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The “Invisible Hand” in the Brain

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The “Invisible Hand” in the Brain

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Abstract.

In this paper, we attempted to find in the brain the factors of the human side, which is responsible for the market mechanism called the "invisible hand" by Adam Smith, by using fMRI experiments. We tried to identify the activated part of the brain that the allocator determines the amount of money to be paid to the responder in playing the ultimatum game. That part is the part with which human being considers the other party's request and considers also its own interests in the process of trial and error consisting of market mechanism. This is because it is thought to be responsible for the function. It is a brain region called the left supramarginal gyrus, and its activation degree has a significant correlation with the sympathy scale of psychology. Accounting information derived from acquisition cost basis is fundamental information for trial and error done in the brain, that is, for market mechanism.

Keywords:

invisible hand, ultimatum game, sympathy, left supramarginal gyrus

1. Introduction

The language of accounting demarcates the discipline's subject matter; it has no specific methodology of its own. The discipline takes as its subjects the accounting systems operated on a semi-customary basis by firms and today governed by public regulators, and the accounting information derived therefrom and made publicly available in economic society. Although the experiential referents of accounting are limited, the discipline's concerns range across many different dimensions. A typical and familiar example is the question of what meanings specific accounting processes, and the accounting information produced thereby, have within business organizations and on securities markets and various other types of markets. In the most abstract terms, the

discipline affords scope to depict trends in corporate society with accounting systems as the core concern.

When tracing developments in corporate society, as the starting point for accounting research the fundamental approach is to employ findings from a variety of methodologically-specific disciplines such as psychology and linguistics. Economics is the archetypal instance. Viewed in this way, accounting is faced with dilemmas at the most fundamental level. Assuming that accounting systems are used within firms and markets, the ways in which accounting systems and accounting information are to be characterized will differ greatly depending on how one understands the concept of “the market.” One of the primary questions faced in accounting is whether to view the market as a place where rational individuals encounter one another as consumers and suppliers, each pursuing their own profit-maximizing behavior, and where prices are brought to equilibrium by auctioneers; or as places where price convergence is guaranteed by the operation of institutions unrelated to such behavior. If the former characterization is adopted, accounting systems can be understood in terms of providing the market with information to aid market participants in their pursuit of profit-maximizing behavior. Under the latter view, however, market participants may not necessarily behave in a manner consistent with the principle of profit maximization based on information provided through historically established accounting systems, but the market nonetheless stabilizes through the use of information through routes not yet fully explicated by scholars of accounting.

With a view to reconsidering the broad-ranging problems outlined above, this paper explores the afore-mentioned question how to characterize the market, to the extent that it concerns the discipline of accounting. For this purpose, the paper examines the ideas of Adam Smith, instigator of the seminal concept of the market. The section of the article immediately following this introduction examines the notion of the “invisible hand,” which lies at the foundation of Smith’s idea of the market and serves as the point of departure for a variety of market-related concepts developed over the subsequent history of the economics discipline. Specific attention is paid to the idea of the “invisible hand,” which generations of scholars have maintained was canvassed by Smith directly in his works *The Theory of Moral Sentiments* and *An Inquiry into the Nature and Causes of the Wealth of Nations*. The third section of the article looks at various understandings of basic market concepts subsequent to Smith, while fourth section identifies the factors common across market concepts developed by Smith

himself and subsequently thereto, and employs the results of experiments on the human brain to pinpoint the regions of the brain which underpin those concepts. The final and concluding section discusses the relationship between Smith's market concept and the active regions of the brain.

2. Adam Smith's "Invisible Hand"

This section identifies common points in Adam Smith's concept of the "invisible hand" through references—both direct and indirect—to the concept in Smith's writings.

2-1. References to the "invisible hand" in *The Theory of Moral Sentiments*: Mechanisms for distribution of essential commodities

Let us first examine a section of *The Theory of Moral Sentiments* where the expression "invisible hand" is employed directly. The following is a direct quote from this section.

The Produce of the soil maintains at all times nearly that number of inhabitants which it is capable of maintaining. The rich only select from the heap what is most precious and agreeable. They consume little more than the poor, and in spite of their natural selfishness and rapacity, though they mean only their own conveniency, though the sole end which they propose from the labours of all the thousands whom they employ, be the gratification of their own vain and insatiable desires, they divide with the poor the produce of all their improvements. They are led by **an invisible hand** to make nearly the same distribution of the necessaries of life, which would have been made, had the earth been divided into equal portions among all its inhabitants, and thus without intending it, without knowing it, advance the interest of the society, and afford means to the multiplication of the species. When Providence divided the earth among a few lordly masters, it neither forgot nor abandoned those who seemed to have been left out in the partition. These last too enjoy their share of all that it produces. In what constitutes the real happiness of human life, they are in no respect inferior to those who would seem so much above them¹.

The landlord—the archetypal rich person—cannot consume all the grain he harvests on his own, so uses the surplus to purchase luxuries. The

¹ Adam Smith, 2003, *The Theory of Moral Sentiments*, pp.165.

manufacturers of these luxuries use the money obtained in compensation for their labor to purchase the grain, which is an essential commodity. Through this chain of events, the grain is dispersed not only to the landlord who produced it but also to the manufacturers of luxuries such as carriages and jewelry. It is distributed across society as if everyone owned land and produced and harvested grain equally. Smith's argument therefore is that rich landlords, led by the "invisible hand [of God]," ultimately achieve virtually the same distribution of essential commodities as would occur if ownership of land was allocated evenly across all members of society. The process therefore leads to the state of nature. In the contemporary terms of market equilibrium, this is analogous to multiple markets converging in equilibrium while satisfying their own demands. It is underpinned by the idea that appropriate distribution will ultimately be achieved as a diversity of people purchase and supply goods on the market through processes of trial and error. Nobody in this process is actually concerned with doing something socially beneficial.²

2-2. Process of formation of Social order or morals in *The Theory of Moral Sentiments*: Sympathy³

² There are two distinguishing features of Smith's work here. One is his understanding that wealth continues to be owned by individuals. The second feature that must be noted is the notion that money is not the same as wealth (money has absolutely no use other than to purchase commodities). It is pointless for a rich landlord to keep the grain produced on his land to himself, or for a capitalist to do the same with the products mass-produced through division of labor, so these goods are eventually exchanged on the market to meet the landlord or capitalist's demand for resources for daily living or luxury items. They are exchanged in turn for new goods and redistributed throughout society. Smith sees money as a medium that facilitates these exchanges and distributions. This idea that money does not exert influence on the real economy is known as the neutrality of money theory. Later to be absorbed into modern economics as a precondition for the quantity theory of money, Smith's ideas about the neutrality of money were not modified by other economists until the work of John Maynard Keynes in the twentieth century.

³ In Japanese, Smith's "sympathy" is usually translated as *dōkan*, but sometimes as *kyōkan*, a term more commonly used as equivalent to "empathy". In the field of psychology, a distinction is made between these two terms. Essentially, sympathy (*dōkan*) refers to cases where the subject (person feeling the sympathy) remains distinct and clearly-defined; empathy (*kyōkan*) is used where the person abandons their distinct self and actually assumes the same feelings as the other party. Smith's use of "sympathy" appears to cover both of these cases, and is used in this paper without regard for the distinction employed in modern psychology.

Smith also develops ideas that could be understood as equivalent to the “invisible hand” in other parts of *The Theory of Moral Sentiments* (hereafter simply “*Moral Sentiments*”). This is where Smith analyzes the process of formation of morals in society. The principal idea constituting this analysis is what Smith calls “sympathy.” *Moral Sentiments* proposes that human beings are aware of the behavior of others in society, and of the gaze of others upon themselves. On this basis each of us stands in the shoes of others to judge whether we should condone or feel indignation at the behavior of others. Smith refers to this sentiment as “sympathy,” and says that we also seek to cultivate the positive sympathy of others toward our own behavior. Building further on this fundamental idea of sympathy, Smith believes that rather than referencing the gaze of any specific individual, we form in our minds the idea of a hypothetical “impartial spectator” in line with the expectations of society. We shape our behavior to appear faultless when viewed from the position of this “impartial spectator,” and use the same position to judge the merit of others’ behavior. As this process is repeated, the moral order of society comes into being. Smith thus asserts the importance of repeatedly correcting and adjusting one’s own behavior through self-reflection in the course of one’s relations with others.⁴ He sees morals as being formed through a kind of “greatest common factor” process.

In *Moral Sentiments* Smith argues that we each observe the moods of others, and comprehend and make judgments about the sentiments that cause them from our own distinct standpoints. What sentiments the behavior of others caused by certain sentiments arouses in its subjects is, however, inevitably based on our own conjecture. The former is defined as a direct process while the latter as an indirect one. If this direct and indirect understanding of others’ sentiments can be termed “sympathy,” it is easy to imagine that others possess sympathy as well.

As a result, human beings living collectively in a society are unable to behave in a manner that diverges greatly from the norms formed through mutual sympathy, even in such behavior is of itself self-serving. Such norms of behavior are rendered within each of our minds as the view of the “impartial spectator,” allowing us to appreciate the universal moral

⁴ This idea is akin to the teachings of Confucius, specifically: “What you do not want done to yourself, do not do to others.” This at essence is the principle of fair play. It can be seen as a minimum standard of social etiquette, rather than a paramount virtue.

standpoints relevant to our contemporary society. We employ these as criteria for our own behavior and thereby ensure that society is kept stable.

We each conduct ourselves in accordance with mutual sympathy and avoid behavior problematic from the socially constructed and sublimated normative standpoint of the “impartial spectator.” This, Smith believed, cultivates a kind of order in (economic) society. It constitutes Smith’s response to the question of “how peaceful coexistence among free and equal self-interested individuals may be achieved without requiring the imposition of power” (Mizuta Hiroshi, 1968). We should note, however, is that this idea of sympathy is predicated on the notion that we comprehend the feelings and circumstances of others as a form of knowledge, having first developed a solid grasp of our own place in the world.

Another point worthy of attention is that sympathy can be generated by both joyful sentiments and ones such as sorrow and anger, but Smith focuses especially on those with negative aspects. He appears to view activities that can produce sympathy in a positive sense, such as charity, as of no use in the maintenance of economic society. The charitable activities of others may cultivate strong sympathy, but this, in Smith’s view, should not lead us to think that the viability of society requires each individual within it to engage extensively in charitable (service) activities. The morals formed through sympathy can be understood as encapsulated primarily in the “fair play” principle of doing no harm to others, rather than as encouraging the active pursuit of charitable (service) activities. Smith believed that when self-interested individuals engage in economic activity in a spirit of fair play in the minimal sense, society will be able to provide all its constituents with essential resources and a minimal standard of living, without the need for power to intervene.

We come to appreciate where the common moral standards for society lie through a process of trial and error, as we discuss, debate, show pity for, and sympathize with many different people. Smith does not use the language of the “invisible hand” directly to describe this process of moral formation, but as Dōme notes, his foundational principles of social order—the

general rules of morality or laws of nature—can be understood as synonymous with the “invisible hand.”⁵

2-3. Process of equilibrium of prices in *The Wealth of Nations*

Now let us turn to the more well-known treatment of the “invisible hand” in Smith’s work. Below is the most famous—to be more accurate, the only—passage on the “invisible hand” in *An Inquiry into the Nature and Causes of the Wealth of Nations* (hereafter *The Wealth of Nations*).

As every individual, therefore, endeavours as much as he can both to employ his capital in the support of domestic industry, and so to direct that industry that its produce may be of the greatest value; every individual necessarily labours to render the annual revenue of the society as great as he can. He generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By referring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by **an invisible hand** to promote an end which was no part of his intention. Nor is it always the worse for the society that it was no part of it. By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it. I have never known much good done by those who affected to trade for the public good. It is an affectation, indeed, not very common among merchants, and very few words need be employed in dissuading them from it.⁶

The producers of goods know that they have produced them at a certain cost to themselves, even if they have no information on the costs which others in the same vocation have incurred in producing the same goods. This is a natural part of knowing oneself. Producers thus always have an eye for

⁵ For Smith, the social order is something designed by “nature,” and human behavior is simply guided by the “invisible hand” of “nature” (Dōme, p.66).

⁶ Smith, Adam (translated by Sugiyama Chuhei and translated/edited by Mizuta Hiroshi), 2000, *Kokufuron* [The Wealth of Nations]. Iwanami Shoten, paperback edition, pp.303-304.

opportunities to sell their goods on the market with a certain quantum of profit. If anyone wishes to purchase the goods at the price selected, they will be sold at that price. It is that simple. What happens when a large number of people engage repeatedly in this process is that those who can manufacture their goods at a lower price have more opportunities to sell their goods. These goods are the first to sell out on the market, followed by those with the second lowest prices, and so on. Ultimately an equilibrium is reached wherein people seeking to obtain the goods cease to meet with those seeking to sell them at a certain price. Under these conditions, those who produce their goods more cheaply and efficiently generally have greater opportunities to secure higher profits, while others are only just able to recover the capital enabling them to continue producing. Nobody oversees this process; it is driven by each individual's self-interest and desire to profit.

Smith called this the "invisible hand," and it is referred to today in terms such as "market mechanisms" and "price mechanisms." Government interference in such price mechanisms, for example by fixing the prices of goods, precludes the natural state in which people freely seek to manufacture, sell and purchase the goods (optimal resource allocation). This idea gives rise to the *laissez-faire* approach which denounces government intervention and calls for the market to be left to private enterprise. From a governmental perspective, it is a mandate for small government (low levels of intervention). It is on the basis of this understanding that Smith has been labelled by later generations as a "*laissez-faire*" economist.

The same understanding constitutes the basic idea of "neoclassical economics," which developed after Smith's time and today constitutes the mainstream of economic thought. Smith's successors, however, did not incorporate all of his ideas into their theories, only certain essential features thereof. The characterization of Smith as "*laissez-faire*" is therefore an oversimplification.

The "invisible hand" aside, Adam Smith is well-known for the concept of division of labour. Using the example of the process of manufacturing sewing pins, Smith explains that rather than having a single worker

perform all stages of the process, productivity can be increased by dividing the process into a number of sub-processes each performed by a different worker, enabling each worker to become specialized in the sub-process they perform. This argument connects with the idea that because no individual produces all the commodities necessary for their own life, society promotes greater levels of exchange on the market, thus invigorating economic activity. Dividing the process of manufacture into a series of finely-distinguished tasks stimulates the processes of exchange and leads to the employment of greater numbers of workers. Moreover, these processes of exchange are kept fair under the guidance of the “invisible hand.” Nobody is overseeing these processes in their entirety, and it is inconceivable that workers are inspired by a sense that they are undertaking their tasks for the sake of wider society. The motivation of capitalists is purely private and self-interested, as they seek higher prices for the goods they produce. The idea is that all this is regulated by the “invisible hand” toward the positive outcome of greater productivity for society as a whole.

3. Development of the “Invisible Hand” Concept: Interpretations of Adam Smith’s “Invisible Hand” in Contemporary Economics

3-1. Rationality-based market equilibrium (pricing theory)

Smith’s idea of the “invisible hand” outlined above was both refined and transformed as the discipline of economics developed after Smith’s time. As it developed, the discipline, and economics after Walras in particular, saw the profit-maximizing behavior of companies and consumers as leading to equilibrium pricing on the market. The process of equilibrium pricing explained in most economics textbooks does not necessarily accord with the image of guidance by an “invisible hand.” In other words, volumes of production and consumption are determined in accordance with the principle of profit-maximizing behavior of sellers and buyers in the market, on the basis of their individual plans and budgets. However, planned production and consumption volumes are items of personal information held by each individual producer and consumer participating in the market, not shared among them. Moreover, because perfect competition is assumed, each market participant is a price-taker: a reactive presence. Here economists postulate the presence of “auctioneers” as mediators who gather and impart price information. These auctioneers collect information on the

production and consumption volumes of individual producers and consumers, establish an equilibrium of these volumes across society and thereby determine equilibrium prices, on the basis of which market transactions are conducted. There is no guarantee that producers and consumers will provide auctioneers with accurate and truthful information, so research is conducted into the design of systems to guarantee such accuracy. It could be ventured that in this kind of orthodox economics, the “invisible hand” is the presence of transparent auctioneers in an iterative auction process (tatonnement). Auctioneers themselves, however, do not maximize their own profits.

3-2. Equilibrium based on irrationality (experimental markets)

The two key features of the orthodox economic concept of markets outlined above are profit-maximizing behavior as a manifestation of rational behavior by market participants, and the presence of auctioneers. In contrast, from the early 1960s onward, efforts were made to demonstrate that markets could achieve equilibrium even in the absence of these key features. First the idea developed that a market could reach equilibrium price, depending on the shapes of supply and demand functions, even if individual market participants did not pursue the kind of profit-maximizing behavior envisaged in orthodox economics. This was consistently one of the major topics of discussion in economics from the 1960s onward. Gary S. Becker⁷—later to be awarded the Nobel Prize—established that the presence of “rational human beings” pursuing profit-maximizing behavior was not an essential condition: equilibrium could be achieved even in a so-called “non-intelligent” human market. In regard to the significance of the auctioneer,⁸ Vernon Smith⁹ used experiments to establish that markets reach equilibrium under double-auction rules. Furthermore, experiments were used in the same way by Gode & Sunder to confirm that markets reach equilibrium even if both conditions central to traditional economics, the rational human being and the auctioneer, are removed at the same time.¹⁰ Debate has continued since

⁷ Gary S. Becker, “Irrational Behavior and Economic Theory,” *Journal of Political Economy*, Vo.70 (February, 1962):1-13.

⁸ J.R.Hicks, *Value and Capital*,

⁹ Vernon L. Smith, “An Experimental Study of Competitive Market Behavior,” *Journal of Political Economy*, Vo.70 (April, 1962):111-37.

¹⁰ D.K. Gode and S.Sunder, “Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality,” *Journal of Political Economy*, 1993, Vol.101, No.1.

Antonio & Sunder¹¹ over whether or not equilibrium across multiple markets, in other words general equilibrium, can be reached following the removal of these two conditions.

Let us examine the findings of Gode & Sunder's experiments that demonstrated how theoretical price equilibrium is reached even in the absence of the two hypotheses of the rational human being and tatonnement. The findings revealed that these two principal preconditions of general equilibrium theory were in fact non-essential. As noted above, Becker had earlier established that even in the absence of the rationality hypothesis, and even where market actors do not actually behave as rational human beings, as long as budget constraints exist the demand function will be downward sloping and the market as a whole will move toward equilibrium in accordance with physical patterns. Gode & Sunder investigated this point further using computerized trading simulations constrained by budgets and within V. Smith's "double auction" environment.

The results of Gode & Sunder's experiments are shown in the Figure 1 below. Price equilibrium is not reached in computerized trading without budget constraints (see upper section of the figure), but is achieved to a considerable degree in budget-constrained computerized trading (a non-rational computer program with constraints only imposed on income and expenditure; see middle section of the figure). In experiments involving trading among humans, who may or may not be rational but do possess memory, price fluctuation was observed in the initial stage, but as time went on there was little or no deviation from equilibrium pricing (lower section of the figure). The point is that computerized trading ("non-intelligent" trading) with budget constraints achieved efficiency equal to between 80 and 90 percent of that of human traders. This proved that price equilibrium could be reached through budget-constrained computerized trading and double auctions without relying on the rational human being model and tatonnement.

¹¹ Antoni Bosch-Domenech and Shyam Sunder, "Tracking the Invisible Hand: Convergence of Double Auctions to Competitive Equilibrium," *Computational Economics* Vol. 16, 2000.

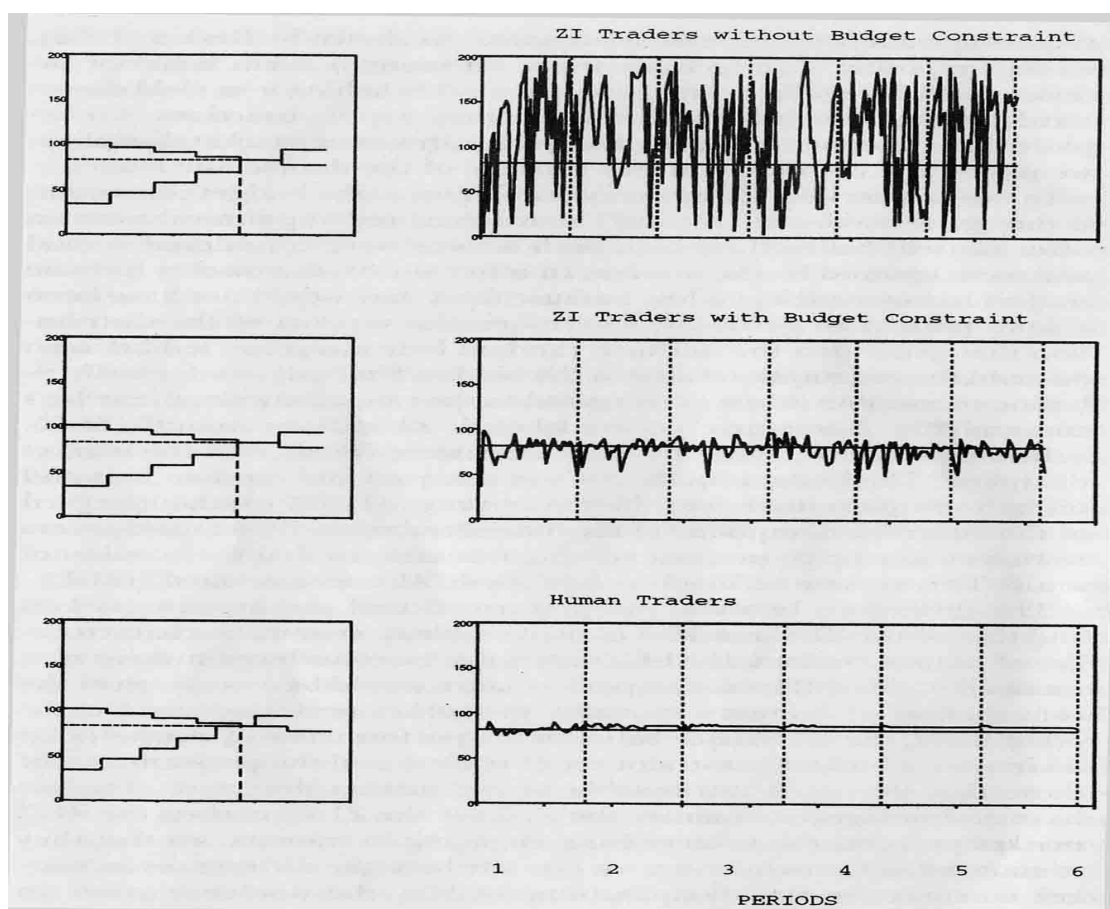


Figure 1. The results of experiments done by Gode and Sunder

This discussion in experimental economics established that market equilibrium could be achieved without relying on the rigid concepts underpinning conventional economics, such as rational human behavior and the role of auctioneers.¹²

3.3 Common understandings: Trial-and-error-based selection/proposal of substitutive behavioral patterns

What human behaviors underpin the “invisible hand” operating in the processes of moral development and market equilibrium? As seen above, the process by which sympathy enables the development of social morality and the process by which prices reach equilibrium in the market—two processes that at first glance appear entirely unrelated—are both conceived and at times expressly labelled by Adam Smith as the workings of the “invisible hand.” The commonality here exists not in the “laws of nature” or other such abstract terms, but in human behavior. What is shared across the

¹² Discussion of Walrasian equilibrium and Marshallian equilibrium is omitted here for reasons of space.

two processes is the understanding that when in society we encounter a third party with different ideas to our own, and it is necessary to engage in some sort of exchange with that party, we present an offer and observe whether or not the party will accept it. If they do, that is the end of the negotiation; if not, we make a substitute offer. This offer reflects our own conduct and calculation of gains and losses—in other words, our self-interest. What we are doing therefore is constructing a strategy of identifying, in the course of negotiation with the other party, points of compromise favorable to ourselves, while predicting how the other party will respond to them.¹³

If the making of these kinds of substitute offers based on selective behavior is taken as the starting point, we can envisage that as we encounter many different people in society, we make decisions on our understanding of what each person might allow and at what point they are likely to show aversion, as well as what our own tolerance levels are. Ultimately we develop within our own minds an objective third party standpoint for judging our own behavior. The process of formation of morals can be conceptualized as one in which each individual's objective third-party perspectives sequentially coalesce in greatest-common-factor form as social morality. In the case of equilibrium pricing in a market, even if market participants lack information on their fellow participants, they gradually gain an understanding of their own situation in the course of trading and begin to trade at appropriate prices, thereby leading the market as a whole to equilibrium. Social morality and equilibrium pricing can both be understood as developing through the same human behavior of repetitive substitute proposal. Under our interpretation of the meaning of Adam Smith's "invisible hand," this repetitive substitute proposal behavior is an important human element in the formation of the "invisible hand" as a system¹⁴.

This idea can also be construed from Gode & Sunder's work. Their finding that trading among non-intelligent actors produces results similar to human trading can be attributed to the fact that while human traders achieve compromise through a process of trial and error, in the process thereof they adjust their own points of compromise; non-intelligent

¹³ Surprisingly, the term "invisible hand (of God)" appears just three times in the writings of Adam Smith. Two of these are discussed in this paper. The remaining one is in a work on astronomical bodies written when Smith was young. It is not possible to include questions of astronomy in the discussion of common issues related to Smith's "invisible hand" in this paper.

¹⁴ Yomogida, Y., Matsumoto, M., Aoki, R. *et al.* (2017) is also developing the same idea concerning social norm formation and developing a similar neuro-experiment idea.

actors have predetermined points of compromise that cannot be adjusted, so they simply pursue the process of trial and error repeatedly.

4. Behavioral Experiments and Brain Experiments: Empathy

4-1. Substitutive behavioral patterns and compromise choices: Ultimatum game

Does human trial-and-error behavior, identified above as a common trait, come about naturally? Hicks also sees this kind of behavior as part of price formation.¹⁵ The results of experiments on the human brain can help to answer this question. Let us refer to the results of an experiment conducted for a separate purpose. The experiment itself involved a repetitive ultimatum game played with both tough responders with strong negotiating skills and responders less skilled in negotiation. It looked at the intracerebral responses of an “allocator” whose role is to determine the allocation ratio, and analyzed the behavior of this allocator as they repeatedly made substitute proposals taking into account their own profits, while distinguishing between tough negotiators and those less skilled. The question here is what kind of mechanisms within the brain accompany the repetitive, trial-and-error behavior of making substitute compromise proposals that take into account the behavior of others while pursuing personal gain. First a preparatory behavioral experiment was conducted to find the regression of allocators’ empathy levels¹⁶ as assessed in a questionnaire, against the allocation ratios of proposals to different responders in negotiation. The results are shown in Figure 2. In Figure 2 R means the following.

Distributions proposed to responders with strong resistance in the final period
R= -----
Distribution proposed to responders with weak resistance in the final period

¹⁵ J.R.Hicks, Value and Capital, Chapter 9.

¹⁶ The questionnaire used to assess empathy was taken from Suzuki, Y. and Kino, K., 2008, “Tajigen kyōkansei shakudo (MES) no sakusei: jiko shikō / tasha shikō no benbetsu ni shōten o atete” [Creating a Multidimensional Empathy Scale (MES): Focus on distinguishing between self-orientation and other-orientation], *Kyōiku Shinrigaku Kenkyū* Vol.56, 487-497.

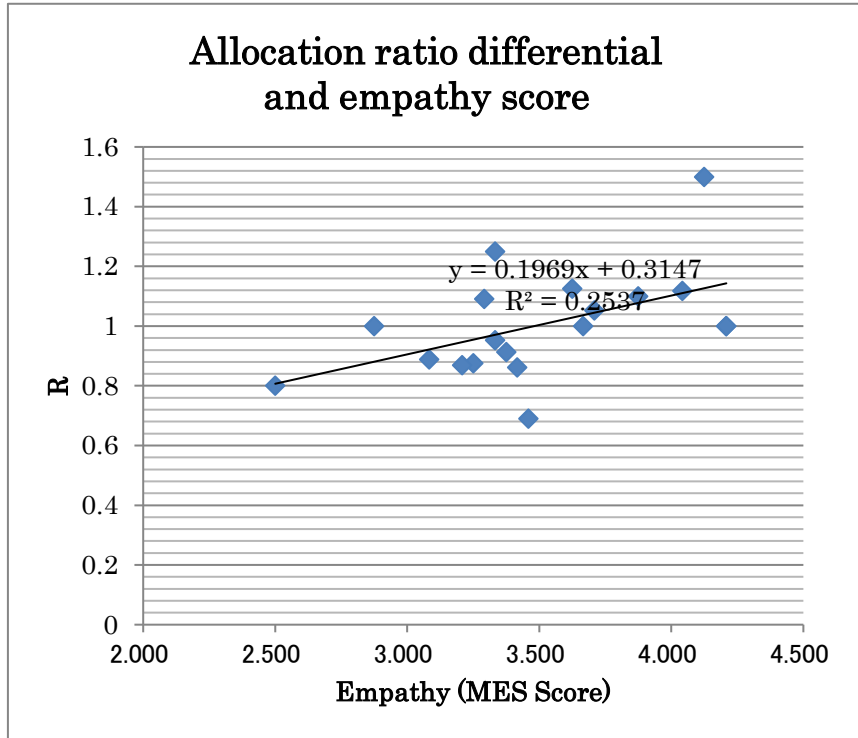


Figure 2. Allocation ratio differential and empathy score

These regression results show a significantly (5%) positive correlation. In other words, they show that allocators with high empathy generally proposed high allocation ratios as time went on in negotiations. Moreover, they show that higher ratios were proposed to tough-negotiating responders than to those less tough. The conditions are different from those of a market, but we can conclude that higher levels of empathy are found in allocators who, in the course of negotiation, weigh up their own gains, repeatedly make new substitute proposals regarding allocation ratios, and advance negotiations in a favorable direction.

Next we investigated which areas of the brain were active when the same allocators made their allocation ratio proposals. The procedural details of this neurological experiment are omitted here, but the results are shown in Figure 2.

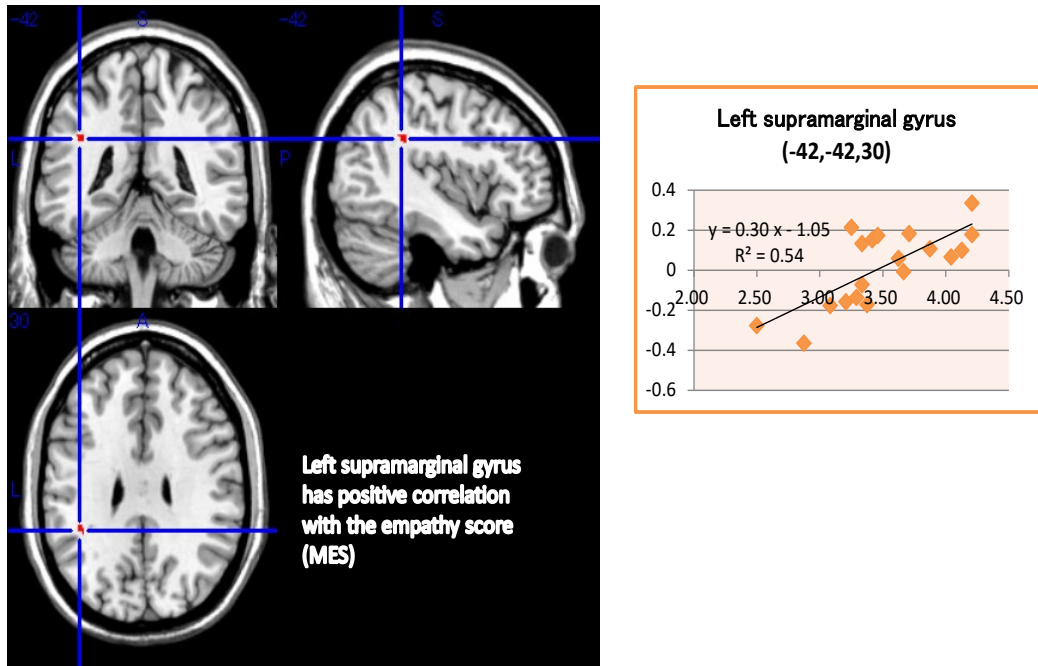


Figure 3. Empathy and activity in the left supramarginal gyrus

Figure 3 shows a regression analysis of empathy levels and the area of the brain that is active when allocators are making their decisions about allocation ratio proposals. Significant activity was detected in the left supramarginal gyrus. Combining the two results in this experiment leads to a finding that an allocator's capacity to differentiate allocation ratios based on the toughness of the responders with whom they negotiate is related to the strength of the allocator's empathy, and the measure of that empathy is significantly related to activity in the left supramarginal gyrus when allocation decisions are being made. In other words, activity in this area of the brain is connected with the process of repetitive substitute proposal. However, this is possibly a manifestation of one factor that underpins empathy in the sense of consideration toward others.

4-2. New horizons in neuroscience: From activity area focus to system (mirror neuron system) focus

Next let us examine the results of several other experiments.¹⁷ The first was conducted by Hartwigsen et al. Details of the experiment itself are omitted here, but the researchers reported that the left dorsal premotor cortex and left supramarginal gyrus complement each other to abstract and reprogram rapid substitutive actions. Studies by Inui offer further insight. Inui found that the inferior parietal lobe (IBL), of which the (left) supramarginal gyrus is part, governs the “like-me” system, which is one of the three systems in the brain that enable human communication: 1) the “like-me” system, 2) the “different-from-me” system, and 3) the prediction and monitoring system. In regard to the construction of images from the standpoints of Self and Other, Inui states: “the activity of the left IPL is restricted by the medial prefrontal cortex (mPFC) when images of the Other are being constructed. As the IPL is part of the ‘like-me’ system, this appears to be restricting the Self standpoint in order to assume the standpoint of the Other.”¹⁸ This may mean that our experiment which observed activity in the left supramarginal gyrus actually identified part of the brain’s communication system (left IPL) when the “like-me” system is in operation. Going a step further, we can look beyond the conventional interpretation of Adam Smith’s “invisible hand” as an abstract reference to divine laws, and see it as referring to the communication system in the human brain which governs negotiation with others. While the formation of social morals is quite literally a process of communication through human language and emotion, price formation in the market can be understood as a process of human communication through the language of pricing.

5. Conclusions

¹⁷ Gasa Hartwigsen, Sven Bestmann, Nick S. Ward, Saskia Woerbel, Claudia Mastroeni, Oliver Granert and Hartwig R. Siebner, " Left Dorsal Premotor Cortex and Supramarginal Gyrus Complement Each other during Rapid Action Reprogramming," *The Journal of Neuroscience*, November 14, 2012/32:16162-16171.

¹⁸ Inui, T., 2012, “Enkatsu na kanshuganteki intarakushon o kanō ni suru shinkei kikō” [Neural mechanisms facilitating intersubjective interaction], *Kokoro no Mirai*, Vol. 9, 14-17. Ogawa, K., and Inui, T., 2011, “Neural representation of observed actions in the parietal and premotor cortex,” *Neuroimage*, 56, 2, 728-735. Ogawa, K., and Inui, T., 2012, “Multiple neural representations of object-directed action in an imitative context,” *Experimental Brain Research*, 216, 1, 61-69.

By extrapolating from the results of brain experiments, we suggest that through the operation of neural systems involving the left supramarginal gyrus, humans repeatedly make substitute behavioral offers that ultimately lead society to a certain convergence (equilibrium). In other words, the function of the “invisible hand” is supported through the medium of empathy. This idea is consistent with the emphasis that Adam Smith placed on “sympathy.” Such convergence is not achieved, however, simply through systems within the brain, but rather operates in conjunction with institutional factors, typically the shapes of demand and supply functions in the market.

Our experiment revealed that the degree of activity in the left supramarginal gyrus in people engaged in a repetitive ultimatum game correlates positively with the degree to which they expand their scope for compromise in line with the resistance of the counterparty to the negotiation. Interpretations of this finding may vary, but Inui asserts that the left supramarginal gyrus is partly responsible for the “like-me” system in the brain. Moreover, medical journals identify the left supramarginal gyrus as a key to accumulating visual data and converting it into actions. In light of these insights, the results of our experiment may show that our brains use the “like-me” system (mirror neurons) to visually confirm the negotiating ability of the counterparty, and if the counterparty shows a large degree of resistance, come to the conclusion through the identification process that the counterparty is troublesome and proceed to make major compromises. This is similar to the process of market price formation in which participants make compromises with suppliers unwilling to give large discounts, or with consumers unwilling to pay large sums of money. It is also conceivably applicable to the process by which a minimum set of moral standards is established within society.

Finally, I must describe the relationship between accounting and the concept of the market based on the interpretation of the invisible hand mentioned in the introduction. It is usually interpreted that the function of accounting information is to provide useful information that contributes to the rational decision-making with market participants, based on orthodox price theory. However, in the price formation process based on experimental accounting examined in the paper (Bosch-Domenech and Sunder, 2000) and in our paper, assuming the trial-and-error negotiation process based on the shape of the supply and demand functions and the budget feeling (profit and loss account), the function of providing budget constraint information to market participants can be understood that the function of simply providing the amount difference information

based on the balance calculation difference is important. This is related to the function of double-entry bookkeeping.

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