Fuqua School of Business, Working Paper)( Sept. 19, 2003). See also, David Kelsey and Willy Spanjers, *Ambiguity in Partnerships* forthcoming Econ. J. (2004)

with regard to risk and uncertainty. Many decades ago, Frank Knight argued that it is the allocation of ambiguous risks which are the basis of all true profit.<sup>143</sup> Hence, understanding how we deal with ambiguity will help us to understand the impact of legal rules on the operations of business. This should then affect both the way we structure the law and the taxation of these entities.

### **E. Jury Decisions**

The traditional law and economics scholarship which analyzes juries focuses on questions of the decisions of the optimal make-up of the jury, the economics of the decision of whether to seek a jury, the decision of whether to seek a jury the number of jurors whether verdicts should be unanimous or merely a majority,<sup>144</sup> should jury service be voluntary or conscripted, etc. The traditional law and economic theory of the jury also examines the efficacy of the jury system itself.<sup>145</sup> This is all done within the context of all actors rationally pursuing their own self-interest. In addition, there are additional analyses of how juries operate including such ideas as the Condoret jury theorem and other game theoretic type of issues.<sup>146</sup>

The behavioral critique of this account is based on the cognitive biases demonstrated in experiments. In particular, it argues that issues such as framing of the questions can have a significant outcome on the decision of the jury.<sup>147</sup> In particular

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<sup>143</sup> Frank Knight, *Risk, Uncertainty and Profit* (Chicago, 1957)

<sup>144</sup> Posner, *The Economic Analysis of the Law* (cited in note 4).

<sup>145</sup> Id.

<sup>146</sup> For a discussion of these problems see Joseph Stiglitz, *Economics of the Public Sector* 163–171 (W W Norton, 3d ed 2000).

<sup>147</sup> Edward J. McCaffrey, et al, *Framing the Jury: Cognitive Perspective on Pain and Suffering Awards*, in Sunstein, *Behavioral Law and Economics* (cited in note 6).

understanding that the difference between framing the question the jury decides as an *ex ante* question or an *ex post*, question can have a significant difference in the decision. This calls into question many of the rules we have in dealing with the jury. Other behavioral scholars also discuss how other cognitive biases such as hindsight bias (which makes it seem like events that actually did occur were more likely to occur *ex ante* than they in fact were) can have a significant impact on the jury.<sup>148</sup> It also discusses problems such as the inability of jury members to calculate probabilities in a Bayesian manner, and the effects this can have on decisions. Importantly, judges do not come away from this account unscathed either.<sup>149</sup>

Neuroeconomics can advance the study of juries by examining what mechanisms jurors use to process the information given to them and how these methods differ in the population. It also might be able to tell us how the individuals in the jury allocate decision making among the group. For example how do group dynamics and social affiliations affect decision-making. It appears that very marginal social attachments can significantly affect decision-making.<sup>150</sup> Evidentiary rules could be drafted to comport better with the way individuals actually perceive evidence. Finally, this field of research can allow us to begin to examine the benefits of the size of the jury and other traditional law and economics questions by examining the advantage of having different types of

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<sup>148</sup> Jeffrey Rachlinski, *A Positive Theory Of Hindsight Bias in Judging*, in Sunstein, *Behavioral Law and Economics* (cited in note 6).

<sup>148</sup> Edward McCaffrey, et al, *Punitive Damages, Assessing Punitive Damages (with Notes on Cognition and Valuation in Law*, in Sunstein, *Behavioral Law and Economics* (cited in note 6).

<sup>149</sup> See discussion in Camerer note 69 concerning how judges predictions about recidivism are normally worse than could be predicted by a simple linear model.

<sup>150</sup> Joshua Greene, et al. *An fMRI Investigation of Emotional Engagement in Moral Judgment* 293 *Science* 2105-2108 (September 14, 2001).

individuals giving their perspective on a decision of liability. In addition, the findings that risk and ambiguity are processed differently would give strength to concerns of how jurors incorporate evidence with precise probabilities with other more ambiguous evidence.<sup>151</sup>

## V. CONCLUSION

This article has discussed how the emerging results from neuroeconomics is almost certainly going to have profound effects on the way we view legal problems. The research already conducted seems to both support and refute the assumptions and conclusions of prior legal scholarship. By understanding the cognitive processes used by individuals, we can significantly progress in our understanding of legal and economic problems. Neurological and psychological evidence shows that the brain is not a Universal Turing Machine swiftly solving partial differential equations, which may seem to be required by some hypotheses.<sup>152</sup> It is well designed to perform certain functions, but it is not as good for other functions. Evolution did not waste energy in devising brain mechanisms that can perform largely irrelevant operations. By exploring these structures, we improve both our understanding of human behavior and our ability to predict how humans will react to the legal rules we wish to adopt.

Now that medical technology has advanced to the point where we can actually examine the brain while it is performing functions, we can move from the simpler models of neoclassical economics or even behavioral economics to examine what is actually

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<sup>151</sup> For an early discussion of the issue see Lawrence Tribe, *Trial by Mathematics: Precision and Ritual in the Legal Process* 84 Harv. L. Rev. 1329 (1971) .

<sup>152</sup> Interestingly, robots are really quite dumb, unable to things that many insects can do. Camerer, supra note 33

occurring at the deeper level of the brain. This will result in better models of human behavior and consequently a better understanding of legal problems.