Individual Unite!
Generating Synergistic Understanding Through Online Prediction Markets

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Abstract

Synergistic understanding is a pre-existing self-organizing phenomenon of social evolution that has the power to generate knowledge to collectively identify and solve problems. Through the networking capabilities of the Internet, online prediction markets can harness synergistic understanding to gather information that would otherwise be lost. The isolated participants in these markets can, through accessing and using information contained within the system, collectively create new knowledge without premeditation. The system these markets create is based upon ten possible components that facilitate synergistic understanding. These components should be analyzed to determine their role in generating accurate predictions.

This paper outlines the theoretical framework for Individuals Unite! (IU!), a collection of online prediction markets open to the public and built upon the ten possible components necessary to produce synergistic understanding and thus accurate predictions. IU! presents a possible solution to a multi-disciplinary range of problems that has the potential to benefit individuals, organizations, and society as a whole. IU! is a worthwhile undertaking for the Symbiotic Intelligence Project of Los Alamos National Laboratory to pursue because it closely aligns with the projects stated goals.

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Chapter 1

Overview: The Goals of Symbiotic Intelligence and IU!

> *There are no more promising or important targets for basic scientific research than understanding how human minds, with and without the help of computers, solve problems and make decisions effectively, and improving our problem-solving and decision-making capabilities . . . The progress already achieved holds forth the promise of exciting new advances that will contribute substantially to our nation's capacity for dealing intelligently with the range of issues, large and small, that confront us. (Herbert A. Simon, 1986)*

It is generally acknowledged that while computers are capable of amazing feats of computation, the likes of which no human could possibly match, the smartest computers are no match for an average human being's analytical ability. Humans, as "the ultimate problem-solvers", are unmatched natural synthesizers of information from the environment (N. L. Johnson, 1999c, par. 3). Honed with millennia of evolutionary force, humans have become powerful and effective predictors.

The effective combination of the two complimentary components of problem solving, that of the computer and that of humans, is the area of interest for the Symbiotic Intelligence Project. The aim of the Symbiotic Intelligence Project is as follows:

> The goal is to analyze and facilitate how people, in the process of accessing and using information on networks, create new knowledge without premeditation. We argue that the symbiotic combination of humans and smart networks will result in a previously unrealized capability of collective problem identification and solution. This capability is based on the pre-existing self-organizing dynamics of social evolution. This symbiotic intelligence will greatly increase the success of organizations

> in achieving their goals, better utilizing their resources and preparing for the future. For the human society as a whole, this new resource will improve our quality of life and vitality as a species. (N. L. Johnson, 2003, par. 1)

The Symbiotic Intelligence Project focuses on three primary questions: "1. Can groups of independent individuals solve hard problems? 2. Under what conditions does the collective advantage occur? 3. What degrades it?" (N. L. Johnson, 1999c, par. 10). The IU! markets address these three questions. Synergistic understanding anecdotes strongly suggest that large groups of people working individually contain a wisdom that is not found in the solitary person and that this wisdom can be applied to and in fact only works well on hard problems. IU! is founded on ten components that structure the conditions under which synergistic understanding will occur and without which predictions may be wildly inaccurate.

The IU! is a tool by which to reach three multi-disciplinary sub goals under that of symbiotic intelligence.

Goal One Develop a tool to answer prediction questions

Solution Synergistic understanding

Goal Two Collect information that would have otherwise been lost

Solution Use smart networks in the form of online markets to generate synergistic understanding

Goal Three Develop conditions that reliably generate synergistic understanding in decentralized networks

Solution Systematically analyze the ten components of IU! to determine their role in the accuracy of prediction results

The following three sections provide an overview of each goal and its suggested solution.

1.1 Synergistic Understanding

As stated, one of the primary goals of symbiotic intelligence is to investigate whether groups of independently working individuals can solve hard

problems. Synergistic understanding is one manner in which independent individuals can solve hard problems, specifically problems of prediction. It can be developed as a tool, like statistical surveys, to answer prediction questions.

Questions about the future abound. Who will be the next president of the United States? Will the stock market close up or down? When will NASA send the next person into space? Will the 2005 Ford Mustang outsell the 2004 model? How much will the next Pixar film make at the box-office? Will the flu season be worse than last year? While we cannot definitively answer prediction questions such as these before they occur, the accurate forecasting of these questions is advantageous for purposes of planning, investing, and influencing the future. Therefore, methods that consistently provide accurate predictions are invaluable to individuals, businesses, and society as a whole.

Prediction is a process of knowledge generation. From a multitude of facts, new inferences can be made. For example, from information about air temperature, humidity, and barometric pressure the weather can be forecasted. This synthesis of information is the process behind knowledge generation and thus prediction.

The process of knowledge generation can be very powerful when done by a large group of people. A group adds knowledge, skills, suggestions, experiences, and problem-solving methods one person alone may not have. It is through the interaction of individually held information that new knowledge is created. Two new pieces of information add not only that specific knowledge, but also any inferences between the other information that can be made. Even the same information from two different people generates knowledge by adding weight to the possibility that the information is accurate and important. If each member of a group adds information, then the larger the group, the more information available.

James Surowiecki in his book *The Wisdom of Crowds* demonstrates the potential resource that the masses could become if properly harnessed. He explains, “Groups are remarkably intelligent, and are often smarter than the smartest people in them” (Surowiecki, 2004, xiii). However, crowds can be unwieldy, contentious, hierarchical or completely unorganized, volatile, and indecisive. The dynamics of large groups have a tendency to inhibit the expression of its full range of knowledge. Therefore, in order to reach its potential for knowledge generation and problem solving, a group should be thought of as a tool that must be utilized correctly.

The science of statistics encompasses the traditional methods of knowl-

edge generation from groups of people. Surveys, such as questionnaires and polls, are the most common manner in which we rely on groups of people for knowledge generation. A survey refers to any method that uses a well-defined population contributing in isolation to answer a question. Surveys require an organizing central body to define and seek the population as well as aggregate the data. They are statistically sound predicting tools; however, their accuracy depends on determining and questioning an appropriate and representative sample of the population.

Not all groups are good knowledge generators. At the extreme, mobs are inefficient and dangerous arrangements to convey the knowledge of all their members. Even many small teams fail to utilize all of the knowledge of their members due to the group dynamics. Social identity plays a major role in group interactions. While diverse perspectives are an important attribute of effective groups, individuals may feel too distinctive and alter their behavior in order to assimilate (Hogg & Abrams, 2003, 414). Social norms pressure individuals to behave as expected (Worchel, 2003, 487). Further, pressures in small groups to reach consensus can lead individuals to seek conformity over accurate answers (Martin & Hewstone, 2003, 348). Gustave Le Bon, the nineteenth century sociologist and cynic of group decisions, called these phenomena a "contagion" that has the effect of altering the "individuals emotions or thoughts as a result of becoming submerged in the crowd" (Worchel, 2003, 488). Surveys eliminate group dynamics by asking individuals their opinion in isolation. However, individuals are still subject to conformity pressure based on the wording of the surveys. Furthermore, surveys depend on determining and questioning an appropriate population. For a survey to generalize to a wider population than those questioned, the sample must be carefully selected.

There is another method to generate knowledge from groups of people that also avoids the pitfall of group dynamics. This phenomenon, referred to here as synergistic understanding, could be developed as a tool to more effectively harness Surowiecki's wisdom of crowds. Most simply, synergistic understanding is the generation of knowledge through the aggregation of individual guesses on particular questions from a decentralized, self-selecting population. The synergism of the collective creates an effect that is greater than the sum of the individual contribution — an accurate prediction. Synergistic understanding avoids the ineffective group dynamics of teamwork. Synergistic understanding avoids hierarchical structures and captures the information that is often lost to bureaucracy, social norms, and fear of judgment. Further, synergistic understanding eliminates the need for a carefully chosen sample population on which the success of surveys is dependent. The phenomenon does not need the best crowd possible to produce results that rival or exceed the predictions of surveys, merely a decent crowd. Table 1.1 summarizes

the major differences between teamwork, surveys, and synergistic understanding in terms of the manner in which they generate knowledge. Whereas teamwork relies on experts and surveys rely on representative samples, synergistic understanding relies on the emergent knowledge of the general masses.

	Teamwork	**Surveys**	**Synergistic Understanding**
Organization	hierarchical	centralized	decentralized
Population Determinants	specific individuals	specific individuals sought	self-selecting
Decision Style	group decisions	individual decisions	individual decisions
Mechanism	experts	representative sample	emergent knowledge
Population Size	best with small groups	requires large population	requires large population

Table 1.1: Methods of knowledge generation from groups

Synergistic understanding offers an alternative to other methods of knowledge generation from crowds that could be both more efficient and more effective if implemented correctly. All methods have different advantages so they cover a wide range of prediction needs; therefore, this phenomenon is not a replacement for, but an alternative to teamwork and surveys. Synergistic understanding has become a particularly feasible alternative due to the spread of the Internet, which allows for easy network forming of decentralized groups.

1.2 Smart Networks and Online Prediction Markets

Many surveys are conducted today via telephone. However, with the prevalence of telemarketers and ever-advancing technology, this technique is becoming a less viable manner in which to contact a representative sample of people living in the United States. Many people refuse to speak to those conducting surveys, mistaking them for telemarketers. With answering machines and caller ID, fewer people are answering their phones. And with unlisted numbers and cellular phones the number

of people who can be reached through the lists of residential numbers that national pollsters such as the Gallup Organization regularly use is greatly diminished. Sampling surveys regularly require five calls to the same number to reach a live person and in New York City the average is twelve attempts (Moore, 2001, 60). The inability to reach those chosen for a survey can lead to error in its results.

While originally the prevalence of telephones in homes led to an unprecedented ability for pollsters to contact the general population, the Internet today is a remarkable resource for connecting the population in a network for synergistic understanding. The Internet should be utilized as a tool to network individuals and generate knowledge.

With the advent of the Internet have come numerous services that easily generate or utilize information that would have otherwise been lost or required a prohibitive amount of effort to compile. Amazon.com's recommendations lists are one such often-touted example (N. L. Johnson, 2003, par. 6). These lists of items in which a user may be interested is compiled automatically based on the purchases already made and what other users who have purchased this book have also purchased. Humans are not involved in their creation. The efficacy of these lists show that human interaction within networks are not random and that by compiling certain types of information (such as purchases made) and comparing with other users, useful generalizations can be captured without any intention on the users' parts.

Similarly, Google's revolutionary fast and useful search engine uses the information containing power of the Internet network to scan over 8 billion web pages quickly. The system by which the network finds the best site is an algorithm called PageRank. The technique is described in the 1998 paper co-authored by the founders of Google as follows:

> PageRank capitalizes on the uniquely democratic characteristic of the web by using its vast link structure as an organizational tool. In essence, Google interprets a link from page A to page B as a vote, by page A, for page B. Google assesses a page's importance by the votes it receives. But Google looks at more than sheer volume of votes, or links; it also analyzes the page that casts the vote. Votes cast by pages that are themselves "important" weigh more heavily and help to make other pages "important." (qtd. in Surowiecki, 2004, 16)

Those who make links are unaware that their actions are adding to the knowledge of relevant sites. They are generating knowledge without premeditation simply through their individually motivated actions. When these actions are taking place within a sufficiently smart network, the

amount of truly useful knowledge that can be generated is staggering as in evidence by Google.

Computers are ideally suited to the computation of vast amounts of data in the manner necessary to support such seemingly personalized information as found with Amazon and Google. The Internet is becoming more closely tied to the people who use it and is better able to serve them. The Global Brain Workshop in Brussels, Belgium was a 2001 conference to discuss this merging of people and networks to produce a new level of organization and new possibilities for problem solving. They note:

> A general trend is that the information network becomes ever more global, more encompassing, more tightly linked to the individuals and groups that use it, and more intelligent in the way it supports them. The web doesn't just passively provide information, it now also actively alerts and guides people to the best options for them personally. To support this, the web increasingly builds on the knowledge and intelligence of all its users and information providers collectively, thanks to technologies such as collaborative filtering, agents, and online markets. It appears as though the net is turning into a collective nervous system for humanity: a global brain. ("Global Brain", 2001, par. 3)

Online markets are of particular value to the harnessing of synergistic understanding. While the ease and ability to conduct surveys was revolutionized by the advent of the telephone in everyone's home, our ability to generate synergistic understanding will be dependent on our use of the Internet. Markets assimilate individual opinion defined by the purchasing and selling of contracts at varying prices through a single dynamic price variable. Markets are a decentralized synthesizer of information capable of handling a large population of participants. Online markets can be thought of as collectively intelligent networks.

1.3 Individuals Unite! and the Ten Components of Synergistic Understanding in a Market

The second and third goals of symbiotic intelligence, to understand the conditions in which a collective advantage emerges and what degrades this advantage, can be determined through a systematic analysis and comparison of predictions made through markets exploiting synergistic understanding with that of the actual result. Through the investigation

of specific components of the market, we can determine the elements necessary for the phenomenon to emerge.

It is important for the accuracy of predictions generated through synergistic understanding that we identify the parameters necessary for its emergence. One of the troubles with an emergent phenomenon such as synergistic understanding is that, by its very nature, it is likely that not one person who contributed to the solution believes the solution to be correct. Just as an average may not be a number in the set of data, the aggregation of opinion may not be one held by anyone in the population. Furthermore, the nature of a decentralized system demands that no one person understands the collective output. Kevin Kelly, in *Out of Control*, states that one of the concerns of a decentralized system is that we can't understand it (195). These two observations have the startling result that it is difficult to tell when a prediction created from the markets appropriately generated synergistic understanding and when it fails to do so. In other words, unless we determine the elements necessary and sufficient for the phenomenon to emerge, we will have no way to know when to trust a prediction.

There is not yet a systematic manner in which to develop synergistic understanding. Individuals Unite! is a hypothetical collection of online prediction markets open to the public that utilize the power of symbiotic intelligence specifically through the networking capability of the Internet to instantiate a mechanism to foster and record synergistic understanding. The purpose of these decentralized markets is to investigate the components necessary to facilitate the emergence of synergistic understanding within a decentralized system. Synergistic understanding differs immensely in form from a survey where there is confidence in results relative to the amount of control exerted over the selection of the population. Instead, there is confidence in the results of the IU! markets based on the coherence of the parameters of the actual population, problem, and market organization to those that are ideal for the generation of synergistic understanding.

The following are the ten components upon which the IU! markets are based:

Population

- Individual Choices: those participating in the market by buying and selling stock must make their decisions independently
- Reasonably Intelligent Population: the participants must have a minimum basis of knowledge in the specific market question

- Diversity: the participants must represent unique qualities or a degree of unique knowledge relative to each other
- Common Worldview: diversity must take place within a set of possible differences shared by all participants
- Population Size: the markets require a sizable population

Problem Characteristics

- Complex Problem: the problem must be of sufficient complexity that one person could not solve it
- Question Requirements: the actual market question must be of a certain type, form, and degree of specificity

Organizational Characteristics

- Decentralization: the system must allow bottom-up informational flow
- Disincentives: the system must incorporate disincentives that encourage only people with a degree of knowledge on the problem to participate
- Aggregation: the system must aggregate participant's choices so that a collective judgment can emerge

The first step in the formation of IU! as a reliable predictor is to determine the parameters necessary and sufficient to generate synergistic understanding. The ten components represent a place to start looking for these parameters. The next step is to evaluate the likely accuracy of each prediction made by judging the coherence of the actual population, problem, and organization with the ideal parameters. Those that are within an acceptable range will produce synergistic understanding and thus accurate predictions. The ten components will be discussed in greater detail in the following section.

Chapter 2

Background

IU! is theoretically grounded in the concept of synergistic understanding, the capabilities of online markets, and the components sufficient to harmoniously combine the two. The following three sections describe in detail these elements of IU!

2.1 Synergistic Understanding: Mechanism and Background

2.1.1 The Mechanism

Synergistic understanding emerges through the aggregating of individual's estimates. People are natural, if flawed, synthesizers of information. By aggregating many of these opinions, the effects of the flaws are minimized and a more accurate answer results. In other words, in complex problems no one individual knows the answer, even though the group as a whole does.

In order to understand the phenomenon of synergistic understanding, consider the jellybean contest conducted at the student center at Kalamazoo College. The contest was open to everyone, cost nothing, and was simple to enter. The jar full of jellybeans was present and could be handled. The jar contained, unbeknownst to the contestants, 3,432 jellybeans. The person whose guess was closest to this number won the jar of jellybeans. In jellybean contests, contestants individually submit their guesses. The contestants have a wide range of incentives (jellybeans are their favorite candy) and expertise (won three previous contests or Jelly Belly employee). They also have diverse means to come up with an answer. Some may count as many as they can and compare that to the volume of the jar. Some may count the average number in a bag of jellybeans and choose some multiple of that. Some may consult their horo-

scope. And those less motivated will just idly write down a number.

The winner of the contest guessed only fifteen jellybeans over the actual number. This is an amazingly close guess out of only 310 total readable guesses in the whole contest. However, after accounting for clearly poor guesses, those under 785 (that number of jellybeans could be counted in the jar) and one guess of 500,001, and deleting the multiple guesses of those who violated the rules and guessed more than once, we can see that synergistic understanding has emerged. The average guess of these participants (a population of 262) was 3421.027, a deviation from the actual number of only 10.97. The data is summarized in Table 2.1. Simply by averaging all of the participant's guesses, the *whole group* outperformed even the winning participant.

Participants	**Guess**	**Deviation**
Winner	3447	15
Synergistic Understanding	Average 3421.027	10.97

Table 2.1: Participant's Guesses

Notice that not one person in the group believed that 3,421 was the correct answer. The participants are not dependent on experts to weight the average. This is a truly emergent phenomenon based on the principle that in a large enough crowd about the same number of people or the same deviation will be guessed over as under the actual amount. The individual human beings are not accurate guessers, but the meta-guesser created by their collective judgment hovers around the correct answer.

2.1.2 Background

Humans excel, in comparison with computers, at solving ill-defined problems — those that have complex goals, multiple solutions, or a changing nature. These complex problems require the application of knowledge, intuition, diagnosis, and analysis. Humans are amazing synthesizers of information from the environment. There is evolutionary force behind our powerful cognitive processes. We are learning and adapting machines. We have a highly developed cognitive capacity for reasoning, analysis, and problem solving. These skills have developed to allow us to accurately predict and prepare for both short-term and long-term future events.

Not only are humans individually powerful problem-solvers, we contribute to problem solving at another level, that of society. Humans are strongly influenced by social interaction. It is often noted in sociology and philosophy that it is hard to detect when an individual ends and society begins in terms of influences on behavior. This characteristic of the species has created another form of "intelligence" — that of society. Society is a higher level of organization in which we all participate. No one person is in control, although we all can effect and are affected by it. The problems that society handles are of a complex nature that one person is not able to manage.

Society can be thought of as a meta-individual that possesses, generates, and acts on knowledge in much the same way a human does. Society is an organizational structure much like that of an ant colony. Ant colonies possess knowledge through time, despite changing membership as ants die and are born. While ants live relatively short lives, colonies can continue transmitting information for about fifteen years, even though not a single ant lives much more than a year and many die after only one day of life (S. Johnson, 2002, 81). The colony maintains a state of autopoieis or continuity in identity despite changes in its parts (Lucas, 2004, par. 11). Societies are also autopoietic allowing us to think of them as meta-individuals.

The Symbiotic Intelligence Project is interested in collective problem solving based on the pre-existing self-organizing dynamics of social evolution (N. L. Johnson, 2003, par. 1). Synergistic understanding is one such pre-existing phenomenon that emerges from the aggregation of individual's opinions. Synergistic understanding refers to the knowledge held by a group of individuals that acts on the meta-level. This group-based knowledge can be considered a "super-informed" individual (N. L. Johnson, 2000, 7). Figure 2.1 shows how a diversity of knowledge from the environment is synthesized by individual problem-solvers whose collective decisions form a meta-individual capable of solving the problem at a level of understanding not possessed by any single individual. This process is the emergence of synergistic understanding. The root of this term, synergism, is the "interaction of elements that when combined produce a total effect that is greater than the sum of the individual contributions" ("Synergism", 2002). As in human societies, synergistic understanding is an autopoietic phenomenon, one that remains despite changes in the individuals contributing.

The phenomenon of synergistic understanding is, for the most part, a currently wasted potential of human problem-solving capabilities. There is no systematic method for the harnessing of this power. The belief in this ability within a large group of people is contained entirely within

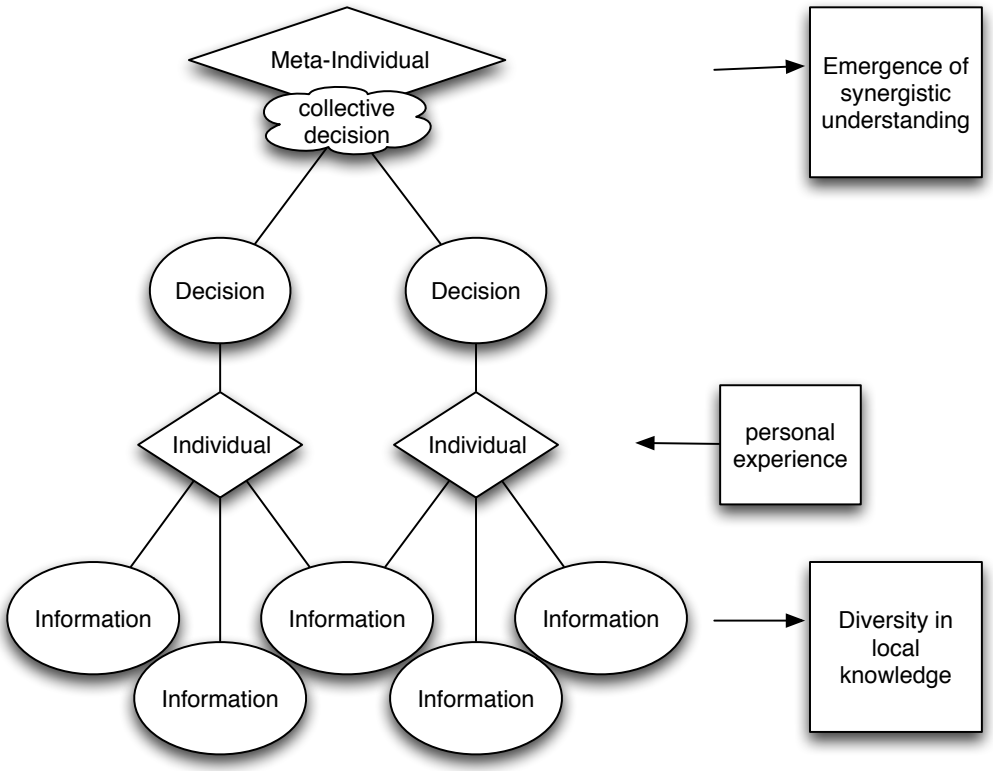

Figure 2.1: Emergence of synergistic understanding

anecdotal evidence such as the jellybean experiment. Surowiecki's book on this quasi-mythical phenomenon he calls the "wisdom of crowds" is full of such anecdotes without providing a detailed method for the extraction of this power. He, instead, amorphously refers to the need for "diversity, independence, and a particular kind of decentralization" (Surowiecki, 2004, xviii).

In the following section, online prediction markets will be offered as a prime method to harness this phenomenon so that it may be efficiently used to generate trustworthy predictions. Synergistic understanding is a noted phenomenon across disciplines, but is one that has not been systematically studied to determine the conditions through which it will emerge and for what purposes it fulfills a role. IU! is a method by which we could study the generation and application of synergistic understanding so that this dynamic of social evolution moves from anecdotal to experimental evidence.

2.2 Why Markets?

IU! is a collection of online prediction markets that will combine the networking power of the Internet with the problem solving capabilities of a collective. A prediction market is one that uses the "information content in market values to make predictions about specific future events" (Berg, Nelson, & Reitz, 2003, par. 1). Prediction markets are an ideal method in which to elicit synergistic understanding because they are decentralized to handle complex problems. Markets are able to handle more complexity than an individual or centralized body could grasp because "knowledge that is implicit, dispersed, and inaccessible by traditional, conscious methods can be organized through markets to create more rational calculation than can elite experts" (Marcus, 2004, par. 11).

The participants in the IU! markets are self-selected, in other words, the population selects itself through individuals' decisions to participate. This method of organization is, at this level, non-competitive; the population will not include only the best guessers. However, between individuals, markets are quite competitive. The markets stress an individual's own self-interest, i.e. each participant is attempting to make money by out-predicting the others. It is from this competitive drive that markets derive their power for prediction. The political economist B. K. Marcus writes, "The power of the market lies in its ability to harness the power of self-interest" (2004, par. 43). Quoting the economist Adam Smith he continues to describe a market participant saying, "... 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 ... By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it" (Marcus, 2004, par. 43). Participants in the markets are contributing to an understanding of a problem much larger than their local awareness allows (N. L. Johnson, 1999c, par. 2). Participants are vying for monetary gain and recognition, while the markets are generating accurate predictions.

A centralized view of market efficiency is traditionally assumed. Here, marginal investors (those most informed) set prices by influencing and guiding the other investors. However, "aggregate market behavior will imitate individual investment behavior only if the total equals the sum of the parts" (Mauboussin, 1998, 2). But markets involve far too complex interactions between individuals for the whole to be merely the sum of the parts. The market has properties unique from those of the individuals that comprise it.

Decentralization, another view of market efficiency, is illustrated by Adam Smith's invisible hand. The invisible hand process requires two

components. First, the outcome must occur with "no explicit agreements between the acting agents" (Joyce, 2001, par. 5). This is another way of saying the system is decentralized and there are no leaders. Second, the outcome is not intentional. In other words, the actions of the agents are not coordinated to produce the actual outcome. The process is invisible because it works even if none of the agents are aware of its existence (Joyce, 2001, par. 5). The outcome of market efficiency satisfies both of these components.

Just as synergistic understanding is independent of the accuracy of individuals' guesses, market efficiency exists even without rational investors. Because markets utilize a similar degree of organization as synergistic understanding to elicit intelligent behavior from irrational individuals, a market is an ideal tool to generate the phenomenon.

IU! is not the first to use markets to harness the power of prediction found in crowds. There are numerous other sites that are watched with interest as their prediction rates of accuracy outdo those of polls or experts and often come startlingly close to the truth. However, these prediction markets are not grounded in the principles of synergistic understanding and fail to incorporate the ten components deemed sufficient for eliciting the phenomenon in markets. We are interested in showing that a foundation in these components will lead to even more accurate and more reliable results. A more detailed analysis of some of the popular prediction markets already available and their critiques will follow after a detailed explanation of the ten components necessary to produce synergistic understanding in markets.

2.3 Ten Components of Synergistic Understanding in Markets

Synergistic understanding is, in fact, a distinct emergent phenomenon that, like other emergent phenomena, will only develop if the proper parameters are present. The purpose of these ten proposed components is to identify the parameters necessary to enable synergistic understanding. These components comprise a theory of the necessary and sufficient conditions to generate synergistic understanding, which can be tested in the format of the IU! markets.

The ten conditions are divided among three classifications — the population, the problem, and the organizational characteristics. The population, those participating in the market by buying and selling stock, must make their decisions independently. They must have a certain minimum

of intelligence in the specific market question. They also must represent diverse knowledge relative to each other, while still belonging to a common worldview. Finally, IU! requires a sizable population. It is also important for the emergence of synergistic understanding that the questions and problems that the market uses are of sufficient complexity and of a certain type, form, and degree of specificity. The organization of the information-gathering body must also conform to certain specifications. The systems must be decentralized to allow bottom-up informational flow. Furthermore, the body must offer disincentives that encourage the population to have a degree of knowledge on the issue. The body's most important role is the proper aggregation of the collected information so that an accurate answer can emerge. The following sections are detailed explanations of the conditions necessary to generate knowledge from the opinions of a group.

2.3.1 Population Characteristics

Individual Choices.

In 1984, Robert Axelrod in his book *The Evolution of Cooperation* explained the phenomenon in which cooperation, instead of defection, is mutually advantageous to those participating. His work was based on a situation from game theory called the Prisoner's Dilemma. The best strategy for the game, called TIT FOR TAT, fostered cooperation when run through many iterations. Axelrod was suggesting that it is actually more advantageous to the individual to cooperate than it is to make immediately self-serving decisions. His work applied to conflict resolutions and deals in politics and business, as well as to the evolution and structure of societies. Axelrod showed that in certain situations, cooperation is the best way to go.

However, the emergence of synergistic understanding is not one of those systems that benefits from cooperation. In fact, it is fundamental to the proper operation of IU! and for the emergence of synergistic understanding, that participants in the markets make independent choices. This is because IU! is fundamentally different from many conventional information-gathering systems. Synergistic understanding offers the advantage of working in the average crowd without the need for random selection, demographic balancing, compatible personalities, or expert identification; however, it requires the population to be autonomously acting agents embedded within an information-rich environment. By requiring independent and anonymous choices, IU! avoids many of the errors in judgment that occur when people deliberate in a group.

Humans are limited in their capacity to process all available information. It stands to reason that if one person is good at solving a particular problem with their limited information, a group would be even better. However, this is true only under certain conditions. Often when working in a group, solutions will not improve. This is particularly apparent in mobs, where violence is common. In mobs, people feel deindividuated and no longer accountable for their actions (Wade & Tavris, 2002, 311). These feelings are often responsible for riots and gangs committing hate crimes (Wade & Tavris, 2002, 312). However, the phenomenon remains even in more sedate situations where groupthink can move a team away from a good answer. Groupthink refers to the process through which each member of the group shifts their opinion to the perceived consensus of the group (Wade & Tavris, 2002, 309). IU! avoids these interactive conditions that lead to group foundering while maximizing the power that groups of people, as amazing information synthesizers, possess. An essential component to this maximization is that participants maintain their individuality by making independent decisions.

IU! is collecting information in a different way from most informational systems; we are not looking for consensus. In the aggregating of knowledge, the IU! does not treat participants as thoughtful, cooperating, and communicative entities responsible for making an accurate decision, but as simply one bit of information, a node. The market is not encouraging participants to agree with each other and present one final decision. Instead, IU! wants to know the decision made after one, independently acting individual reconciles his or her own thoughts on the matter using the available local information.

People are most certainly embedded in a complex network of information collecting, sharing, and generating and it is this embeddedness that makes for a good problem-solver. However, in the end, IU! requires that individuals make their own decisions to avoid the errors in judgment that occur through the poor aggregating techniques found everywhere from mobs to boardrooms.

Further, IU! will ask questions on issues that may be sensitive or personal. It is essential to getting accurate information that those participating feel that they can express their beliefs in anonymity and without feeling influence from others. IU! will limit communication between participants in multiple ways. First, participants will use screen names to identify themselves and there will be no association available publicly between the screen names and actual people. This will allow participants to remain anonymous. Second, the website will not support the use of participant discussions about the polls; we will provide no web log site. This will reduce communication to a great extent. Third, because IU!

is available throughout the world, running into and identifying specific users (known only through a screen name) will be unlikely. Fourth, it will be explicitly expressed as against the rules to discuss opinions between participants or work together, and those found to be in violation of this rule will have their account terminated permanently and will not receive the payout of their account balance.

As globalization increases our personal connectivity, IU! offers the opportunity to not only put the information we detect naturally and easily through our thorough embeddedness to good financial use, it also allows participants to act entirely independently in an increasingly intertwined world.

Reasonably intelligent crowd.

IU! is founded on the belief that people are not flawless decision makers. We are not entirely rational beings. Humans are limited by what the computer scientist and philosopher Herbert Simon called "bounded rationality." As he stated it, people "experience limits in formulating and solving complex problems and in processing (receiving, storing, retrieving, transmitting) information" (qtd. in Williamson, 1981, 553). A human being is a good, but not ideal, complex problem-solver. Synergistic understanding utilizes a better one, namely the unit of voting participants. Individuals are lacking pertinent information, and we can assume that different people are missing different bits of relevant information. Therefore, a collection of these people will have more knowledge than any one single person, even the most intelligent.

When in the context of a particular question or problem, it is very difficult to ascertain who is the most intelligent person on the subject, defined as the person most capable of solving a particular problem. The most intelligent person could be considered the one with the highest IQ. In other situations, the most intelligent may be an expert in the field with the most years of experience. However, it is sometimes the fresh perspective that is most useful because those not versed in the typical ways of solving a problem may be the most capable of coming up with workable, innovative solutions. So how can we ascertain who is the most intelligent? Synergistic understanding bypasses the need to find the most intelligent person and instead utilizes a large group of those merely qualified. There is no need to test, rank the best, and rely on the opinion of one or a select few.

Even though IU! is not searching for the most intelligent in a crowd to answer questions, it is important that the participants base their opin-

ions on something more than just idle guessing. Participants must possess a degree of knowledge. This degree is not quantified by the IU! system. Instead, participants self-select based on the discouraging nature of the financial disincentive for poor (uninformed) choices. Only those reasonably confident, or at least not idly guessing, will play with real money at stake. The markets leave the information upon which participants base their opinions (e.g. personal source, intuition, tarot cards) to the individuals. It is the self-selection to participate in real money markets that ensures a reasonably intelligent crowd.

The use of a reasonably intelligent crowd as the agents of the IU! system is similar to the evolutionary process referred to as "survival of the adequate" (N. L. Johnson, 1999b, par. 3). One manner in which we typically solve complex problems is to convene a group of people with experience and knowledge in a subject and allow them to develop a solution together. However, much is dependent on finding the appropriate people to compose this committee and on creating an environment in which they feel they can express what they truly believe. Synergistic understanding avoids the identification of those experienced and knowledgeable in favor of those merely adequate. This non-competitive population selection in which only the worst candidates are discarded has its precedence in nature. A weak form of natural selection works not by choosing the fittest to survive, but by eliminating those that are clearly not good solutions (Kelly, 1994, 373). In essence, mother nature is choosing not to identify the best adaptive solution but to keep all the merely good solutions. The best solution "arises as a selection by the system dynamics from a diversity of potential solutions" (N. L. Johnson, 1999c, par. 5). A reasonably intelligent crowd embodies a diversity of potential solutions. The "survival of the adequate" strategy is supportive of a robust system because it encourages diversity by limiting the competition between agents to be in the population.

Diversity.

For IU! to generate accurate knowledge, the population must be diverse. Diversity is a relative term, and like degree of intelligence, its type and extent are not explicitly quantified. The market requires that the population is of the type of diversity that leads to different decision-making information and approaches. The creation of a diverse population of participants is left to the general appeal of the Internet to a demographically spanning set of users and the inherent variability in any large group of people.

IU! encourages diversity through its accessibility via the Internet com-

bined with the non-competitive self-selecting mechanism of the incentives. Although the Internet is not universally available, it is an efficient way to reach a wide range of people. It is not important that all races, nationalities, education and income levels are represented, as long as that does not hinder the influx of unique knowledge and its interpretation.

Diversity is the fundamental mechanism behind the emergence of synergistic understanding. Diversity "provides the basis for an explanation of why collective effort by a group can often outperform an individual: by virtue of being different, individuals can improve upon each other's solutions to a problem" (Hong & Page, 1998, 2). By utilizing a population that represents different pieces of information, we are able to gain a better whole picture, which is necessary for accurate predictions. Diverse agents have different local knowledge or different problem-solving approaches.

To understand how diversity in local knowledge can generate new knowledge, consider the following model. Suppose that nine participants have knowledge in only three categories. The answer to a particular question, such as "Will Jay be class president?", will be dependent only on the number of ones compared to the number of zeros in the 11 relevant categories. The ones represent a universally accepted desirable trait in a class president and the zeroes, a universally undesirable trait. The participants' guesses and collective decision is summarized in Table 2.2.

	0	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**Outcome**
Adam	0	0	0									**0**
Bob		0	0	1								**0**
Cam			0	1	1							**1**
Dan				1	1	0						**1**
Evan					1	0	1					**1**
Fred						0	1	0				**0**
George							1	0	1			**1**
Harry								0	1	1		**1**
Ivan									1	1	1	**1**
DECISION												***1***

Table 2.2: Local knowledge generates new knowledge

These nine participants are diverse in the local knowledge they possess, while being homogenous in terms of how they interpret each column. Each considers the three categories of which they have information

	0	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**Outcome**
Adam	0	0	0									**0**
Bob		0	0	1								**0**
Cam			0	1	1							**0**
Dan				1	1	0						**1**
Evan					1	0	1					**1**
Fred						0	1	0				**0**
George							1	0	1			**1**
Harry								0	1	1		**1**
Ivan									1	1	1	**1**
DECISION												***1***

Table 2.3: Different approaches generate new knowledge

and simply choose the majority (ones or zeros) for their outcome. Adam knows nothing about the information that Harry has and vice versa. No one has enough information to be able simply to count the number of ones and zeroes. However, when their judgments are aggregated, their collective decision accurately reflected Jay's presidential status. If everyone were like Adam and Bob, party to only the information in the first four categories, the entire group would incorrectly, and overwhelmingly declare the wrong outcome. They would see more zeroes and consider Jay a poor choice when in actuality Jay has more desirable traits than undesirable ones. Also notice that three of the nine participants voted incorrectly and that five of the nine people were only 66% sure. This demonstrates that even inaccurate diverse opinions helpfully contribute to the generation of synergistic understanding.

Diversity in approaches to problem solving is as important as diversity in local knowledge. Imagine that Adam, Bob, and Cam use the approach that they rely exclusively on their first impressions, defined in Table 2.3 as the leftmost column in their local knowledge. Dan, Evan, and Fred rely on the synthesis of information they have gathered, or the average of their three columns as in Table 2.2. Finally, George, Harry, and Ivan rely on their latest bit of information, or the rightmost column in their local knowledge. Compare the outcomes of Table 2.2 and Table 2.3. The decision is still the same; however, students contributed different answers to the collective. Through their work on collective intelligence in computer simulations, Lu Hong and Scott Page have shown that both diversity in local knowledge and in problem-solving approaches are sufficient for a collective to solve complex problems (1998, 4).

With all the ways that people can differ in opinion, it seems as if people would rarely express similar beliefs at all. However, it is expressly through the influence of others that opinion can become consensus. This is why it is necessary to have both an originally diverse population, and one that remains independent from the influence of others.

Common worldview.

Of course, diversity is a context dependent term. Although the members of IU! must be different from each other, the participants must be relatively similar to the population at large in which the market questions are situated. For example, you cannot ask a population of people who cannot conceptualize the value of material goods to predict the most popular sports utility vehicle model in 2006. The population must be internally diverse, but share a common worldview, and one that incorporates the spirit of the market questions. In other words, in order for diversity to be of any value, the unique contributions ought to be "potentially coupled by the system dynamics" (N. L. Johnson, 1999a, par. 11).

Population size.

The conditions for creating synergistic understanding are not quantifiable amounts. Instead, there are certain specifications that must more or less be met in combination with the other components of synergistic understanding. It is therefore difficult to determine precise population sizes. The Iowa Electronic Markets, a collection of online political markets, has outperformed national polls in predicting election outcomes in 9 out of 15 comparisons (Berg, Forsythe, Nelson, & Reitz, 2002, 4). These markets operated using only between 12 to 500 participants. In shortest path simulations for autonomous agents in a maze, a Los Alamos National Laboratory study used large populations of 100 to 2000 agents (N. L. Johnson, 1998, 5). IU! hopes to attract a population size even larger than the agent-based studies through better advertising than the Iowa Electronic Markets. A sizable population is important so that the effects of diversity are fully felt. The less diverse the participants or the more complex the problem, the larger the population required for the emergence of synergistic understanding (N. L. Johnson, 1999b, par. 29).

2.3.2 Problem Characteristics

Complex Problem.

IU! will contribute solutions to those inscrutable problems that will not yield to the diligent efforts of one brilliant problem-solver. The goal is to reveal through synergistic understanding what is not readily apparent to individuals. We are particularly interested in prediction questions, as they are, by their very nature, complex problems because they depend on a constellation of factors.

Question Requirements.

Any prediction market will only be accurate if the questions are of a certain type, format, and degree of specificity. Prediction questions about future events come in three types (Spann & Skiera, 2003, par. 11). A question may ask for an absolute number (On what date will 2005 Mustang sales surpass one million cars sold?). A question may ask for a relative number (Will the stock market close up or down today?). Or a question may ask about whether an event will take place (Will George W. Bush be re-elected president in 2004?).

There are two formats that synergistic understanding can develop useful and accurate answers for: polling and pure prediction. Polling refers to a question that asks the crowd what they want, as in political elections. Each member of the crowd has the ability to affect the election through voting. However, in answering the question for the market "Who will win this election?" an individual does not have to choose the candidate for whom they will vote. For instance, if some participants voted for Ralph Nader in the 2000 presidential election they may have predicted that Al Gore was going to win, knowing that while they were going to vote for Nader, most people would not. This example shows the harmful effect of influence on predicting; if everyone both predicted and voted and did so in the same way, the prediction would be perfect.

Anytime the individuals that do the predictions are also able to directly affect the outcome of the question itself, it is a poll. In the case of IU!, a political election is not necessarily a pure poll. Because IU! is online, anyone, even those not registered or eligible to vote (non-citizens for example), may still make a prediction. However, a poll is a special type of prediction that can cause problems in any prediction market. For example, if a market asks for the likelihood of a terrorist attack within a certain period of time, terrorists could participate in the market and skew results toward their plans. Pure prediction, on the other hand, is not directly affected by the individuals doing the predicting. The classic

jellybean contest presented earlier is one example, as long as the person who filled the jar is not guessing.

The stock market is both a poll and prediction. The stock market is a poll in that people who buy and sell stocks (thereby affecting whether the market moves up or down) are also able to answer the prediction question, "Will the market close up or down today?" However, it is generally assumed that the vastness of the market and most individuals' role in it is so miniscule that little is left up to individuals; therefore, the stock market is using pure prediction.

It is essential that the questions posed are highly specific so that participants are able to ascertain whether they are capable of offering a good guess and that all participants are answering with a common understanding of the spirit of the problem. The question must specify when the market will close, what constitutes a win, and the payout plan so that participants can make informed guesses.

2.3.3 Organizational Characteristics

Decentralization.

Decentralization refers to a property of a system where decisions "are made by individuals based on their own local and specific knowledge rather than by an omniscient or farseeing planner" (Surowiecki, 2004, 71). In the IU! markets, the population's individuals independently choose when and in what to participate. There are none but the most basic rules and no authority monitoring its use. A central command system, such as those that typically operate in government and organizations, is inflexible and unstable causing it to be slow to recognize the need for and initiate change (Kelly, 1994, 12). However, prediction markets need to move quickly in response to the whims of the trading participants. IU! combines three prime examples of decentralization — the Internet, free markets, and social dynamics — into a system that is ripe for the generation of synergistic understanding.

The Internet is an international, largely unregulated, decentralized network connecting computers and thus individuals. It is perhaps "the most visible decentralized system in the world" (Surowiecki, 2004, 70). The free market economy is often touted as a major success of decentralization. Markets have no centralized authority and are instead run by the forces of supply and demand. Adam Smith's "invisible hand" is a metaphor for decentralization. The term refers to "any individual action that has unplanned, unintended consequences, particularly those which

arise from actions not orchestrated by a central command and which have an observable, patterned effect on the community" (Joyce, 2001). In other words, self-interested individuals in a market produce global effects reflected in the prices of the stocks. Finally, social dynamics such as those that lead to the emergence of synergistic understanding are decentralized. The phenomenon is based on the assumption that "if you set a crowd of self-interested, independent people to work in a decentralized way on the same problem, instead of trying to direct their efforts from the top down, their collective solution is likely to be better than any other solution you could come up with" (Surowiecki, 2004, 70).

There is an important implication of decentralization that must be recognized for the IU! markets to thrive. Decentralized systems can be neither understood nor contacted (Kelly, 1994, 195). There is no person or group to turn to for answers or to place blame. As in the jellybean example, it is likely that not a single person believes an answer generated from synergistic understanding to be true. Decentralization works over the heads of every individual, so there is no way to "check the work" for possible mistakes. Instead, we must set the parameters sufficient for synergistic understanding and then trust the result.

Distributed intelligence in a decentralized system is an important way to solve problems and increase our knowledge because it produces answers to questions that are too complex for an individual or group to grasp. Individuals, teams, and organizations are not the only way to solve problems. Systems such as IU! make decentralization "feasible, profitable, and competitive" (Kelly, 1994, 191).

Incentives.

Only those who feel confident in their guesses should participate in the markets to ensure that IU! utilizes a reasonably intelligent crowd. In order to encourage participants to play only if they are reasonably assured of their decision, IU! offers financial incentives based on participants' performance. Incentives are positive or negative reinforcers that will encourage one to participate if they desire the reward or not to participate if the consequences are too great. The incentives and payoff must be such that they will attract those knowledgeable from many diverse spectrums to participate, and that they will discourage those who are idly guessing from participating.

Adding a financial incentive also encourages people to play for similar reasons. If participants are playing only to see the effect of their vote, their interpretations of information pertaining to the vote will be different

from someone who is trying to make money. Money is widely held as a motivator. Those who see it as such will be operating in a worldview similar enough to encourage synergistic understanding.

The IU! markets, unlike some other markets, are not a means to earn or supplement an income. In other online prediction markets, the best-performing participants never earned more than a few hundred dollars (Spann & Skiera, 2003, par. 27). As a further incentive, each market and IU! collective will be a rank-ordered tournament where those with the highest portfolio values will be posted on the site. Spann and Skiera indicate that in their empirical studies both forms of incentive lead to good prediction results (2003, par. 15).

Aggregation.

Synergistic understanding is based upon the assumption that in a large enough and diverse enough population and with the right type of question, there will be a balance of opinion sufficiently off the mark in both directions to average out to a good prediction. This is another instance of Adam Smith's invisible hand which "may be more powerful than some may have thought; it can generate aggregate rationality not only from individual rationality but from individual irrationality" (qtd. in Mauboussin, 1998, 3). This phenomenon was demonstrated in the jellybean contest experiment. The aggregation of the error-filled opinions submitted used the simple but extremely powerful tool of averaging to generate a rational result.

Aggregation in IU! takes place in a different manner than mathematical averaging. An IU! market is a prediction market or one "designed and conducted primarily for the aggregation of information so that market prices forecast future events" (Berg et al., 2003, 3). The price of the stocks reflects the averaged opinion of the group. The value of a specific stock depends on how likely the participants *as a collective* believe this particular outcome will be. The economist Jack Treynor concludes that the accuracy of market prices "comes from the opinions of a large number of investors who err independently" (Treynor, 1987, 50). In other words, it is not a group of wise investors who guide the market prices, but the average of all the investors who all make different errors in judgment. Treynor explains, "It doesn't take knowledge of [jelly] beans, jars, or packing factors for a group of students to make an accurate estimate of the number of beans in a jar" (1987, 50). Just as it doesn't take knowledge of company assets, published research, and analyst opinion for a group of investors to set accurate market prices.

Chapter 3

Analysis of Existing Markets

There are a number of online prediction markets already in existence. In this section, we will explain and critique five such markets, which cover a wide range of uses and formats for prediction markets. Some organizations use the information for profit, some for educational and research purposes, and some for entertainment. We will look specifically at the markets' adherence to the ten components necessary to produce synergistic understanding.

3.1 Collective2 Corporation

The Collective2 Corporation investigates ways to effectively earn money in financial markets. One method explored is the aggregation of individuals' predictions made on the website tradingbrain.com. This site creates information in the form of predictions on the movement of specific stocks on the New York Stock Exchange. Collective2 gathers this information from the collection of participants' individual predictions for which they receive monetary gain or imaginary loss (if their account dips below zero). The individual predictions are aggregated using a "distributed decision-making" trading algorithm ("Subscribe", 2005, par. 1). TradingBrain sells the collected information on seven to ten stocks to individuals for $275 per month and to institutions for $625 per month. Customers receive this information daily via e-mail.

The participants of TradingBrain are paid to predict the movement of three specific stocks (up or down) each day the New York Stock Exchange is open. The participants will earn money if they correctly predict the movement of the stocks (a fixed amount is earned or subtracted for each prediction). However, if the account balance goes below zero, they will not be charged the difference. Collective2 offers a "performance-based compensation system" where the participants are considered legally in-

dependent contractors to the business ("What is TradingBrain", 2005, par. 9).

It is interesting to note that it is considered cheating if individuals maintain multiple accounts, which would result in a lack of diversity, or discuss their predictions with other TradingBrain users, which would result in dependent choices ("TradingBrain Terms of Service", 2005, par. 13). Anyone found doing either would have their account terminated without pay regardless of the amount they are owed.

The site does not follow all of the components for the emergence of synergistic understanding. Participants on tradingbrain.com can never lose money. If an account balance is negative, money is not owed to the Collective2 Corporation. Furthermore, participants will not be paid unless their account exceeds $50. This arrangement removes participants from incentives to do well. The predictions, therefore, may not come from a crowd that is reasonably intelligent on issues of stock prediction because idle guessers will have nothing to lose in the simple up or down guessing game. While synergistic understanding depends on errors in judgment of participants, if the errors are too great or too many, an accurate prediction will not emerge.

There is no data available as to the efficacy of the TradingBrain prediction method, which uses a trading algorithm as the aggregation tool instead of online markets. This site offers an alternate method to utilize the power of both the Internet and synergistic understanding to facilitate symbiotic intelligence without the use of markets.

3.2 The Hollywood Stock Exchange

The Hollywood Stock Exchange (HSX) is a patented artificial prediction market using virtual money as an incentive for participants to buy and sell shares in markets regarding various aspects of the movie industry from projected box office sales to Oscar winners. The HSX sells the information collected from the markets to entertainment, consumer product, and financial institutions. The HSX is one of a few sites running what the NEC Research Institute calls web market games, which are currently being studied for their ability to mimic the prediction power of real markets (Pennock, Lawrence, Giles, & Neilsen, 2001, par. 3). The site, started in 1996, has over 20,000 weekly participants ("About HSX", 2006).

The HSX has proven remarkable in its prediction capabilities. The markets predicted eight out of the eight selected Oscar categories for 2005. According to the website, since 1999, it has accurately predicted

between 74% and 87% of the winners of all categories. Overall, it is consistently more accurate than most polls and experts ("Hollywood Stock", 2005, par. 2).

The HSX markets meet all five of the population requirements for synergistic understanding. Players individually choose stock using their login name and password. However, they are able to talk to each other using login names through at chat feature of the site. The nature of the market on the Internet assures diversity and a common worldview. There are over one million registered users on the exchange, so markets have large populations ("About HSX", 2006). Those choosing to participate in the markets are most likely a close approximation to a reasonably intelligent crowd since there are the incentives of virtual money known as Hollywood Dollars and a leader board to urge players to guess responsibly. However, the lack of real money incentives means that the players don't have anything tangible to lose, so the intelligence of the crowd cannot be assured.

The HSX asks prediction questions, which are, by their very nature, complex problems due to the number of factors that influence future events. The HSX does not ask explicit questions. Instead, a question as to the popularity or value of a movie or actor is implicit in the market prices of the stock as they are traded. This is essentially the same as explicitly asking, "Will this stock end up or down?" Due to the nature of online markets, the HSX is a decentralized system. Further, it uses market prices to tabulate the aggregation of individual choices. However, the markets fail to use real money incentives and may be less accurate for this reason.

The rate of high prediction success is correlated with a fairly close adherence to the ten components of synergistic understanding. However, the HSX is a different type of market than IU!. The HSX is a web market game and to this extent is fundamentally different than a market based in real money.

3.3 FutureMAP and PAM

The Futures Market Applied to Prediction (FutureMAP) was a proposed program funded and run through the Defense Advanced Research Projects Agency (DARPA) of the Department of Defense. This prediction market's intended use was within the United States government in departments such as the Central Intelligence Agency, the Federal Bureau of Investigation, and the National Security Agency to gather important information

predicting events such as the collapse of governments and economies in the Middle East. The program was meant to exploit the power of prediction markets to "avoid surprise" ("DARPA", 2003, par. 2). The FutureMAP program was installed to gather the information that would otherwise be lost to bureaucracy, interdepartmental communication problems, and political or social pressures. In this program, participants would be free to express their views anonymously and without accountability so intuition and unpopular views may be expressed.

A Congress-banned extension of the FutureMAP program, the Policy Analysis Market (PAM), would have allowed the general public to participate in a similar prediction real-money market environment. The program was shut down after public outrage declared it immoral to encourage people to gamble on disasters such as terrorist attacks and the collapse of governments (Guggenheim, 2003, par. 8). PAM also suffered from many technical and theoretical flaws. For example, to some extent, PAM is a poll in that potential terrorists, for example, could participate in a market predicting the likelihood of terrorist activities within a certain period of time. In this case, the terrorists would not only execute their plan, they would also make money from the United States government for correctly predicting that it would occur (Pennock, 2004, par. 6–7). Further, it is still an open question as to whether the general public, or those who choose to participate, have the knowledge base to provide accurate answers to the posed questions.

Despite these setbacks, the Department of Defense was confident in the power of prediction markets to predict hostilities. Figure 3.3 came from the now defunct DARPA FutureMAP website. The graph shows the accuracy that market predictions are believed to have.

Because the markets are no longer in existence, it is difficult to determine the degree to which they embraced the ten components necessary to produce synergistic understanding. There is potential for the PAM program to suffer from a lack of diversity, as the markets are US government sponsored, deal with fairly expert-specific domains, and are of a grim nature. These factors may be unappealing to many in the general population. However, DARPA does recognize that the markets must "be sufficiently robust to withstand manipulation" ("DARPA", 2003, par. 3). On the other hand, the markets have intended worldwide participation. Indeed, many of the topics would be best answered by those living outside of the US. This suggests a possible difficulty with the common worldview criterion. Finally, the questions posed may not be complex enough. Recall that in order for a problem to be considered complex, a single person must not be able to figure out the answer. In the case of terrorist attacks, this may not be true. While many factors could thwart a planned at-

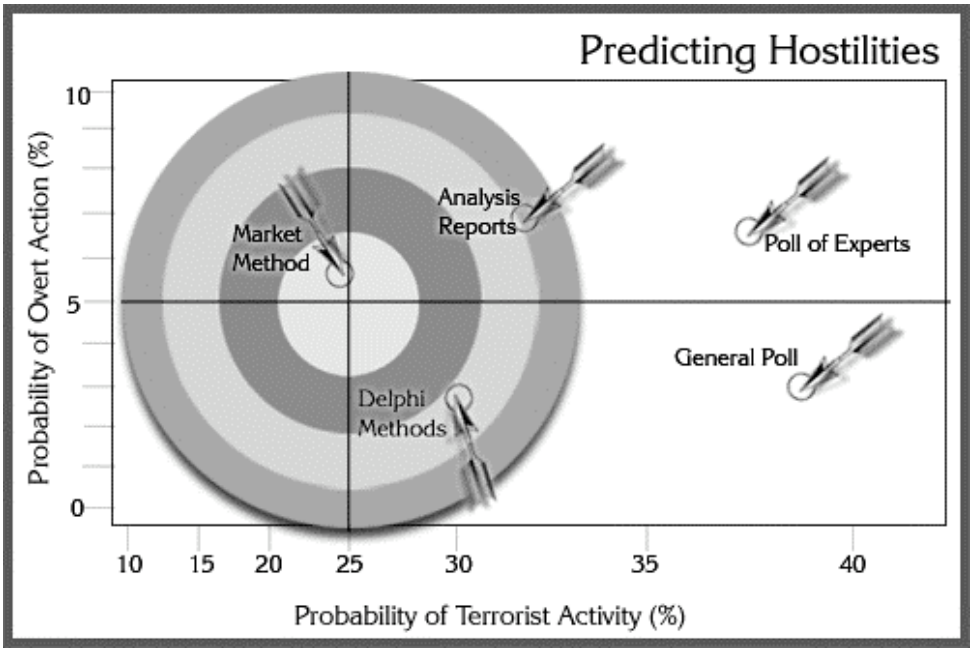

Figure 3.1: Predicting hostilities[a]

[a]From Information Warfare Site. 1 March 2005. http://www.iwar.org.uk/news-archive/tia/futuremap-program.htm. Originally a DARPA (2003) site http://www.darpa.mil/iao/FutureMAP.htm.

tack from actually occurring, it is likely that a terrorist or assassin would have "insider information" that prevents the problem from being complex enough.

The FutureMAP and PAM programs were intensely researched experiments that failed to reach testing phase due to public outrage, congressional bans, and technical flaws. IU! offers the opportunity to test the efficacy of real-money markets available to the general public for the emergence of synergistic understanding and thus prediction accuracy without the ethical and political constraints.

3.4 TerrorXchange

The TerrorXchange (TX), started in 2004, is a virtual stock market trading shares of stock whose prices reflect the predictions of those in the market. This market is instituting a version of the PAM program envisioned by DARPA. The website is an independent way for individuals to analyze the terrorist threat and the probability of other major international news events without depending on the government or media ("TerrorXchange",

2004). The TX uses virtual dollars, known as TerrorDollars, as an incentive to guess correctly. Participants can earn imaginary money and leader board recognition based on net worth.

The TerrorXchange fails to meet multiple synergistic understanding requirements. First, the TX violates the rule of independent choices by allowing participants to speak with each other through web logs. By allowing direct contact between the participants in the market environment, the aggregating power of synergistic understanding will be diminished. Second, the TX uses its homepage to link participants to news sources considered to be relevant to the questions being asked in the market. This feature of the site may limit the diversity of the markets' populations because many participants would base their decisions on these sources alone. Third, the markets suffer from poorly worded questions. It is a necessary component to the emergence of synergistic understanding to clearly state what will be considered a "win" so that those with pertinent information recognize whether it will benefit them or not. Finally, because the TX does not use real money, the markets could attract many idle guessers who are simply trying their luck without having to put any real stake in their decisions.

The TerrorXchange does not offer any data showing the market prediction accuracy. While the stated mission of the markets is "to provide accurate data for statistical analysis of potential threats for government, business, and individuals," it appears as though the site has become more of a friendly Internet community where participants can discuss world news events, fears, and insights ("TerrorXchange.com", 2004).

3.5 Iowa Electronic Markets

The Iowa Electronic Markets (IEM), run by faculty of the business college at the University of Iowa, are mostly economic and politically based online stock markets. These real-money markets, started in 1988, sell futures contracts with participants using accounts between $5 and $500 (US) total. Most markets are open to any participant worldwide, although a few are reserved for academic traders only.

The IEM consistently outperform polls. In the twelve years that the political markets have been studied, the average national poll error was 1.93% whereas the average market error was 1.49% (Berg et al., 2002, 4–5). In the IEM, the aggregation of individual opinion generates accurate predictions without having to define and seek out a specific population the way the Gallup poll does. Figure 3.5 shows the accuracy of the IEM

compared to polls in fourteen national and international elections over a series of years. On average, the IEM is more accurate during both the week before the election and the election eve.

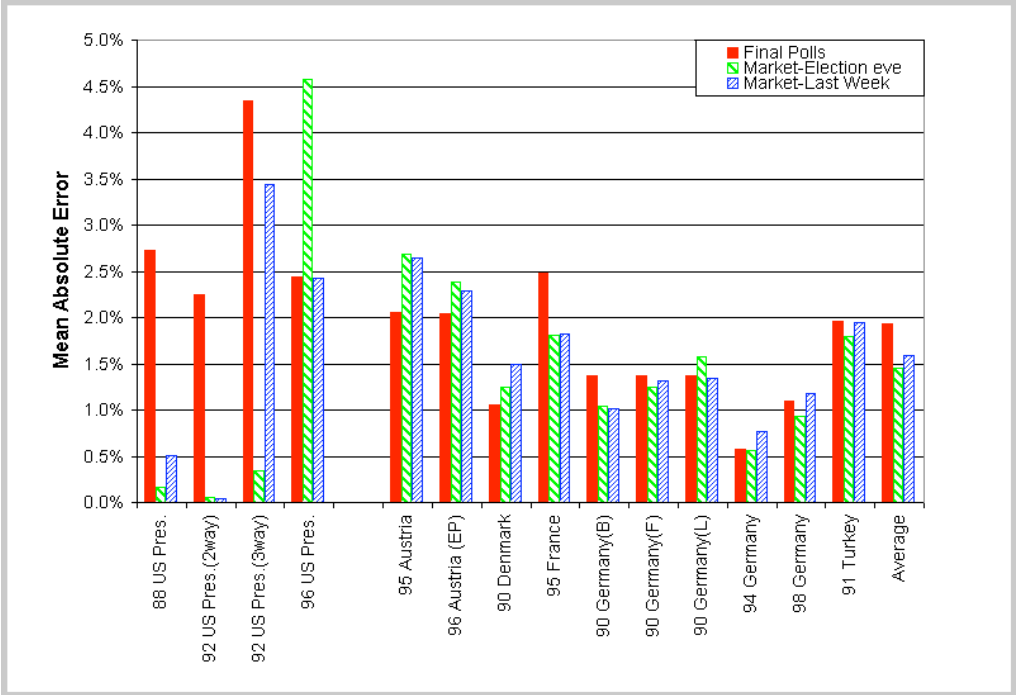

Figure 3.2: IEM accuracy compared to polls[a]

[a]From "IEM Accuracy Compared to Polls." Previous Market Performance. Iowa Electronic Markets. 2 March 2005. `http://www.biz.uiowa.edu/iem/media/previous.html`.

However, the IEM does not fully incorporate all of the components of synergistic understanding. The population characteristics are lacking adherence in a few measures. Only between a dozen and five hundred people participate in most markets (Berg et al., 2002, 1). This tiny population threatens diversity. Further, the markets are used as a teaching aid in classrooms. It is possible that students do not represent a diverse or intelligent enough crowd. Students are not truly free to participate only if they feel they have a good guess. A more accurate performance may result through increasing visibility in the world while maintaining real-money incentives. This would increase population size and diversity without an analogous decline in the population's intelligence.

Berg and the other primary researches into the IEM do not believe that the markets work due to the aggregation of a reasonably intelligent crowd. In other words, they do not believe a phenomenon such as synergistic understanding is at play. Instead, they believe the markets work

due to "marginal investors" or a small group of foresighted traders who override the uninformed mass of traders (Surowiecki, 2004, 278). However, it is unlikely that in markets that are restricted to a maximum of $500 dollars, as is the IEM, a small group of traders could control the prices of the market over the biased crowd (Surowiecki, 2004, 278–279). Surowiecki uses the example, in his book *The Wisdom of Crowds*, of the 1988 presidential market. After reviewing the analysis of Forsythe et al., he concludes:

> The average marginal trader did invest twice as much money as the average non-marginal trader. But this means that the 'smart' traders controlled only about a quarter as much money as the 'dumb' ones did. If the supposedly dumb traders' judgment was collectively bad, there would have been no way for the smart traders to counterbalance it (279).

IU! offers the opportunity to study a market that is founded not on a belief in the "marginal investor" but on the synergistic understanding inherent in a crowd.

Synergistic understanding is the basis for the generation of accurate predictions from a crowd of individuals. It is this phenomenon that must be created in online markets. None of the five existing markets just analyzed meet all of the conditions necessary to reliably produce synergistic understanding and thus are not as accurate or reliable as prediction tools as they could be. B. K. Marcus asserts:

> Government-developed "planned markets" such as the Pentagon's PAM, "virtual markets" such as the Hollywood Stock Exchange, and low-risk *hampered markets* such as the IEM (which only allows $500 trading accounts) will not be able to operate as efficiently or accurately as would true capitalist markets, which allow for real profit and real loss. (par. 13)

The IU! markets are based firmly in the ten components sufficient for producing synergistic understanding and are therefore a sound place to begin exploring the phenomenon and our true prediction potential.

Chapter 4

Framework of the IU! Markets

The preceding sections of this proposal have dealt with the theoretical framework supporting Individuals Unite!. However, there are practical considerations concerning the development of online markets as well. The following is a brief outline of some of these practical considerations.

4.1 Gambling

Unlike in the stock market, participants will not actually own a share of anything tangible with the purchase of the prediction stock; therefore, IU! is a gambling website. However, it differs significantly from online casinos. IU! limits participants to one thousand shares of stock in any one market or the equivalent of $1,000 (US). In other similar markets, such as the Iowa Electronic Market, the majority of participants are investing significantly less money (Berg et al., 2002, 1). Further, IU! fosters competition between anonymous individuals to encourage personal prediction improvement through the posting of participants' portfolio records. IU! does not resemble "the house" in a casino because the markets are not designed with odds to favor the site. In fact, IU! will neither earn nor lose money from the markets.

4.2 Legality

IU! is a futures market and as such is under the jurisdiction of the Commodity Futures Trading Commission (CFTC), which "has issued a 'no-action' letter to the IEM, stating that as long as the IEM conforms to certain guidelines, the CFTC will take no action against it" ("Frequently", 2005, par. 4). IU! operates similarly to the IEM and would thus be subject to the same guidelines imposed by the CFTC. IU! is exempt from online

gambling laws because the company is not profiting from the markets.

4.3 Virtual Markets

One goal of IU! is to demonstrate the power of synergistic understanding on a large scale in order to encourage its use and refinement. To this end, IU! will also have virtual money markets with incentives based exclusively on peer recognition of achievement through participants' posted portfolio performance. Because real-money incentives are not used, thus one of the ten components is not met, we will not expect reliable and accurate predictions. By sponsoring virtual money markets IU! not only spreads the concept of synergistic understanding to more people, it also helps to attract a larger possible population in the real-money markets by attracting people to the site. Those who have a chance to originally guess free of financial consequences may then feel more comfortable participating in the real-money markets.

4.4 Operation Details

When a new participant enters the site, they must provide a baseline of identifying information in order to choose and activate a password screen name. Those unwilling or unable to participate in real-money markets will not have to provide credit card information but will be restricted from participating in real-money markets. Everyone will receive virtual dollars to spend in the virtual markets. Regardless of whether the incentive is real or virtual money, payoffs will be calculated in the same manner.

Once participants buy their stock, they will have a portfolio. The portfolio will be available to the participants to track their shares. Those with the best portfolio performances will be listed with their prediction accuracy record. This list will not include how the participants voted, only their success. It will encourage both personal achievement and competition within the site as an incentive independent of money. In fact, in the virtual money markets, this recognition will serve as the only incentive.

Each IU! market will be based around a question, for example, "Will George W. Bush be re-elected president of the United States of America by the Electoral College in the November 2004 national elections?" As soon as the market opens, months in advance of the election, those enrolled in IU! may buy futures shares in the question up to a value of $500 (US). Each market will be open twenty-four hours a day, with prices updating

every half hour. Every market will have a predetermined closing time and date after which point no more shares can be bought or sold. The closing price of the shares will be the price that affects the participant's portfolio.

For example, as in the case of our election market, participants can buy and sell shares up until midnight of November 1, 2004. Once the Electoral College determines who is president, participant's portfolios will be updated to reflect the accuracy at prediction. Any amount owed to IU! will be deducted from participants' accounts. At this time, participants may cash out and receive any money they have earned or they may keep it available in their account.

4.5 Payoff Technicalities

Participants' portfolio values reflect the amount they have earned or lost based on the dividends of their shares whose price (liquidation value) is determined at the close of the market. Most markets will operate with shares selling between $.01 and $1.00. With this configuration the price of the stock reflects the percentage of participants who believe the question or stock to be a winner. If, in our example, the Bush contracts are selling for $.60, this says that the aggregation of participants' beliefs holds that it is 60% certain that Bush will win the election.

When a participant puts up an ask to sell his or her shares, the offer will be placed in a queue to be revealed when it becomes the best offer in the queue. Short sales are not allowed. In the case of multiple choices in a market, for example, a presidential election market that includes Bush, Kerry, or Nader, contracts will be sold in packages containing one of each. Each package will sell for one dollar. At the close of the market, a liquidation price will be determined based relative to the outcome. For example, because Bush won, his contracts will be worth $1 and the Kerry and Nader contracts would be worth nothing. If one has either a package or a Bush contract, he or she will earn back their one invested dollar. If one has a Kerry or Nader contract, he or she will lose their one invested dollar. Notice that there will be an equal number of every individual contracts for Bush, Kerry, and Nader. The prices of the stocks, because they are between zero and one dollar reflect the percentage of assurance that each candidate will win. This configuration is based on that of the Iowa Electronic Market, which has been in operation as a non-profit educational and research based organization of real-money markets since 1988 ("About the IEM", 2005, par. 1–3). The configuration assures that IU! will neither gain nor lose money through the markets themselves.

This is merely a rough framework to explain some of the details of the actual design of IU! as the primary aim of this proposal is the theoretical framework, not the practical considerations, behind these markets.

Chapter 5

Conclusion: The Promise of IU!

Even before Charles Mackay published his popular tome *Extraordinary Popular Delusions and the Madness of Crowds* in 1841, groups of people have been considered illogical, unpredictable, and dangerous. It is a commonly held belief that groups of people have a powerful effect, sometimes expressed as "madness", that appears to transcend the summed power of the individuals. Through IU!, we have the ability to harness this power found in crowds without creating mob mentalities. The individual maintains independent reasoning, for most never even know the other members of the crowd, but contributes to the generation of new knowledge through synergistic understanding.

IU! will help to extend synergistic understanding as a resource to the world. There is information to be discovered simply through the aggregation of individual's opinions. The information may go against the intuition of every individual in the group including the best thinkers on the matter. In this situation, no single person has a solution, but the group as a whole does; the group has synergistic understanding. IU! will produce a new way of generating knowledge that can solve today's problems and benefit both individuals and institutions.

The IU! markets can

- liberate people from the media. When predicting future events, a person may compare media opinion with IU! data as another source. Sam Savage, a professor at Stanford University recalls his first comparison of an online prediction market with punditry saying:

  > Listening to continued predictions on the evening news that the United States would find [weapons of mass destruction] in Iraq, while my laptop computer told me otherwise, left me feeling liberated from the traditional media. (par. 23)

- liberate people from hierarchies. A paper pusher's opinion in IU! is

just as valid as his or her boss's. Everyone can share information in a manner in which it will be weighted equally in IU! markets.

- express information that would have been lost to bureaucracy, social norms, and fear of judgment. Because the participants are anonymous, an individual is free to follow intuition, secret sources, and unpopular opinions without fear of repercussions.

Further, IU! is highly compatible with the worthy aim of symbiotic intelligence to unite humans and networks to "improve our quality of life and vitality as a species" (N. L. Johnson, 2003, par. 1). The information collected through the markets could have applications to solve problems facing society today, such as the infiltration of terrorism, the prevention of disease outbreak, or the easing of traffic flow. IU! is harnessing the power of crowds to solve problems that will not yield to individuals or teamwork.

IU! is intended to meet the following three goals: to develop a tool to answer prediction questions, to collect information that would have otherwise been lost, and to develop conditions that reliably generate synergistic understanding in decentralized networks. These broad research goals and their solutions represent the core of IU! and the issues of prime interest to the Symbiotic Intelligence Project. The Project paper "Self-Organizing Knowledge Systems: Enabling Diversity" laments the lack of "enabling methodologies and theories, along with the data needed to test the new technologies" (1999c, par. 4). Individuals Unite! provides a methodology (the markets built on ten components) and the theory (synergistic understanding) needed to construct a program that can produce data on the efficacy of this particular instantiation of symbiotic intelligence.

As yet, there is little systematically collected evidence supporting the existence and conditions necessary to produce synergistic understanding. However, this alternative method to knowledge generation is worth looking into because initial anecdotes, such as those proffered by James Surowiecki, suggest that synergistic understanding is a very powerful concept and one that should be of prime interest to researchers in the new science of symbiotic intelligence. The ten components should be tested through online markets to explore the parameters necessary for synergistic understanding to occur so that the method can become both efficient and trusted.

Developing trust in synergistic understanding is of prime concern for the success of the phenomenon as a prediction tool. Kevin Kelly, in *Out of Control*, states that one of the concerns of a decentralized system, such as IU!, is that we can't understand it (195). Synergistic understanding gen-

erates solutions that one person acting alone cannot answer. Accepting solutions produced through synergistic understanding may be problematical at first. It is difficult to make an important decision based on mere averaging. If questioned, it is highly likely that not a single person in the group believes the synergistic understanding solution to be the correct answer, as in the case of the jellybean contest. It is difficult for us to pass over the suggestion of the smartest person in the crowd in favor of a general, faceless group's average suggestion. After all, whom do we hold responsible for an incorrect answer? However, by creating an Internet site, bringing this concept out of government defense strategy and financial institutions and into the general world populace, the phenomenon will become less foreign, and more likely to be trusted.

The greatest strength of IU! as a research tool into symbiotic intelligence is that it is a combination of networks and the general population. Unlike many of the simulations conducted at the Los Alamos National Laboratory, the agents in the IU! markets are human not computer-generated facsimiles. IU! is not a simulation of a phenomenon, it is the actual generation of a phenomenon. We feel that it is essential for the furtherance of research into symbiotic intelligence that data is collected from actual human interaction with networked technology, as opposed to computer-agents simulating humans. An essential tenet to the symbiotic intelligence program is that computers are unable to demonstrate all of the qualities of humans and synergistic understanding is one such quality. While computer simulations provide useful insight into group phenomenon, IU! will provide data about an actual human-network symbiosis in a real-world setting — and this is the promise of IU!

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