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Developing a Philosophical Profile of the Individual for Complex Problem-Solving Through Agent-Based Modeling

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DEVELOPING A PHILOSOPHICAL PROFILE OF THE INDIVIDUAL FOR COMPLEX PROBLEM-SOLVING THROUGH AGENT-BASED MODELING

by

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ABSTRACT

DEVELOPING A PHILOSOPHICAL PROFILE OF THE INDIVIDUAL FOR COMPLEX PROBLEM-SOLVING THROUGH AGENT-BASED MODELING

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Old Dominion University, 2009

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Research that focuses on the emotional, mental, behavioral and cognitive capabilities of individuals has been abundant within disciplines such as psychology, sociology, and anthropology, among others. The main argument made in this dissertation, however, is that a different perspective is necessary in order to gain insight about individuals when facing the complex problems that are presented within engineering and management disciplines. This is done by developing the Philosophical Profile of the Individual (PPI) that uses epistemology, ontology and teleology as underlying dimensions of philosophical predispositions. The epistemology dimension considers whether an individual is an Empiricist or a Rationalist, the ontology dimension consists of the Substantive and Process predispositions, and the teleology dimension represents whether the individual is goal-oriented or not. By using these three dimensions, researchers may understand how an individual chooses to acquire knowledge about a certain problem, how an individual defines a problem and how the purpose towards a certain future is obtained.

Through a Rationalist Deductive Methodology, and the use of Agent-Based Modeling as a tool, insight is gained on how different individuals with different philosophical profiles deal with complex problems, which are defined in terms of the amount of available information, stability, ambiguity, number of entities, and temporal constraints.

The results indicate that certain predispositions are suited for certain types of problems, and therefore individuals with certain profiles have better capabilities to deal with complex problems. These results are based on the amount of capability gained by an individual, and the time it takes the individual to solve a complex problem.

The future implementation of the developed profile (PPI) into various industries and organizations could have a range of implications. When individuals become aware of their reasoning process, of how they approach certain problems, and of how other people may approach the same problems, the communication between individuals can improve. This would, in turn, create more coherent teamwork, improve leadership and management skills, and increase self-awareness. All of these properties are crucial for successful businesses, organizations and individuals, which supports the foundation of the discipline of engineering management.

This dissertation is dedicated to my dearest mother, to whom I am grateful for everything she has given me, and continues to give to this day.

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1 INTRODUCTION

This section presents an introduction to the research conducted in this dissertation. The first part is an elaboration on the nature of the research problem investigated. The research problem is followed by the purpose of this research, which then leads to the research questions to be answered. Following this, the main concepts used throughout the research are defined in detail, and the last part presents the significance of this research.

1.1 Research Problem

Personality profiles to classify individuals have been developed and applied in areas such as psychology, sociology and physiology, through indicators and tests such as Myers-Briggs Type Indicator (MBTI) and Big Five, among others. Analysis of the profile of an individual is crucial in social sciences, since it provides the necessary tools and explanations for why individuals make certain types of decisions, how they approach uncertainty, how they behave the way they do when faced with complex situations, and what their reasoning processes are (Bozkurt, Padilla and Sousa-Poza, 2007).

Nowadays, personality theories are starting to become more and more part of popular culture, with personality questionnaires popping -literally, via pop-up windows- everywhere over the World Wide Web. There is no doubt that personality-type indicators and trait theories, such as Myers-Briggs and Big-Five, respectively, have proved to be useful for organizations and individuals in many ways. However, these instruments (mostly MBTI and Big Five) have also received criticism concerning their reliability and validity. For instance, Big Five (or the NEO Personality Inventory) has been criticized due to its lack of connection between the personality traits and human behavior (Van Houten, 2004). This was due to the fact that no one had analyzed how the identified personality traits influenced the behavior of individuals. The MBTI has also been criticized with respect to its validity and reliability (Garden, 1991; Johnson et al, 1998; McCrae and Costa, 1989; Michael, 2003; Walck, 1992).

In order to find different ways of identifying and effectively measuring personality factors and their influences, various personality theories have been developed,

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This dissertation uses the APA style

such as the Comrey Personality Scales (Comrey, 1970), Jackson Personality Inventory Revised (Jackson, 1994), Linear-Nonlinear Thinking Style Profile (Vance et al., 2007) and Big Six (Watson, Clark and Chmielewski, 2008), among others. However, one of the problems that scholars and practitioners have started to face is that the newly developed personality theories and profiling indicators do not seem to be able to provide sufficient understanding of the human mind and behavior, especially when facing complex problems of today. The complexity of the problems that an individual deals with today has become an issue on its own, prompting research in both the academia and the practitioner world. Jackson (2006) stated that if organizations wish to remain viable, they have to respond to the constant changes within their environments in a frequent and quick manner. These changes in the environment are only part of the complex situations and complex problems that individuals have to deal with within any kind of organization. Therefore, it is crucial to look at the characteristics of these complex problems, and look for ways that will bring at least the possibility of a solution. Gaining insight about how individuals make decisions, how they acquire knowledge, how they define and shape the things around themselves, and how they deal with the future are some issues that needs to be addressed. In order to reach a certain level of understanding, the profile of an individual needs to be considered from a different perspective. Rescher (1998) has stated that complexity in everyday life has a great impact on our knowledge and understanding of the world, and on how we manage this world. While it is important to consider the attitudes of an individual, e.g. whether the individual is an introvert or an extravert, in light of increasingly complex problems, a different framework needs to be used, or at least considered.

Engineering Management is a discipline that takes pride in being a bridge between the engineering practice and the management practice. Combining appropriate tools from both sides proves to be beneficial when dealing with complex problems. However, the human factor and the social issues that arise from these factors deserve far more attention than they currently receive. With technology developing at warp speed, it is the duty of both scholars and practitioners to re-route the attention to social factors and human behavior. Rubinstein (1986) states that the way individuals perceive reality, the way individuals think, and the way individuals solve a problem should be considered

within a context. He notes that this context is structured in levels, where the higher level is the culture, and the lower level is the individual values. The new perspective this research intends to bring will be part of this lower level. Stepping aside from the cognitive foundations of past personality theories, it is argued in this research that philosophical underpinnings of an individual provide a different perspective in hopes of understanding worldviews and predispositions of individuals, and how different individuals deal with different problems.

1.2 Research Purpose

Increasing understanding of personality also increases self-awareness, which is important in any context, such as self-improvement, better relationships with other individuals, having a better understanding of the environment, etc. (House, Shane and Herold, 1996). Improving the basic functions of interaction with other individuals such as communication and learning may have implications on the day-to-day lives of individuals. Developing new approaches to solving complex problems will prove to be important for individuals. The results of this study and implications for future research will represent this importance.

The purpose of the current study is to contribute to the engineering management body of knowledge by developing a theoretical personality profile for dealing with complex problems, using philosophical paradigms as main dimensions. By doing so, an understanding of how philosophical paradigms can be introduced as personality dimensions will be established, and insight on how these profiles deal with complex problems will be gained.

1.3 Research Questions

The depth of the scope of this research prepares the grounds for multiple research questions to be answered. In order to provide a sufficient level of detail to the study, the research problem is represented as two main research questions and related sub-questions.

The first research question is related to the use and place of philosophy within personality theory literature. It presents an elaboration on philosophical paradigms as underlying dimensions for personality profiles when dealing with complex problems.

- *Research Question 1:* How can the profile of an individual be defined and understood in terms of philosophical dimensions?
  - *Research Question 1.1:* Why is philosophy crucial in exploring the predispositions of individuals?
  - *Research Question 1.2:* Which philosophical paradigms represent appropriate dimensions for a philosophical personality profile of the individual, and why?

The second research question is related to the context in which the philosophical profile of the individual can be used and applied.

- *Research Question 2:* In what context can the philosophical profile of the individual be applied and provide significant results?
  - *Research Question 2.1:* What types of capabilities do philosophical paradigms provide to individuals?
  - *Research Question 2.2:* How does an individual with a certain philosophical profile relate to and attempt to solve complex problems?

1.4 Research Significance

Psychological profiles provide necessary information on the type of personality an individual possesses, and have proven to be beneficial within organizational settings. For instance, CPP Inc., the official publisher of the MBTI assessment, has reported that the use of Myers-Briggs Assessment has increased team-building performance in companies such as Sony and Pioneer Hi-Bred International, Inc. and has also improved leadership skills at the Center for the Health Professions at the University of California (Case Studies, http://www.cpp.com, 2009). Similarly, by using the Thomas-Kilmann Conflict Mode Instrument, CPP has established that call centers can increase customer satisfaction through effective conflict management, and through a two-year long application of the California Psychological Inventory at St. Luke's Hospital and Health Network, where management turnover was reduced, and ROI increased drastically.

Similar to psychological profiles, a philosophical profile can provide access to the embedded values of individuals, their biases, assumptions and predispositions (Bozkurt et

al., 2007). This dissertation presents a philosophical profile of an individual that can be used to establish predispositions and identify possible ways an individual chooses to address complex problems. The particular importance of using philosophical foundations is that these philosophical paradigms affect the manner in which an individual perceives and defines the world around him/her, and the manner in which he/she acquires knowledge. Babbage and Ronan (2000, p. 405) have stated that philosophical foundations "guide what observations will be made, what questions will be asked, and what conclusions will be reached." The personality phenomena has been studied extensively in many formats, but identifying the underlying philosophies of individuals will not only fill a significant gap, but may also be a starting point both for academics and practitioners to consider philosophical aspects of any personality related research topics.

As the problems that people deal with evolve and become more complex with time, the need to establish new tools in order to deal with them becomes critical. Identifying the components of complex problems, and analyzing how different profiles deal with complex problems is another aspect of this research in terms of significance. The complexity of problems that both individuals and organizations face today seem to be increasing, and problem-solving has become a crucial tool for identifying and decreasing complexity. Since the problems are getting more and more complex, the tools and capabilities an individual possesses should be honed and different perspectives should be sought accordingly. Being aware of different worldviews and predispositions is the first step for reaching these new capabilities.

Cervone and Shoda (1999, p. 5) have stated that "personality theories must be judged in part on their ability to deliver useful solutions to social and personal problems," which identifies two major gaps this research addresses. The first is proposing a new personality profile, and the second is analyzing how this personality profile deals with complex problems. Briggs (1992) noted that a substantiated framework for the structure of personality may generate specific hypotheses on how various constructs and measures are related, what the relationships between the personality variables and other variables are, and finally, "how individuals with particular personality characteristics will react to certain types of interventions or manipulations" (p. 254). The results of this dissertation could also lead to similar questions that may be answered in future studies. One of the

advantages and reasons why a Rationalist Deductive Methodology has been used in this research is in direct relation to Briggs' last point, which is to be able to experiment, explore and therefore gain insight on how different individuals deal with different problems.

The final significance of this research is its relation to the field of Engineering Management (EM). EM consists of a wide spectrum of topics, from the "hard" subjects such as Modeling & Simulation, Cost Engineering, Risk Management, etc. to the "soft" issues such as Organizational Behavior, Organizational Analysis, etc. The challenges of combining such diverse topics are evident both in research and practice. The current shift of focus from "industrial" topics to topics such as System of Systems Engineering, Socio-Technical Systems, and Complex Organizational Analysis is proof that it is impossible to ignore the "human" or the "people" component anymore. Majority of the issues that these topics struggle with is due to the fact that even in a small team, each individual will bring to the table their own background, education, culture, etc. Establishing a common medium to work towards common goals is the most important issue, especially for engineering managers.

1.5 Definition of Main Concepts

In any research, it is important to properly identify and define the key concepts that will be used throughout the research. The concepts which are described below are crucial concepts that form the basis of the current research. Tallman et al. (1993) stated that clarity and communicability of key concepts are two factors upon which any theory depends. The following definitions are provided to clarify the author's thought process to the reader, and provide clear definitions of the concepts used throughout this study since some of the concepts that are vital in this research are subject to interpretation. Each of the concepts below are also elaborated on and explored in detail in the following Background Research section.

- **Personality:**

Since the field of personality is concerned with the individual as a whole, as well as differences in individuals, it is clear that there will be various definitions of personality. Maddi (1996, p. 5) suggests that reviewing all existing definitions of

personality will only make the individual "become lost in a maze of words that could make but little impact." Having said that, he provides a useful definition in Maddi (1980) of personality, one that is appropriate for the context of this present research:

> Personality is a stable set of tendencies and characteristics that determine those commonalities and differences in people's psychological behavior (thoughts, feelings, and actions) that have continuity in time and that may not be easily understood as the sole result of the social and biological pressures of the moment (p. 10).

The tendencies Maddi talks about, in his own definition, are "the processes that determine directionality in thoughts, feelings and actions; they serve goals or functions" (Maddi, 1996, p. 8). This concept of tendencies shares a similar ground with "worldviews" and "predispositions," which form a part of the foundation that this present research is built on.

- **Worldview:**

The phrase "worldview" comes from the German word *Weltanschauung. Welt* is the German word for 'world,' and *Anschauung* is the German word for 'view' or 'outlook.' Wisdom (1972) in fact uses the word *weltanschauung* instead of *worldview,* stating that the word *worldview* may have mystical overtones, which is not necessarily true, but nevertheless possible. Maslow (1971) also chose to use the German word, but unlike Wisdom, he did not provide the English translation. Even though *weltanschauung* seems to be a commonly used word, especially in personality literature, for the purposes of this research, *worldview* is going to be used to describe the view or perspective on the world; they are sets of beliefs and assumptions that describe reality (Koltko-Rivera, 2004).

- **Predisposition:**

In this research, the term "predisposition" is used in a parallel context to worldviews. The predisposition of an individual is defined as the initial, instinctive reaction of the individual to a set of conditions or situations. The predisposition of an individual may depend on the upbringing, the education, the culture, the environment and other elements. Even though this predisposition is an embedded value within the

individual, given certain circumstances, he/she may choose to act in a way that is contradictory to the initial predisposition.

- **Philosophy:**

The definition of philosophy according to Webster's New World Dictionary is: 1. orig., love of, or the search for, wisdom or knowledge, and 2. theory or logical analysis of the principles underlying conduct, thought, knowledge, and the nature of the universe. Ladd (1913, p. 1) has called philosophical discussion "peculiarly confusing and mischievous." Benjamin (1942) has very correctly stated that concepts relating to philosophy are "notoriously vague," but this vagueness can be eliminated simply by reaching to the core meaning of these terms, which is common in almost all of the usages. Different literatures decompose philosophy in different ways, even though the origin of the word remains the same; however, the paradigms that form philosophy vary across disciplines. These paradigms that philosophy deals with will be discussed further in the next section.

- **Premise:**

Premises are sentences, or statements that need to have one important characteristic; they need to make a claim that is either true or false (Baggini and Fosl, 2003). They are the starting point of a philosophical argument, and they lead to a certain conclusion.

- **Axiom:**

According to Miriam-Webster's Online Dictionary, an axiom is defined as: (1) a maxim widely accepted on its intrinsic merit, (2) a statement accepted as true as the basis for argument of inference. Baggini and Fosl (2003) provide a definition that includes the *premise* concept described above. They state that an axiom "is a proposition that acts as a special kind of premise in a certain kind of rational system" (p. 26). From this definition, it can be concluded that axioms are a special case of premises, and that they are assumed to be true.

1.6 Overview of Dissertation

In this Introduction, the problem was introduced, followed by the purpose of the research. The research questions were identified, and the significance was presented. Following

this, the main concepts used in this research have been introduced, and definitions have been provided. The remaining sections flow as follows:

- In Section 2, a comprehensive background research which includes three main components, namely Individual, Philosophy and Complex Problems is presented.
- In Section 3, the theoretical foundation for the philosophical profile of the individual (PPI) is built and discussed.
- Section 4 is the Research Methodology. This part is an elaboration of the overall research process, starting with the Research Paradigm, and ending in the Research Methodology that is being used in this research. Canons that are followed throughout the research are also identified and discussed.
- In Section 5, the specific Research Method is discussed, which includes the Agent-based simulation model. A detailed description and step by step approach is provided on how the ABM was built for the PPI and complex problems.
- In Section 6, the data collected through simulation is analyzed, and the results are presented.
- Section 7 conveys the research implications, and presents a discussion on the overall research, and suggestions for future research are outlined.
- In Section 8, the limitations of the study and the research contributions are presented.

The layout of the dissertation is presented in Figure 1.

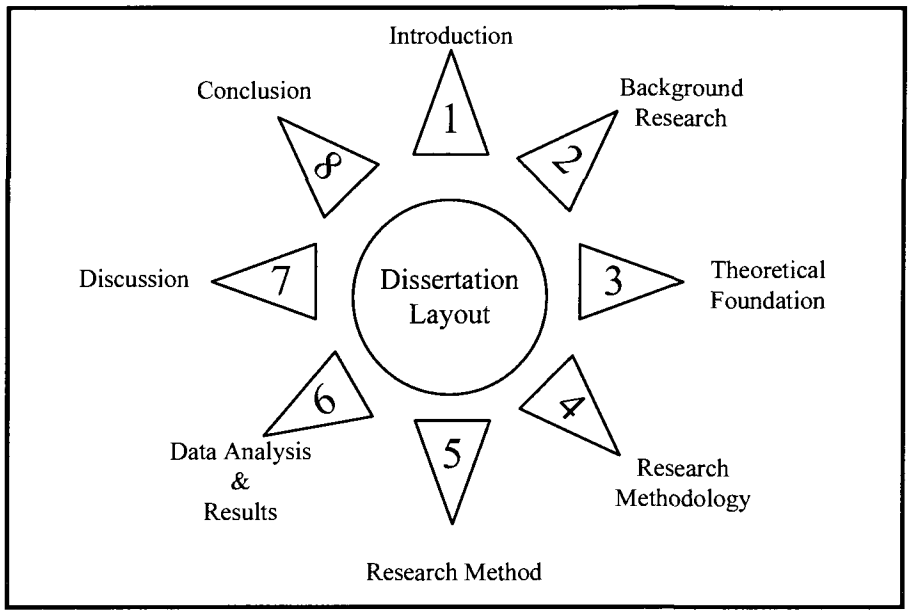

Figure 1. Layout of dissertation

The purpose of each section, and the expected deliverables and outcomes are identified in Table 1.

Table 1. Purpose and Outcome of Dissertation Sections

SECTION	PURPOSE	OUTCOME
1. INTRODUCTION	Present essential components of research and describe the initial layout	Research Problem, Research Purpose, Research Questions, Research Significance and Main Concepts
2. BACKGROUND RESEARCH	Review background and analyze relevant literature to establish solid groundwork	Literature Review on Personality, Philosophical Paradigms and Solving Complex Problems
3. THEORETICAL FOUNDATION	Identify and discuss building blocks, establish and present main theory through premises	The general theory of the philosophical profile of the individual and specific propositions
4. RESEARCH METHODOLOGY	Describe general and specific research perspectives, outline methodology	Research Paradigm, Rationalist Deductive Methodology, Canons of Research
5. RESEARCH METHOD	Present details of research method, including the simulation medium, construction of ABM, and explicitly establish rules for computer implementation	Specific Research Method, and steps of the Agent-Based Model to be used for simulation
6. DATA ANALYSIS & RESULTS	Outline experimental setup, present analyses and results	Results of simulation, general and specific canons of research
7. DISCUSSION	Further discuss results and finalize research perspectives	Research Implications and overall discussion of the entire research
8. CONCLUSION	Establish closing arguments; discuss important aspects in addition to the main section	Limitations, Delimitations, Contributions and Future Research

1.7 Summary of Introduction

One of the main issues this research intends to address is the increasing complexity of the problems that individuals have to face. Especially from an Engineering Management perspective, it is not enough to be equipped with certain engineering and management

tools in order to deal with the problems. Focus has currently shifted to the social, soft components within situations. The manner in which an individual defines these problems, chooses to acquire knowledge about the problems, and how the individual relates to the future in terms of purpose are crucial factors. In order to have the necessary capabilities for dealing with such problems, certain questions were addressed that guide the research. The purpose of this research is to contribute to the engineering management body of knowledge by developing a theoretical personality profile for dealing with complex problems, using philosophical paradigms as main dimensions for predispositions. The research purpose and the research questions serve as boundaries that will shape the scope of this research. The next section is an elaboration on the background research that was conducted.

2 BACKGROUND RESEARCH

This section provides a comprehensive background research on three main components of this dissertation: the individual, philosophy and complex problem-solving (context). The intent of this section is to establish the necessary background and foundation supporting this research as well as to clarify this research's boundaries and scope.

2.1 Outline of Background Research

The background of this study draws upon theories from numerous disciplines, and is divided into three main components: the individual, philosophy and context, which is complex problem-solving. In this part, important concepts, issues and studies for each topic are discussed in detail. Figure 2 presents the outline of the background research.

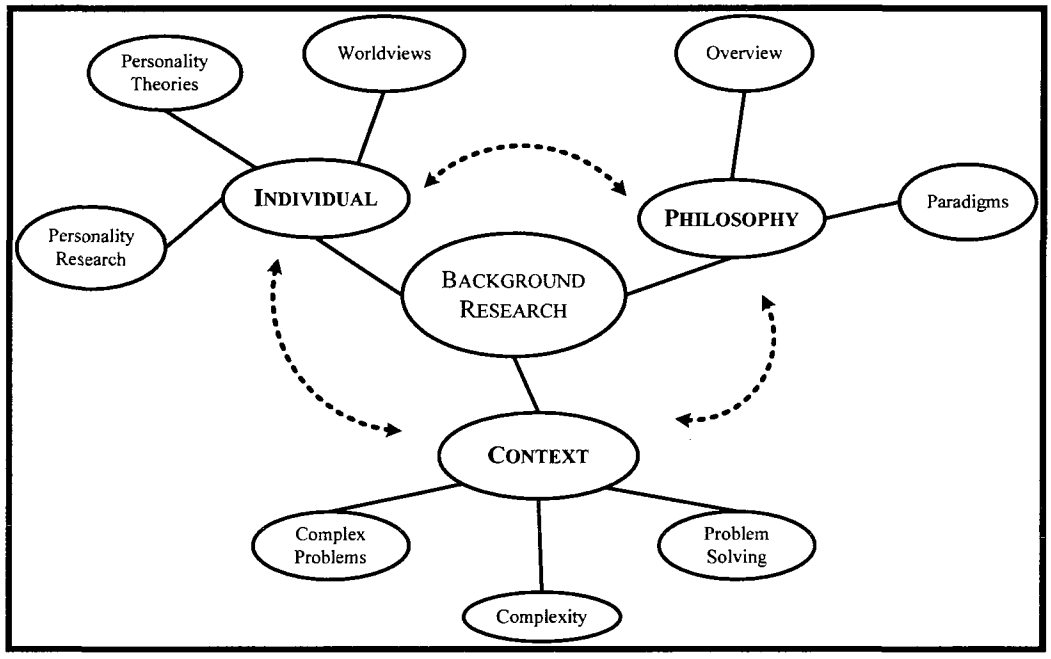

Figure 2. Outline of background research

The background research starts with the *individual* component, which consists of the body of knowledge related to personality. This part starts with a general overview on

the different major personality theories that were developed throughout history. It is not within the scope of this dissertation to provide detailed discussions on each of the personality theories. The purpose of presenting the major personality theories in sufficient detail is to give the reader an insight on the major theories and what perspectives they present about individual personalities. The next component of the section is related to the individual and presents an overview of various studies conducted using different personality theories. In order to establish the need for a new way of profiling an individual, it is important to first have an understanding on why and how personality theories are being used in different domains. The last stream of literature passes through the "worldviews" and "predispositions" body of knowledge. What is meant by worldviews and predispositions, why and how they tie with personality profiles is explained. The connection between worldviews and philosophy is also discussed in this part.

The second main area, which is the *philosophy* component, provides an introduction to the basic structure of the philosophical profile that will be discussed in the latter sections of this dissertation. Before exploring the underlying philosophies of individuals, it is crucial to have a firm understanding on the philosophical arguments. An overview of the philosophical inquiry paradigms is the starting point of the philosophical section. Following this, the paradigms are examined in hopes of clarifying some of the basic arguments of individual philosophies. Similar to the personality literature, each of these philosophical paradigms lead to major bodies of knowledge that is not only impossible to cover within one document, but more importantly, it is not the purpose of this dissertation. The philosophical paradigms are discussed in sufficient detail as to assist the theoretical foundation of the personality profile to be established in this study, which is aligned with the research purpose and research questions.

The last section of the background research is about the *context* in which the profiles are developed, explored and applied, which is the complex problems literature. This section provides an introduction and discussion on general problem-solving literature, followed by an overview of what complexity is, and the process for solving complex problems.

2.2 Relevant Literature on the Individual

Research on the human mind and individuals' behavior goes as far back as the late 1700's. Psychology initially grew out of philosophy and pathology, but it is commonly accepted that Freud was the founding father of the area. After more than three-hundred years, researchers are still combating questions on why individuals act the way they do, how they make decisions, and what their thinking processes are. However, the main difference between current and past research on personality theories is the research and development of situational and environmental variables.

In the present, personality research has entered into most fields, from sociology to engineering. The sole purpose of the following is to present a background for this current study.

2.2.1 Personality Theories

Personality theories provide useful ways to understand human behavior, which is connected with the cognitive and emotional processes (Gulliford, 1992).

There are five main components for individual personalities:

1. They are built-in attributes
2. They influence the thinking process and actions
3. They do not change throughout lifetime
4. They are an overall pattern, observed within long time
5. They are core tendencies (or characteristics)

The pioneering American psychologist, Gordon Allport (1937) described two major ways to study personality, namely the nomothetic and the idiographic. *Nomothetic psychology* seeks general laws that can be applied to many different people, while *Idiographic psychology* is an attempt to understand the unique aspects of a particular individual.

Mayer (1998) stated that the field of personal psychology lacks a coherent structure, and that it is usually divided into two different frameworks, being either theory or research. He argues that the framework dealing with theory divides the discipline according to its major theorists like Freud, Jung, Rogers, Maslow, etc. The research frameworks, on the other hand, divide the discipline according to areas of empirical

investigation, such as repression, traits, social cognition, etc. A general framework for personal psychology, he proposes, needs three main components: it should be *impartial* relative to theory and research, should be *inclusive,* and theoretical distinctions should be sufficiently *clear.*

Maddi (1996) developed three models of theorizing personality, namely the *conflict* model, the *fulfillment* model and the *consistency* model. Pervin (1980) took a more detailed approach. His personality theories were divided between Psychodynamic Theory, Phenomenological Theory, Cognitive Theory, Trait Approaches, Behavioral Approaches and Social Learning Theory. This classification, however detailed, is not comprehensive.

Every researcher seems to agree on the fact that there cannot be one single all-inclusive personality theory, since an agreement on even the definition of personality is nowhere to be found. The researchers define personality in the way that they want to approach the topic. Eysenck, in his last journal paper publication, has criticized the personality handbooks from the 1970's till the 1990's because of their lack of discussion on what an acceptable theory of personality would be from a paradigmatic base (Eysenck, 1997). It is neither within the power of this researcher, nor within the scope of this research to solve the issues of classifying personality theories. However, following a strong inherent sense of being organized and meticulous, different categories of classification are combined to carry out the literature review for personality theories in a rigorous manner. Table 2 is used as a general guideline in order to have an orderly elaboration of personality theories that will serve the purpose and the scope of this research.

Table 2. Overview of Personality Theories

Personality Theories	Main Theme	Main Authors	Example
Trait	Predispositions to respond a certain way. Stable over time. Basic units of personality.	Allport, Eysenck, Cattell	16 Personality Factor Inventory, Big Five
Type	Distinct and discontinuous.	Jung	Myers-Briggs Type Indicator
Psychoanalytical	Innate forces. Inner, biological factors.	Freud	The unconscious; ego, super-ego, id
Behaviorist	Effects of external forces, external stimuli.	Pavlov, Watson, Skinner	Stimulus-Response Consequence Model
Cognitive	The way people think. Perception, analysis, interpretation.	Rotter, Bandura, Kelly	Social Learning Theory, Locus of Control theory
Humanistic	Human context, person-centered.	Maslow, Rogers	Person-Centered Theory, Hierarchy of Human Needs

2.2.2 Trait Theories

Pervin (1980, p. 232) defined trait theories as theories that "suggest that people have broad predispositions to respond in certain ways." For instance, if a person prefers going out to staying home, enjoys parties and similar gatherings, these habits can be grouped into the trait of "sociability." Traits are considered to be relatively stable over time, and different among individuals, and they are believed to influence behavior. Humphreys and Revelle (1984) have stated that personality traits are summaries of consistent behaviors throughout various situations.

One of the major trait theorists is Gordon Allport. He believed that traits are the basic units of personality. He proposed three different kinds of traits: *Cardinal traits* describe such strong dispositions that almost every behavior and action of a person can be traced back to the trait itself (i.e. Marquis de Sade). *Central traits* are the traits that are usually used to describe a person. *Secondary dispositions* are the least generalized and consistent of all traits. An important point to make is that Allport did not state that all traits are situation-independent. He acknowledged the importance of the range of

behaviors across situations. Pervin addressed this issue as such: "Trait concept was necessary to explain the consistency found in behavior; and recognition of the importance of the situation was necessary to explain the inconsistency or variability of behavior" (Pervin, 1980, p. 237).

Another important theorist, H. J. Eysenck (1947), was a strict advocate of scientific research, objective measurement and statistical analysis. His *three-factor model* of personality traits was one of the dominant models of personality structure in the 1950's. Supporting trait theory, he stated that there was a need to develop adequate measures of traits and a trait theory which could relate performance in different areas in a meaningful way and thus establish the biological foundations for the existence of each trait (Pervin, 1980).

Cattell (1957), similar to Eysenck, had a strictly scientific approach to studying personality. Being a research assistant to Charles Spearman, this is not surprising. The basis of his research to personality was the *factor-analytic* model. Similar to Allport, Cattell had his own distinction for traits. *Surface traits*, he argued, "are expressive of behaviors that on a superficial level may appear to go together but in fact do not always vary together and do not necessarily have a common cause" (as cited in Pervin, 1980, p. 248). *Source traits*, however, "expresses an association among behaviors that do vary together to form a unitary, independent dimension of personality" (Pervin, 1980, p. 248). The main result of Cattell's work was the 16 Personality Factor Inventory. The main problem with the 16-factor model was that the 16 traits were accepted to be too many, and the results of both the three-factor and the 16-factor models were not replicable across categories such as gender, age or methods (Zuckerman et al., 1993). Even though this is the case, Cattell's contributions to the personality assessment field have been acknowledged as very important and essential (Digman, 1990).

A more popular example to the trait theory approach is the Big Five theory (or the Five-Factor Model), whose five traits are Extraversion (or Surgency), Neuroticism (vs. Emotional Stability), Agreeableness, Conscientiousness (or Dependability) and Openness to experience (or Culture or Intellect), sometimes represented as OCEAN. Initiated by Allport and Odbert's (1936, as cited in Goldberg, 1990) cataloging around 18,000 terms, Cattell used this list as a starting point to construct a stable classification of 35 variables

(Cattell, 1943). Following Cattell's studies, the Big Five reached its fully developed version through Fiske (1949) and Tupes and Christal (1961). After a brief hiatus of twenty years, it was reintroduced to the psychology literature and research through several studies (e.g. Costa and McCrae, 1985; Digman and Takemoto-Chock, 1981; Goldberg, 1992; McCrae and Costa, 1989). Digman (1990) has reported many studies that have found correlations with the Five-Factor Model, such as heritability of personality (Plomin and Daniels, 1987), direct measures of family influence (McCrae and Costa, 1988), cross-cultural comparisons (Bond et al., 1975), masculinity-femininity (Farnill and Ball, 1985), and personality stability (Costa and McCrae, 1988).

Trait theories have been criticized (Block, 1995) because they are purely descriptive and offer little explanation for underlying causes of personality, the classifications are oversimplified, and finally, in underestimates the effects of specific situations. This is, however, according to trait theorists, a faulty criticism. Trait theories do not attempt to ignore the person-situation interaction, simply because there is no way of considering the person outside of the situation to begin with. These theories only emphasize the role of personal dispositions in behavior. The effects of trait theories and their place in personality history is undeniable, especially since theories such as the Big Five are still being used as part of establishing characters of individuals.

2.2.3 Type Theories

Type theories of personality provide a classification of different categories for people; a person can either be this type or that type. These categories are distinct and discontinuous, as opposed to the trait theories. For instance, according to the type theories, a person is either an introvert or an extravert; whereas according to trait theories, introversion and extraversion are two opposite ends of a continuous scale. The most widely used psychological type theory is Jung's character typology. The Myers Briggs Type Indicator (MBTI; Myers, 1962; Myers and McCaulley, 1985) is a widely used and highly regarded, self-report, forced-choice inventory for understanding and interpreting personality, and derives most of its underpinning theory from Jung's Psychological Types ideas. Myers (1962) built on Jung's theory by adding two different orientations to the outside world, and called these judging and perceiving. The first dimension consists of

four functions, namely sensation, thinking, feeling and intuition; and the second dimension consists of two attitudes, namely extraversion and introversion.

Both attitudes - extraversion and introversion - are present in every person, in different degrees. No one is a pure extravert or a pure introvert, and more recent studies (notably Eysenck) indicate that a big majority of people are actually a reasonably well-balanced mixture of the two types, albeit with a preference for one or the other. Two people may look at the same situation and yet see different things. They see things in terms of themselves and their own mind-sets, or their predispositions.

Jung's typology has been criticized for being hard to operationalize and measure (Eysenck, 1973; Mendelsohn, 1965; Stricker and Ross, 1964), which is one of the reasons why MBTI has been receiving criticism to this day (Garden, 1991; Johnson et al, 1998; McCrae and Costa, 1989; Michael, 2003; Walck, 1992). However, MBTI has established itself as one of the major personality indicators in literature, and is being used continuously today. The trait theorist Eysenck, in his Eysenck Personality Questionnaire (EPQ; Eysenck and Eysenck, 1968) also developed an extraversion-introversion scale, and in a research done by Steele and Kelly (1976), it was found that this scale in the two questionnaires had high correlations. This correlation, despite the different nature of the theorists, shows that the extraversion-introversion scale is a valid scale within self-report questionnaires.

Another example to the type theories is the Type A/Type B theory, which was developed by Friedman and Rosenman (1974). This theory specifically dealt with different personality types that may have a relation to coronary heart disease. In various reviews of literature on Type A behavior, Kunen and Stamps (1991, p. 924) have noted that in order to successfully identify the core of this behavior pattern, further research needs to be conducted to "describe the personality structure of the Type A individual in terms of well-established personality inventories." The purpose of their study was to look for a relationship between measures of Type A behavior pattern and the 16 Personality Factor model. They concluded that consistent correlations could be established between Type A personalities as measured by the Student Form of the Jenkins Activity Scale that was developed by Glass (1977) and the 16 PF Personality Questionnaire, that was developed by Cattell (1986).

The classification of different types of individuals has been the major focus of type theories, and the dominant theories (MBTI and Type A/Type B) are now a part of current everyday life for some individuals. How useful, accurate and robust these types are, is also part of ongoing research.

2.2.4 Psychoanalytical Theories

Psychoanalytic theory, developed initially by Sigmund Freud during the latter part of the 1900s, formed the foundation of modern psychology. Much of the theory and research that came later, even if it disagreed with psychoanalytic thinking, was nevertheless shaped and influenced by its perspectives. Sigmund Freud is considered to be the father of psychoanalysis. His studies were based on the notion that "human beings are motivated by powerful innate forces, to which he gives the name instincts, or drives" (Ewen, 1980, p. 13). Due to his extensive studies on the unconscious, it is now a widely accepted fact that "a part of human personality…is below the level of awareness" (Ewen, 1980, p. 13). According to Freud, from the moment of birth, the child passes through many psychosexual stages, which are essential to the development of personality. These stages are the oral stage, the anal stage, the urethral stage, the phallic stage, the latency period and the genital stage. Due to the emphasis on the unconscious, the psychoanalytic theory also focuses greatly on dream interpretation.

Freud, like any other researcher, was not without his critics. His studies were criticized because of their lack of internal consistency, for being too subjective and uncontrolled, for overemphasizing the biological determinants of personality and for lack of empirical foundation (see Ewen, 1980; Ewen, 1998).

Among the pioneering psychoanalysts who have opposed Freud's theories are Carl Gustav Jung and Alfred Adler (for more insight on the relationship between Freud and Jung, see Alexander, 1982; Eisold, 2002). In terms of dreams, on the contrary to Freud, who suggested that the symbols in dreams are reflections of infantile and sexual urges, Jung suggested "the notion of an autonomous realm of archetypes reflecting transcendent aspirations in the psyche" (Eisold, 2002, p. 512). Putnam (1917) suggests that Jung and Adler had misconceptions of their scientific duties, which in turn caused

them to reject Freud's theories without sufficient reason, even though these theories had permanent value.

2.2.5 Behaviorist Theories

Pavlov (1927) was the first behaviorist who focused entirely on the effects of external forces. His work was based on his "classical conditioning." John Watson also followed in Pavlov's footsteps. Skinner, another major behaviorist, believed that "the goal of a scientific psychology is to predict and control future behavior; and, like Watson, he warns that this objective cannot be achieved by any theory which attributes our actions to inner causes" (Ewen, 1980, p. 394). B. F. Skinner's belief system was based on the concept of operant conditioning (Skinner, 1963; Skinner, 1989). He stated that behavior of individuals was not only triggered by the environment, but was selected by the environment as well (Skinner, 1987).

Similar to the psychoanalytical theories, behaviorist theories have also impacted the discipline of psychology in a great way; however, another similarity between the two theories is the extremist approach to personality. Whereas Freud focused merely on the inner, biological factors, Skinner's focus was merely on the external stimuli. It is established today that the human mind and behavior are much more complicated than what each of the theories tried to explain. Eysenck (1997) has passionately stated that "personality cannot be understood with the biological side remaining in a Skinnerian black box!" (p. 1224).

Following this statement, the next part is going to focus on theories of personality that do not only consider external factors, but more importantly, focus on internal processes and mental compositions within individuals.

2.2.6 Cognitive Theories

Cognitive theories focus on the cognitive processes of individuals. These are internal processes that mostly deal with perception, information processing, learning, reasoning, etc. Unlike the behaviorist theories described above, the cognitive theories of personality emphasize the internal nature of the mental processes that take place within an individual. According to Schwenk (1984), cognitive psychologists have conducted studies in order to identify a wide range of cognitive processes that will provide helpful simplifications to a

decision-maker. Shuell (1986) stated that with cognitive psychology, the focus is not only on behavior, but also "on the mental processes and knowledge structures that can be inferred from behavioral indices and that are responsible for various types of human behavior" (p. 414).

Albert Bandura is one of the founding fathers of cognitive theory. He has developed the *Social Cognitive Theory* (Bandura, 1986) in which he notes that self-regulation of motivation and performance is established through regulatory processes, such as self-efficacy. In Wood and Bandura (1989), the research was focused on how the social cognitive theory applies to management of organizations. That is, how personal factors and behaviors contribute to organizational and environmental dynamics. Bandura (1990) has stated that even though there have been criticisms towards the social cognitive theory, presenting it as merely based on processes rather than structures, this theory, in essence, rejects the separation of process and structure. He goes on to state that structures of personality are created by processes; therefore, it is difficult to think of a personality process that is *not* based on structure.

Another important theory of cognition is one that focuses on *information-processing*. According to Schneider and Shiffrin (1977), the two main types of information processing are *controlled* and *automatic*. In controlled information-processing, a sequence of nodes are activated through the person's control. Automatic processing, on the other hand, is activated through an input-whether internal or sensory-which is outside the individual's control.

Studies focusing on cognitive theories deal with various variables, such as decision-making (see Schwenk, 1984, for a review), learning (Shuell, 1986), epistemic processes (Estany, 2001; Kruglanski, 1990), problem-solving (Frederiksen, 1984; Tallman, Leik, Gray and Stafford, 1993), operations research (Klein, 1994), political belief systems (Conover and Feldman, 1984) and improving construct validity (Embretson and Gorin, 2001), among others. Since it deals with basic internal processes and structures within an individual, these theories (and studies) are extremely crucial for further development and understanding of personality research.

2.2.7 Humanistic Theories

Humanistic psychology is a school of psychology that emerged in the 1950's in reaction to both behaviorism and psychoanalysis. It is concerned with the human dimension of psychology and the human context for the development of psychological theory. Abraham Maslow and Carl Rogers were the founding fathers of this new perspective to personality. Maslow (1971) stated that this new kind of psychology is different than Freudian and behaviorist psychologies in many ways. Rogers named his theory "person-centered theory" (Rogers, 1945). According to him, "human beings are motivated by a single positive force: an innate tendency to develop our constructive capacities and grow in ways that maintain or enhance our total organism" (Ewen, 1980, p. 322). In a joint paper written by Rogers and Skinner (1956), they both state their opinions on certain issues concerning the control of human behavior, and how the human behavior can be explained, predicted, shaped and influenced by conducting experiments and acquiring knowledge through scientific means. In this symposium, Rogers states that instead of utilizing scientific knowledge to control and "depersonalize" human beings, this knowledge and behavioral sciences should be used to free them, to help individuals be adaptive and aware of their choices, and to "bring about constructive variability" (p. 1064).

Maslow shared Rogers' view on human nature. He argued, however, that "the various human needs differ considerably in their level of prominence: some remain relatively unimportant, and unnoticed, until others have at least to some extent been satisfied" (Ewen, 1980, p. 346). He developed the widely-used Hierarchy of Human Needs (Maslow, 1943), which consists of five levels. It starts with basic *physiological* needs at the bottom, followed by *safety* needs, *belongingness* and love needs, *esteem* needs, and finally the need for *self-actualization*. One of the leading worldview scholars, Koltko-Rivera has suggested in a recent study that the later version of Maslow's research (Maslow, 1969, as cited in Koltko-Rivera, 2006) includes *self-transcendence* as another level in the hierarchy, beyond self-actualization (Koltko-Rivera, 2006).

Researchers' objectivity in studies dealing with personality was another common issue that both Maslow and Rogers have shared, and considered to be extremely important. In a study conducted in 1945, Rogers suggested that the nondirective interview

technique could be an appropriate method applicable to social research (Rogers, 1945). He noted that the unbiased characteristic of this method would make objective research on human behavior possible. Maslow, in 1937, had faced a similar problem when he "attempted" to study the relationships between dominance behavior and social behavior, but failed because of "the multiplicity of theories, the variability of concepts and of terminology, the sheer complexity of the problem itself, [and] the impossibility of separating the superficial from the fundamental" (Maslow, 1937, p. 488). However, almost 40 years later, in one of his last articles, Maslow (1971) noted that he rejects positivism, behaviorism and objectivism as theories of human nature. He states that the study of "objects and things" cannot be used to study human beings. According to him, if individuals are conscious of what they are doing and are "philosophically insightful" in doing it, then the experiences shared by individuals could lead to no revelations (Maslow, 1971, p. 153).

2.2.8 Research Using Personality Theories

Establishing a common medium to work towards common goals is already an important issue within an organization, especially when dealing with complex problems. Alignment of personal objectives with the organizational objectives is a challenging issue, even without the dynamic effects of the environment. Once the complex situational elements and the dynamics of the environment are included in the equation, survival seems to be the sole objective of any organization. This is where the topic of personality and personality theories become most crucial. The mere reason for establishing measures of personality is inherently related with dealing with problems. These problems can be related with everyday one-on-one relationships, or with professional, job-related relations. As Wittmann and Hattrup (2004, p. 394) has stated, "research in psychology is beginning to shed light on the processes by which humans acquire knowledge of complex systems, make decisions in such environments, and react to feedback from these systems."

Different personality measures (mostly Big Five and MBTI) have been associated with a variety of topics, such as job fit (Chatman, 1989; Ehrhart, 2006; Erdogan and Bauer, 2005; Gulliford, 1992; Miller, 2003; O'Reilly et al., 1991), decision-making (Gul,

1984; Haines and Leonard, 2007; Leonard et al., 1999), dealing with risk (Campbell et al., 2004; Lark, 1991; McCarthy, 2000; Schaninger, 1976), teamwork (Darling, 1990; Manning et al., 2006; Tett and Murphy, 2002), problem-solving (Nauta et al., 2002), personnel selection (Marcus et al., 2006; Salgado, 2003), leadership styles (Cable and Judge, 2003; Hanbury et al., 2004), job performance (Ashton, 1998; Barrick and Mount, 1991; Hurtz and Donovan, 2000; Tett and Burnett, 2003) and job satisfaction (Downey et al., 1975), to name a few. There seems to be a continuous demand for relating personality traits with organizational settings and practice-oriented measures. All of this is done in order to increase satisfaction and productivity, whether from an organizational sense or a personal sense.

There are certain benefits that come out of these types of research. One of the main advantages is that they provide insight on how different personality measures can be correlated with organizational variables, which may in the end serve the need to justify issues such as team-building, employee hiring, etc. Personality questionnaires can also benefit from these types of research. The more empirical the research is, the more statistical proof is obtained relating to the instrument itself.

However, these studies are not without limitations. Following a brief scan of literature, it can easily be said that most of the studies on personality measures use either the Big Five or the Myers-Briggs Type Indicator. For instance, Hogan (as cited in Barrick and Mount, 1991) proposed six dimensions, where the Extraversion dimension would be split into Sociability and Ambition. What is more interesting is that at the same time, there is a fair amount of research going on that deal with the limitations and weaknesses of these same questionnaires (see Pittenger, 1993). It is understandable -and necessary- that new personality measures and theories need time and a great amount of rigorous research needs to be established so that robust and feasible theories can be included in the body of knowledge. However, it is argued in this dissertation that by modifying the fundamental assumptions and underpinnings that the traditional personality theories are based on, the discipline can be pushed even further. Table 3 is a summary of different research areas that look at personalities of individuals.

Table 3. Example Research Using Personality Theories

Discipline	Author
Job Fit	Chatman, 1989; O'Reilly et al., 1991; Miller, 2003; Erdogan and Bauer, 2005; Ehrhart, 2006
Decision-Making	Gul, 1984; Leonard et al., 1999; Haines and Leonard, 2007
Dealing with Risk	Schaninger, 1976; Lark, 1991, McCarthy, 2000; Campbell et al., 2004
Teamwork	Darling, 1990; Tett and Murphy, 2002; Manning et al., 2006
Personnel Selection	Salgado, 2003; Marcus et al., 2006
Leadership Styles	Cable and Judge, 2003; Hanbury et al., 2006
Job Satisfaction	Downey et al., 1975; Agho, Mueller and Price, 1993; Watson, 2000; Judge, Heller and Mount, 2002; Franek and Vecera, 2008
Problem-Solving	Weinman, 1987; Wolfe and Grosch, 1990; Adeyemo, 1994; Nauta et al., 2002; Morera et al., 2006

2.2.9 Worldviews

Worldview is an interesting and difficult concept to analyze. The interesting aspect comes from the fact that there is actually a literal definition of the word, unlike other intangible concepts, such as personality, leadership, etc. As defined in the earlier section of the dissertation, the word itself comes from the German word *Weltanschauung*, which literally means "world view." It is described as a belief, an assumption, or an outlook towards reality. The difficulty here comes from the fact that such a simple word can carry so much baggage within itself. There are countless ways that different constructs can be, and are, being built into worldviews.

Pepper's World Hypotheses (Pepper, 1942) includes four major philosophical worldviews, namely Formism, Mechanism, Organicisim and Contextualism. In an effort to measure these worldviews, Harris et al. (1977) constructed the World Hypothesis Scale (WHS). Germer et al. (1982) operationalized the world hypotheses by constructing the Organicisim - Mechanism Paradigm Inventory (OMPI).

In their research analyzing worldviews, Johnson et al. (1988) conducted two different studies. The first study was done by using the WHS and the OMPI, in order to examine and compare both scales. The results were in favor of the OMPI, by means of higher intercorrelations and validities. The second study was done in order to test the prediction that individuals "will behave in a manner that is consistent with their philosophical worldviews." To test this, they used the OMPI against different personality scales, including the MBTI, the California Psychological Inventory, and Edwards Personal Preference Inventory, etc. Their studies concluded that the OMPI scale of philosophical worldviews somewhat correlated with a variety of the personality scales, most strongly with MBTI and CPI. It is not surprising that individuals with an organismic worldview were identified as more social, more intellectual and more intuitive; whereas mechanistic individuals were found out to be more shy, concrete, "down to earth" and "sense-oriented." Even though this study has its limitations, it is still a good example on how worldviews and personalities are associated.

In another study, conducted by Babbage and Ronan (2000), the relationship between philosophical worldviews, scientific tendencies and personality have been examined. They have stated that philosophical foundations, or worldviews "guide what observations will be made, what questions will be asked, and what conclusions will be reached" (Babbage and Ronan, 2000, p. 405). Their study was mostly based on the research conducted by Johnson et al. (1988), described above. An additional scale they used was the NEO Five Factor Inventory (Costa and McCrae, 1992). They also changed the sample domain, and used academically-based scientists, as opposed to university students. Their study also provided empirical support that there is a link between philosophical worldviews, scientific predilections and personality.

There is a clearly established link between worldviews and individual personalities. Whether this is a statistically strong correlation or not does not underestimate the value of the argument that worldviews are intertwined with personality profiles. This is why the underlying component of the proposed personality profile can be seen as philosophical worldviews. These underlying philosophical constructs for the worldviews, or predispositions, will be discussed in the latter sections of the literature review.

2.3 Philosophical Paradigms

The second component of the Background Research section is the discussion of philosophical paradigms. As outlined in the Introduction section, this research focuses on building a philosophical profile of the individual and analyzes how these different profiles deal with complex problems. The relationship between philosophy and personality constructs have been briefly addressed in the previous sub-section and will further be elaborated in Section Four. This background research on individual philosophical paradigms is intended to provide support for the latter arguments.

2.3.1 Overview of Paradigms

There are different paradigms that philosophy is concerned with, and depending on the researcher or the discipline, these paradigms tend to alternate usually between three or four types. A paradigm is a general perspective or way of thinking that reflects fundamental beliefs and assumptions (Kuhn, 1970). Mingers (2003) provides a more detailed definition for a paradigm: "A paradigm is a construct that specifies a general set of philosophical assumptions covering ontology (what is assumed to exist), epistemology (the nature of valid knowledge), ethics or axiology (what is valued or considered right), and methodology" (p. 559).

Denzin and Lincoln (1994) consider Ontology, Epistemology and Axiology as the main philosophical paradigms. Ruona and Lynham (2004) include Methodology within Axiology, whereas Guba and Lincoln (1994) discuss Ontology, Epistemology and Methodology as the main components of philosophy. In order to create a more compelling and comprehensive philosophical profile of the individual, additional aspects of philosophical paradigms should be considered. For this reason, one further paradigm is included in the philosophical categories, which is the Teleological paradigm.

Ontology has been associated with religion (Sontag, 1956) and metaphysics (Kienzle, 1970; Sontag, 1956). The context that is of interest in this research is similar to the one proposed by Fine (1991), which is the manner in which an individual sees and constructs reality that makes him/her predisposed to the way he/she understands that reality. The definition an individual has of himself or herself, and his or her surroundings will have strong implications on his or her mindset and actions.

Epistemology is the philosophy of knowledge or of how we come to know. It deals with the question of what can be known. It is also closely associated with the psychology of cognition (Goldman, 1978), with the premise that one cannot give the best advice about intellectual operations without detailed information about mental processes. Another approach for Epistemology deals with probability, as a mode of justification (Pollock, 1983), with the assumption that the rationality of belief is almost entirely a matter of probabilities. The Epistemological paradigm as it applies to this research discusses how the individual seeks knowledge about reality.

Teleological questions deal with the purpose of inquiry (Griffin, Shaw and Stacey, 2000). The main teleological question is why does a particular phenomenon become what it becomes? The Teleology paradigm is directly related with the state of the future as well. Therefore, how the individual sees the future and why he or she chooses to act a certain way according to that future will be discussed within the Teleologies.

Axiology is associated with morality and ethics (Kupperman, 1996) and it is the branch of philosophy that is concerned with the concept of values. The set of beliefs, attitudes and values that arise out of an individual's moral philosophy of ethical ideology provide a framework that individuals can use to consider ethical issues and make ethical judgments (Barnett, Bass and Brown, 1994).

The paradigm of *Methodology* deals with the specific methods in which knowledge is obtained (Leedy and Ormrod, 2001). This paradigm can be assumed to be one level more specific than Epistemology. Whereas Epistemology is the theory of acquiring knowledge, Methodology is the detailed explanation and description of "how" and through which means this knowledge is obtained. Methodology is epistemology within an implemented and more pragmatic level, and tends to be associated more with doing research, rather than being considered as part of any literature related to personalities or psychology. Therefore it will not be considered here as part of the philosophical paradigm literature.

2.3.2 Ontology

Ontology, in a very simplified sense, deals with the nature of things. Smith (2003) provides a concise definition of ontology: "Ontology as a branch of philosophy is the

science of what is, of the kinds and structures of objects, properties, events, processes and relations in every area of reality" (p. 1). Therefore, as Solem (2003) puts it, ontology is "our picture of how the world looks; our worldview" (p. 439). There are different views about what constitutes an item being accepted into ontology. For some, it is merely a matter of existence or being; for others, it is a matter of real existence or being, where this is something that stands in contrast to ordinary existence or being (Fine, 1991). Fine further elaborates that an item is accepted into ontology because it should be there, not because someone put it there. Ontology is total, it includes everything that is accepted and ontology is actual, it includes everything that is correct to accept (Bozkurt, Padilla and Sousa-Poza, 2007). Many ontological levels can be established, in terms of individual/group levels (Nonaka and Takeuchi, 1995), in terms of being in and out of observation, and in terms of what is being observed (Rescher, 1996). Klemke (1960) discusses a phenomenalist philosophy, which includes the particulars/universals ontological discussion. He defines ontology as *what exists.* He defines *universal* and *individual* as:

> Universal: the repeatable character, whose instances are commonly called qualities of individuals or relations among individuals; hence, that which is never wholly contained in any one presentation, unless it exists only in that one presentation (which could never be known with certainty to be the case)
>
> Individual: That about which a quality or qualities may be predicated, or that which may stand in a relation to other individuals (p. 256)

From an empiricist stance, he states that an individual cannot perceive or sense or directly know the universals. If the universals exist, then for the individual to have any information or knowledge about them, there should be another way other than direct acquaintance. This principle of acquaintance is the philosophical concept in which the term empiricism has been associated (Hochberg, 1965).

Another approach to ontological school of thought is the *subjective/objective* perspective. Solem (2003), modifying the concepts that were discussed in Morgan and Smircich (1980), discusses these two opposing extremes of ontological thought as *Realism* and *Nominalism*. Realism is the school of thought in which reality is defined as being external to the individual; it is objective by nature, and is "out there," which means that the individual can reach the reality that is outside him or herself. Reality defined by the realists is a hard and concrete structure. Nominalism, on the other hand, advocates that reality is produced by the consciousness of the individual, that it is a product of one's own mind, and is therefore subjective by nature.

The philosophical thought of *Process Ontology* versus *Substance Ontology* has been set forth and argued extensively by many individuals, one of the founding fathers being Alfred Whitehead. Whitehead's Process Philosophy is built on the foundational arguments of change and evolution (Romer, 2006). The view of reality from a process philosophy perspective is based on conceptual contrasts, such as being and becoming, process and thing, and event and structure (Kakol, 2002).

These two different predispositions are generalized categories that have implications on almost any aspect of the everyday life of an individual. For instance, when an individual is put into a position where he/she needs to deal with a complex problem, a crucial point is how the individual perceives this problem. Some individuals tend to see problems as a whole, or as one process; while some individuals tend to see smaller entities and instances coming together to form the problem.

This is the main distinction of the process vs. substantive approaches. Similarly, Smith (2003) identifies individuals from these different schools of philosophy as substantialists and fluxists. The former consider ontology as a substance (or thing) based discipline, and the latter type, for whom the concept of ontology has been centered on events or processes. A person can see reality as individual elements, or a collection of these elements. The individualistic or reductionist approach corresponds to a substantive related ontology, whereas the collective approach corresponds to a more process related ontology (Rescher, 1996). The way we see things around ourselves also puts into perspective where we stand as individuals. Therefore, the element vs. whole approach is a crucial aspect of the ontology. Due to this very specific distinction, Rescher's Process vs.

Substantive Philosophy argument (Rescher, 1996; Rescher, 2006) is the main school of thought that is the ontological focus of this research.

Rescher (2000) describes a process in three factors: a process is complex, since it has distinct stages or phases connected together in a sequence; this complexity also contains a temporal component; and a process has structure. He presents five propositions that process philosophy is based on:

1. Time and change are the principal categories
2. Process is a principal category of ontological description.
3. Process is more fundamental (or no less fundamental) than things for the purposes of ontological theory.
4. Several major elements of ontology (such as persons, material substances, etc.) are best understood in process-linked terms.
5. Contingency, emergency and creativity are among fundamental categories.

According to Rescher, the process philosophy is concerned with "what exists in the world and with the terms of reference in which this reality is to be understood and explained" (Rescher, 2006, p. 1). Processists argue that everything surrounding the individual is best understood as processes (modes of change), rather than things (fixed stabilities) (Rescher, 2006). A substantive-ontologist, on the other hand, will see reality as "a collection of *things* and *objects*" (Rescher, 2000, p. 11). Seeing the world as a process, Rescher argues that "a coherent conceptualization of nature" has been established, and the problem of having a lack of understanding on laws and principles of nature is avoided.

Table 4 is a summary of the characteristics for both philosophies (Modified from Rescher, 1996).

Table 4. Process Philosophy vs. Substantive Philosophy

Substance Philosophy	Process Philosophy
Discrete	Interactive
Individual	Functional
Separateness	Wholeness
Passivity	Activity
Uniformity of Nature	Innovation
Unity of Being	Unity of Law
Stability	Fluidity

2.3.3 Epistemology

A major branch of philosophy that has been devoted to analyzing the method of acquiring knowledge is called "epistemology" or the "theory of knowledge" (Churchman and Ackoff, 1950). Epistemological beliefs are individuals' beliefs about the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides and how knowledge occurs (Hofer, 2002). Questions put forward by epistemology include: What are the sources of knowledge? What is the nature of knowledge? Is our knowledge valid?

The Epistemological paradigm is related to *how* the individual tends to seek knowledge about reality. The two main currents that are of interest in this research are Empiricism and Rationalism. As Reichenbach (1947) stated, both of these paradigms were formulated as philosophical systems during the times of Greek philosophy, starting with Socrates, Plato and Aristotle. Matthews (1984) noted that the Empiricist-Rationalist debate has preoccupied many philosophers, psychologists and linguists. The two epistemological arguments have been chosen according to the following criteria:

- General philosophy literature
- Use in similar context
- Scale between extremes

- Openness to argumentative structure

As will be seen from the discussions below, a plethora of studies have been conducted, and arguments have been made on these two paradigms. The purpose of this discussion is to present sufficient background on both concepts so that when they are used as dimensions for the philosophical profile, the basic premises of the two paradigms are made clear from the beginning.

- **Empiricism:**

The Empiricism Thesis states that one cannot have a source of knowledge in a subject area or for the concepts that are used in that area other than *sense* experience (Stanford Encyclopedia of Philosophy). Therefore, empiricism is a theory of knowledge which emphasizes those aspects of scientific knowledge that are closely related to *experience*, especially as formed through deliberate experimental arrangements. Empiricism is strongly tied to scientific method. One of the essential requirements of this method is that hypotheses and theories have to be tested against observations, rather than resting solely on a priori reasoning, intuition, or revelation.

Krikorian (1950) states that the one common aspect in all empiricists was that they all accepted *experience* as the final decider on any question or fact; however, he goes on to state that due to the flexible nature of the word "experience," some modern empiricists have shifted to considering *experiment* as the replacement. Krikorian also joins this group and states that "for an empiricist the definition of what a thing is [is] to be found in the experimental procedure..." (p. 258). Moore (1902) has devoted an entire paper on *experience and empiricism*, so has Dewey (1905); these papers have been discussing this argument since the turn of the century. Benjamin (1942) has also touched on this point and argued that since everyone experiences things differently, with different degrees of clarity, using the word "experience" is one of the reasons why there is vagueness in the definitions. Johnson (1974) states that empiricism is usually tied with perception, which means that the characteristics of the objective world itself are available to individuals without any subjective opinions, beliefs or interpretations. He also notes that the main reason why perception, and therefore empiricism, is of interest to philosophers is because perception results in knowledge. In describing empiricism, the Scottish philosopher James has stated that "the subject has to *learn everything* from the

object, to conform to *it*, to learn *its* ways, to reproduce *it*" (as cited in Seth, 1893, p. 551). He also notes that through empiricism, the constant variety and change within reality is revealed, while the same reality is stereotyped through rationalism.

Benjamin (1942) describes the three dominant forms of empiricism as Positivism, Constructivism and Realism. Positivism has its roots in the hypothetico-deductive method. The primary goal of positivistic inquiry is an explanation that ultimately leads to prediction and control of phenomena (Ponterotto, 2005). Strong ties to empiricism makes this epistemological perspective scientific and experimental based. Positivism states that reality exists independent of people and can be objectively investigated by employing valid and reliable measurements. In positivism, the correspondence theory of truth enters the arguments. The source of truth is in reality; therefore a statement is proved to be true if it agrees with an independently existing reality and is false if it does not (Kim, 2003). Solem (2003) has defined the positivistic epistemological debate as consisting of hard knowledge, which is real and is capable of being transferred and transmitted in a tangible format.

Constructivism, on the other hand, assumes knowledge to be soft and more subjective. This type of knowledge is more intangible, and is based on experience, insight and personal nature of the individual. Constructivism is considered as a modified version of positivism, and argues that reality is constructed within one's mind. It still carries on the basic premise of positivism, which is the necessity of hard data and facts; however, it is more flexible in the sense that knowledge can be an extension of what is known, rather than the direct relation to the thing that is known. According to Bird (2003), constructive empiricism argues that data radically underdetermines the theories, since there can be many possible scenarios (or hypotheses) that are consistent with evidence that is collected. Realistic empiricism also shares this trait, and further states that soft data may exist, beyond that which can be sensed and inferred. Dickson (1995) notes that sometimes the best way to explain a phenomenon that was observed is by using causal relationships, that some unobservable entity has caused the phenomena. These entities can be assumed to be theories at best.

In criticism of Empiricism, Chisholm (1948) discusses the "relativity of sense perception" argument, which argues that a statement based on senses (or sense-datum) is

not enough for the statement to be true; in order for this to happen, the things-perceived should be considered conjointly with observation-conditions. However, he leaves the question of what is sufficient to justify perceptual knowledge, open-ended. Benjamin (1943) has noted that through certain rules of deductive logic, individuals can test hypotheses, and the results can be verified, which would eventually generate truth, rather than error. He states that "[t]he empiricists have given us a logic of the *testing* of ideas, but no logic of the *acquisition* of ideas [italics original]" (p. 16).

Empiricism is undeniably one of the major paradigms of philosophy, and is very dominant among certain individuals who feel that observation, experimentation, testing and experience are at the root of creating knowledge.

- **Rationalism:**

Rationalism is the philosophical belief that asserts that the truth can best be discovered by reason and factual analysis. It is the epistemological theory that is based on the premise that significant knowledge of the world can best be achieved by a priori means; therefore, it is in contrast with empiricism. Rationalistic epistemology is characterized mainly by a deductive process of argumentation, that all knowledge could be derived deductively. According to the Stanford Encyclopedia of Philosophy, to be a rationalist is to adopt at least one of three claims. According to the *Intuition/Deduction* Thesis, some propositions in a particular subject area are knowable by individuals by intuition alone. Still others are knowable by being deduced from intuited propositions. The *Innate Knowledge* Thesis states that individuals have knowledge of some truths in a particular subject area as part of their rational nature. The last claim is the *Innate Concept* Thesis, which states that individuals have some of the concepts they employ in a particular subject area as part of their rational nature.

It is interesting to note that in the early and mid 1900's, Rationalism was not a favored concept, and was mostly used together with the term "so-called," as in "the so-called Rationalists" (Ladd, 1913; Moore, 1948). However, the advocates of Rationalism as a philosophical inquiry paradigm have been unyielding enough that even today there are studies being conducted on this particular subject. It has been discussed in many concepts, such as theology (Green, 1972) and linguistics (Stich, 1979), and is still being discussed as a philosophical paradigm itself.

Moore (1948) argues that the distinction between empiricism and rationalism in terms of *a priori/a posteriori* context is "unfortunate," because the concept of *a priori truth* itself is not defined clearly. Therefore, he distinguishes the two paradigms by stating that a priori knowledge for a rationalist individual does not mean that there is knowledge prior to all kinds of inspection, but only to *sense-related* inspection. He states that the *reason* a rationalist uses is not necessarily equal to *reasoning*, but is equivalent to rational seeing, which also includes intuition. The contrast with Empiricism comes from the fact that empiricists have limited their knowledge only to sense experience. Wilson (1926) argued the same issue, and stated that rationalism does not say that all that is known is a result of the mind thinking things that are true; but rather, *part* of the knowledge is produced by the senses, and part of it is through *a priori* cognition.

Ruja (1938) defined rationalism as "the belief that nothing occurs which can not be explained somehow, and to explain is to subsume under or to infer from a principle wider than the principle describing the datum in question" (p. 285). This is in contrast to the arguments discussed above in empiricism that anything that can be known or learned comes from the object itself. To support the argument that mere evidence is not sufficient, Bealer (1999) presents the Gettier examples and researchers who are advocates of the coherence theory of truth (who he "coherentists"). It is important to stress here that "good evidence" is not sufficient anymore to be considered as a source of knowledge; it is, however, required for critical understanding (Bealer, 1999). The rationalists agree that knowledge may come from experience; however they disagree in the fact that it *must* (Haserot, 1947).

2.3.4 Teleology

Historically the term "teleology" has been subject to considerable ambiguity, being used within three contexts, with two that merge into each other (Weber and Rapaport, 1941):

> The first may be called the descriptive sense in which the term is regarded as synonymous with purposive or having a purpose. It is used to describe a common mental attitude in which some plan is projected for the future. In the second sense, the term is taken to mean that the

> goal or end towards which a process is directed is itself a determinant of the process. The third sense, which may be called the metaphysical sense, is nothing more than a systematic extension of this same principle to the entire universe. Reality is conceived to be a hierarchy of ends, exhibiting varying degrees of systematic completeness and tending toward a single end, which thus to the extent to which all other things are instruments in its service determines their existence and character (p. 70)

Perlman (2004), in his efforts to develop a taxonomy of teleological theories, has noted that since teleology has been included in various fields it has become difficult to establish a full grasp of the relevant teleology literature, which may be the reason why many theories on teleology have been proposed yet not completed.

Purpose can be related to active behavior (Rosenbueth et al., 1943) towards the attainment of a goal. Given that teleology is purposive and goal oriented (Rosenbueth, et al., 1943; Weber and Rapaport, 1941), purposeful active behavior represents the inherent sense of teleology. However Rosenbueth et al. (1943) go a bit further to define the concept. A teleology is based on feed-back to be predictive (extrapolative) and non-predictive (non-extrapolative).

Teleology is an area of philosophy which explains the future in terms of the past and the present based upon the study of purpose, ends, goals and final causes. Teleological assumptions deal with the purpose of the actions. It is a philosophical principle which explains that purpose or goal is the final cause for guiding movement of an entity. For this reason, the teleologies described by Stacey et al. (2000) are considered in this research. This teleological framework includes 2 main components. The first component deals with the assumption of future. This assumption in itself has two components. The movement can be toward a known state, or an unknown state. The second component of the teleological framework is the reason for movement into the future. There are 5 teleological perspectives defined by Stacey et al. (2000) that deal with the reason for movement. These are *Natural Law Teleology, Rationalist Teleology, Formative Teleology, Transformative Teleology and Adaptionist Teleology.* The first

three teleologies correspond to the known state of the future, and the last two correspond to the unknown state of the future.

Natural Law Teleology assumes that the future is a repetition of the past. The purpose of movement or change is to sustain an optimum state. Self-organization is non-existent, and the nature of change is fitting and aligning.

In *Rationalist Teleology*, there is a chosen goal in the future, and the movement is towards realizing that chosen goal. Yet again, similar to Natural Law Teleology, self-organization does not exist. The origin of variation is through rational processes. The decision maker points to the chosen goals of the organization and designs a system of rules and procedures to achieve them, or identifies systemic interactions that might undermine their achievement.

Formative Teleology is when there is an implication towards a form of self-organization, though without significant transformation. In this teleology, the final state, or the future, can be known in advance. The movement is to realize or sustain a final form, which is already there.

The future is unknowable yet recognizable in *Transformative Teleology*. Continuity is the underlying concept for this particular teleology. A perpetual motion defines the state of the future, and the purpose of the movement or the action. An iterative process sustains continuity, with a potential for transformation as well. There may be gradual or abrupt changes, or no change at all in the identity.

The *Adaptionist Teleology* is different than the others in a way that the environment is a part of the teleology. Adaptation to an environment which may change in unknowable ways is the base of the teleology.

2.3.5 Axiology

Axiology, defined by Encyclopedia Britannica, is the *theory of value* (from the Greek word *axia*, meaning value or worth), and therefore, is the "philosophical study of goodness, or value, in the widest sense of these terms." Hart (1971), when discussing the theory of values, states that current axiological studies deal with problems such as the

nature and status of values, whether values are relative with respect to the social environment, or are related to the idiosyncrasies of individuals, etc.

Schlenker and Forsyth (1977) and Forsyth (1980) have divided individuals into two groups according to their ethical ideologies: *Relativistic* individuals reject general, universal moral principles; whereas *idealistic* individuals believe that moral actions need to have positive outcomes, and that the behavior of any individual should be according to whether any other individual will be harmed or not in the process. In the empirical studies that were conducted by Forsyth through the 1980's (Forsyth, 1980; Forsyth, 1981; Forsyth and Pope, 1984) suggest that individuals with these different ethical ideologies also present differences in terms of their ethical judgments with respect to certain ethical issues. Kohlberg (1983) has suggested that moral values of individuals change as they go through different stages in life. Brown (1938) discussed the psychological basis of ethics, and presents the differences between psychology and ethics:

> Whereas ethics is the science which deals with what ought to be, with codes of conduct that ought to be followed, with types of character that ought to be created, and so has reference to a standard of goodness or rightness, psychology is a natural science, stressing merely the laws of sequence in mental processes (p. 1).

The "codes of conduct" that Brown talks about could be interpreted as being similar to the "moral values" that Kohlberg discusses. The disposition of an individual would not remain constant as the individual matures. Different events, interaction with other individuals and social issues may change how the individual regards his/her own moral values and judgment towards ethical issues. Barnett, Bass and Brown (1994) have looked at the issue of business-related ethical issues, and have concluded that the ethical judgments of people with respect to different business-related issues changed according to their ethical ideologies. An ethical ideology, as defined by Schlenker (2007), is a set of beliefs, values and standards that define the orientation of an individual towards right and wrong. This orientation can also be related to a belief in a just world, which is a concept

that was extensively studied by Dalbert et al (2001). According to these studies, this belief stems from an obligation to behave fairly, interpreting events in one's life in a meaningful way, and a confidence that one will be treated fairly by others. The research conducted by Wolfradt and Dalbert (2003) showed certain correlations between certain factors of the Big Five Personality Test and the belief for a just world. For instance, the more strongly individuals believed in a just world, the more tendency they showed for conscientiousness. However, there was no correlation with respect to extraversion.

2.4 Solving Complex Problems

Problem-solving has been of interest to researchers since the 1940's. From early experimental studies to current studies which incorporate many different research methodologies, from survey to simulation, it is clear that problem-solving is a crucial element for academia, as well as for industry practitioners. Throughout his/her life, an individual will most definitely face all types of problems, from most simple ones to the more complex problems. Without any exception, any profession will have complex surroundings, creating complex problems. One has to be aware of the tools and techniques available within, in order to efficiently deal with complex problems. In this research, philosophical predispositions will provide capabilities for individuals to deal with these complex problems.

This section is divided into two main parts. In the first part, an overview of problem-solving literature is presented. The second part is an overview of the different bodies of literature that deal with complex problems, situations or systems. The purpose of this section is to look at how these different studies analyzed complexity, and what major constructs were used to describe complexity in general, and complex problems in particular. It is important to note that the *complex problems* literature is not the same as *complexity* literature. Important studies within complexity literature will be discussed with the purpose of identifying characteristics for complex problems.

2.4.1 Defining and Solving Problems

There are three common elements in almost all the definitions for what a problem is: These three elements are an initial (or perceived present) state, an end (or perceived desired) state and the obstacles that make up the gap between these two states, or the

processes that need to take place to bridge the gap between these two states (Rubinstein, 1986). Problem-solving is a goal-directed sequence of cognitive operations (Newell & Simon, as cited in Ginossar and Trope, 1987). Personality and problem-solving has been associated together in many studies (Adeyemo, 1994; Barry and Stewart 1997; Dailey, 1978; Morera et al., 2006; Weinman, 1987; Wolfe and Grosch, 1990).

Tallman and Gray (1990) define problem-solving as a process that involves, at minimum, three stages: recognition, selection from among alternative courses of action and evaluation of outcomes. A problem, according to them, is a barrier to attaining a desired goal under conditions of uncertainty. It is also important at this point to mention that problem-solving and decision-making are two different processes. Problem-solving is defined as a process that is driven by a related series of various decisions (Tallman and Gray, 1990). Differences in problem-solving styles for individuals may depend on social learning, genetic factors and cultural conditions, among other variables.

Lohman (2002) states that there are seven stages for effective problem-solving:

1. Problem identification
2. Goal selection
3. Generation of alternative solutions
4. Consideration of consequences associated with alternative solutions
5. Approach to decision-making
6. Implementation of solutions
7. Evaluation of solutions

The recognition (Tallman and Gray, 1990) or the identification of a problem (Lohman, 2002) are closely related to *problem representation*, which is one of the elements that problem-solving contains, according to Frederiksen (1984). He states that inaccurately representing a problem or an incomplete representation of a problem may result in a no-solution situation. Tallman et al (1993) have argued that problem-solving involves four stages: perception of the problematic situation, searching for and processing information that will assist in problem-solving, engaging in problem-solving activity, and finally evaluating the outcome of this activity. Whether problem-solving is described by three, four or seven stages, there are some factors that are common to all of the definitions:

- problem needs to be *identified* or acknowledged
- problem needs to be *represented* or described
- *information* about the problem needs to be *collected*
- the *information* needs to be *processed*
- alternative *solutions* (if any) need to be considered
- *decision* has to be made

In Polanyi (1957), two kinds of problem-solving are discussed. The first kind is a *Systematic* operation, which is a wholly deliberate act, and the second kind is a *heuristic* process, which is a combination of active and passive stages. Frederiksen (1984) also discusses different types of problem-solving procedures, including certain heuristics (Newel and Simon, 1972; Polya, 1946), hypothesize-and-test method and the best-first search (Simon, 1980) and theory of planning (Sacerdoti, 1977).

Becker and Baloff (1969) analyzed the effects of organization structure on problem-solving. They define complex problem-solving as "requiring specification of a number of potential solutions and then selection of one of these alternatives as the solution" (p. 261). For efficient group problem-solving, they considered three kinds of behavior: generation of alternatives, information processing and decision-making. Shaw (1932) studied individuals within an actual problematic situation that would call for real thinking to arrive at a proper solution. In her study, the problems involved a number of steps, which all had to be correct before the right answer was obtained. The information available to the individual is an important issue in problem-solving. Campbell (1968) argued that a major difficulty in solving problems in real-life situations is selecting the data relevant to the problem, among many other amounts and types of information that are not required.

Simon and Newell (1962) defined the problem solution by a current state, a desired state, and the means to go from the first state to the second state. There are many possible solutions between the initial state and the desired state. Middleton (2002) also used Newell and Simon's (1972) conceptualization for problem-solving: problem state, which is the information the problem-solver knows about the problem; the goal state, which the solution of the problem; and the search space, which is all possible strategies for solving a problem. Ray (1955, p. 134) uses a similar definition when he states that

problem-solving is "the process of changing a given situation to a specified given situation, the process being new to the solver, and ending when the solution is achieved-which means that the process is not repeated." This definition includes the common current state and end state properties of problem-solving; it also includes the repetitive nature of problem-solving, which tends to include feedback loops and learning on the side of the problem-solver.

Karlins (1967) argued that an individual's pattern for information search is a possible way of looking at problem-solving behavior. This point of view is less about the end result (the solution) of the problem, and more about the earlier phase of problem-solving, which is the way the individual looks for information and the type of information for which they look. The crucial point is not how much information is acquired, but how and what kind of information is obtained when dealing with unknown problems. However, a major difficulty arises when the individual has to deal with complex or ill-defined problems, where it is not possible to define the problem state properly. Goals and strategies may be not possible to identify as well. This issue will be further elaborated in the latter sections.

The Basadur Creative Problem-Solving Profile (Basadur, Graen and Wakabayashi, 1990) includes four styles for problem-solving:

- *generator*: learns by experience and uses Knowledge (K) for generating ideas
- *conceptualizer*: learns by abstract thinking and uses K for generating ideas
- *optimizer*: learns by abstract thinking and uses K for evaluation
- *implementor*: learns by experience and uses K for evaluation

Similarly, the Social Problem-Solving Inventory-Revised (SPSI-R), developed by D'Zurilla et al. (2002), consists of five main dimensions. The first is the Positive Problem Orientation, which has statements such as "if I fail, I don't give up." The second dimension is the Negative Problem Orientation, which has statements such as "I worry too much." Rational Problem-Solving, which would include any individual who tries to predict pros and cons, is the third dimension of the inventory. Another style that is being suggested is the Impulsivity-Carelessness Style, which deals with individuals who would

state "I act on the first idea I have." The last style is the Avoidance Style, in which an individual would take the stance of waiting and seeing if the problem would go away.

Nair and Ramnarayan (2000, p. 308) note that "the definition of the initial state would reflect the individuals' understanding of the nature of the problem at the beginning, and the desired end-state would be described as the goal expected to be achieved by solving the problem." Berthon, Pitt and Morris (1998) also relate perception to problem-solving, and state that the perception of a problem and its consequent definition is delimiting the subsequent course of problem-solving action.

This is an indication that Ontological predispositions affect how an individual defines the problem. Epistemological predispositions determine how the individual gains insight and knowledge about the problem, and Teleological predispositions relate to the end-state of the problem, or the goal that is needed to be achieved for the problem to be solved.

Berthon, Pitt and Morris (1998) also state that some individuals may not be clear on their goals when solving a problem, which means that their preferences or goals may be unclear. Also, individuals may start seeing the problem differently over time. As Nair and Ramnarayan (2000) have stated, complex problems tend to evolve from one state to another, which means that the goal set in the beginning may get redefined as the problem-solver gets close to the solution. From time = 0 to time = t, the problem may have changed characteristics. This is in line with the temporal and also teleological component of complex problems.

Davey, Schell and Morrison (1993) conducted a review of studies relating MBTI with problem-solving and decision-making. They stated that within a highly uncertain environment, the lack of facts and time constraints, upper-level management individuals showed a tendency to refer intuitive cognitive styles. As a result, better solutions were arrived at through high consistency of approaches. Mitroff and Kilmann (1975) associated four Jungian-types and four different kinds of managers, and looked at how each type of manager would deal with an organizational problem, and how they would make a decision. Similarly, Simon (1970) analyzed effects of problem content on problem-solving. Problems were presented either as an abstract or meaningfully coded form. It was hypothesized in the study that different sets of problem-solving processes

would be used for different problems. The results indicated that the abstract problem was solved with less constraining strategies and with more risk-taking in decision-making.

2.4.2 Complex Problems

Complexity is a concept that has been part of many (perhaps too many) debates in literature; these debates include complexity itself, what constitutes something as being complex, having definitions for wicked problems, initiating newly emerging discussions over complex situations, etc. Biggiero (2001, p. 3) defines complexity as "an object that cannot be predicted because of logical impossibility or because its computability would require a computational power far beyond any physical feasibility." He states that "complex" is not the same as "difficult," although they have been used synonymously. He suggests that difficulty, with enough computational power, can be predictable, either through deterministic or through stochastic means.

Bar-Yam (2003) states that complexity is due to interdependencies between different parts of a system; for example, a change in one part of a system may have an effect on other parts of the system. He also defines complexity of a system as "the amount of information needed to describe it" (Bar-Yam, 2003, p. 12). This amount of information is also related to the level of detail that is required in this information. According to Rescher (1998), complexity has various characteristics, starting with the number and variety of the elements involved, and their interrelations. He also states that complexity may have degrees; something can be more complex or less complex. Rescher (1998) classifies complexity into three modes: Epistemological Mode, Ontological Mode, and Functional Complexity, and within these modes, he defines nine different complexities:

1. *Descriptive Complexity*: Amount of effort given to provide a description of system
2. *Generative Complexity*: Length of instructions necessary to produce system
3. *Computational Complexity*: Time and effort to solve problem
4. *Constitutional Complexity*: Number of elements
5. *Taxonomical Complexity*: Variety of elements

6. *Organizational Complexity*: Variety of different ways to arrange components (interrelationships)
7. *Hierarchical Complexity*: Elaborateness of the different levels within entities
8. *Operational Complexity*: Different types of functions
9. *Nomic Complexity*: Intricacy of laws governing the system

Overall, these clusters and definitions are in line with other definitions that are discussed in this section. The number of entities, the temporal aspects and the elaborateness (may be considered to be similar to ambiguity, since it relates to how clearly the problem can be defined), are all common characteristics.

From a problem-solving perspective, Ray (1955) relates complexity to the amount of work an individual needs to do in order to solve the problem. Xu et al. (2007) have stated that defining complex problems is a good starting point for solving them, but finding a common definition is not always possible. Jackson (2006) argues that a holistic perspective is needed to approach complex problem situations. Managers are given simple solutions to complex problems, which do not work, because they focus on parts rather than the whole problem, and interactions between parts are ignored, and one solution is generalized, when it should be custom-tailored. This is one of the biggest reasons why complexity becomes an issue when dealing with problems. Jackson also states that "managers today are expected to cope with increasing complexity, change and diversity. Complexity stems from the nature of problems" (Jackson, 2006, pg 648).

It becomes crucial to provide a context to problem-solving. Hall and Paradice (2005, p. 447) state that "information is not separate from its context because the interpretation of incoming data streams is dependent not only on the perception of the receiver, but in the context of the moment...problem definition and formulation play an important part in all information acquisition, especially when resources are limited." According to Goldman et al. (1999), complex problem-solving is a domain which includes cognitive activities such as planning, formulation of goals, searching and retrieving information, coordinating multiple resources and revision. This definition includes the feedback process described by Ray (1955), in the form of revisions.

Fernandes and Simon (1999) identify problems within a continuum between ill-structured and well-structured. Well-structured problems contain the following characteristics:

- A definite criterion for recognizing solutions and a mechanizable process for applying that criterion
- At least one problem space where the problem states may be represented
- A structure where state changes can be represented as transitions
- Representation of knowledge the problem-solver can acquire
- Reflection of state changes
- Basic processes

They argue that when presented with a complex stimulus, a person perceives in it what he or she is ready to perceive; the more complex or ambiguous the stimulus, the more the perception is determined by what is already in the individual, and less by what is in the stimulus. Barrows (as cited in Lohman, 2002) note that for ill-structured problems, the nature of the problem is unclear; some information (though not enough) is provided to solve the problem; more than one way to solve the problem exists and finally the problem does not have a single right answer.

The problem characteristics provided by Hood, Logsdon and Thompson (1993) include severity, which impacts the problem has on the community and organizations within it; complexity, which describes difficulties in understanding the fundamental causes of the problem, and resource availability, which deals with sources and amounts of resources that are currently and potentially available for addressing the problem. When high severity, high complexity and low resource availability are combined in the same situation, this makes for high problem conditions. This resource availability problem is in line with the lack of information Barrows was discussing.

Similar to the definition provided by Goldratt where he said "complication solutions don't work, simple ones might" (as cited in Hutchinson, English and Mughal, 2002), Hutchinson et al. (2002) define a simple solution as "a solution to a wicked problem that is effective and technically feasible, economically sustainable, and politically implementable to such a degree that it can be successfully implemented to resolve the problem" (p. 258). This simple solution may not be the optimum, because we

may never know the optimum solution. Developing solutions depend on knowledge (documented information, internal knowledge and knowledge of others), tools (analytical and experimental), and intuition (new insight and new approaches).

Berthon, Pitt and Morris (1998) create a matrix of problem types. The first dimension they use for problem type is structured vs. unstructured problems. They describe structured problems as unambiguous, routine, closed and well defined; whereas unstructured problems are unique, complex, ambiguous, open-ended and poorly defined. The second dimension they have used is related to temporal components, which they identified as strategic vs. operational. Strategic problems consist of a long time horizon, and the key concern in strategic problem-solving is effectiveness. Operational problems, however, have a short time horizon, and as opposed to efficiency, the key concern with this type of problem is efficiency.

The structured vs. unstructured division of problems is not uncommon. Augier, Shariq and Vendele (2001) have also divided complex problems into such two groups. They also argued that the time available to solve the problem is part of problem-solving. The problem-solving matrix they have developed has, therefore, four components. When time is long and problem is structured, the problem-solving response will be through *analysis*. When time is long but the problem is unstructured, the response will be through *simulation*. When the time horizon is short and problem is structured, the response will be via *heuristics*. When the time horizon is short and problem is unstructured, the problem will be solved through *improvisation*.

Quesada, Kintsch and Gomez (2005) have addressed the need for a common definition of complex problem-solving, and provide one. According to their study, a complex problem will have three main components. If a problem is *dynamic,* this means that the task environment may change independently of the solver's actions. If the problem is *time*-dependent, this means that decisions must be made at the correct moment in relation to environmental demands. The last component is *complexity* itself, which is described as most variables not relating to each other in a one-to-one manner. They also state that a problem requires not one but a series of decisions. They have looked at complex problem literature and describe four different approaches to problem-solving. The first approach is *naturalistic decision-making*, where the research is purely empirical

(field research), where simulated environments are not being used. The second approach to problem-solving is *dynamic decision-making*, where simulations in economic environment are done. The third approach is the *implicit learning* in system control, which is a more mathematical, computational type modeling; and finally, the *European Complex Problem-solving*, which started in Germany.

Funke (1991) is one of the leading researchers of this movement, and according to him, complex problems can be defined by five main criteria: The *availability of information* about the problem, the precision of *goal definition* (including the existence of multiple goals), the complexity of the problem (which includes the *number of variables*, the degree of the interrelations and the type of the relationship), the *stability or the time-dependency* of the problem, and the *dynamism* or the *uncertainty* of the problem. Rubinstein (1986) traces the complexity of a problem to the number of relationship between its elements. Steinberg (1983) also stated that the complexity of a problem depends on the number of components, as well as the problem solver's familiarity with the context of the problem. He looked at how these two variables affected the strategy the problem-solver developed, and how this strategy was transferrable. He defined solving a problem as developing a successful strategy to a problem. The individual will be successful regardless of the chosen strategy if the problems are simple problems. The same strategy used for a simple problem may not transfer successfully into solving a complex problem. Using invalid reasoning may work when solving a simple problem, but not a large/complex problem. Trial and error also worked better when dealing with a simple problem, rather than a complex problem. Even though these studies show that complex problems and simple problems have distinct differentiations, Davis (1969) states that simple problems can be compounded in various ways to form complex problems. These complexities of the problems that are being dealt with also are reflected in the environmental conditions as well.

Downey, Hellriegel and Slocum, Jr. (1975) looked at the construct of environmental uncertainty, and analyzed two instruments. The first scale they looked at was developed by Lawrence and Lorsch (1967), which characterizes the uncertainty as follows: lack of clarity of information, general uncertainty of causal relations, and long-time span for feedback of results. The first characteristic can be considered as a

combination of ambiguity, as well as a lack of information. This is in line with previously discussed issues with complexity. The second characteristic they discuss deals with the relationships (causal, in their case) between variables, and the third characteristic is a temporal component. The second instrument that was used in Lawrence and Lorsch's study was the scale devised by Duncan (1972), which also considered three different issues regarding uncertainty: lack of information regarding factors related to decision-making, lack of knowledge about the implications of an incorrect decision, and how to evaluate the importance of environmental factors on the performance of the organization.

In Lloyd (1978), the focus of the research was on managerial problems whose characteristics echoed complex problems. These characteristics included many variables, complexity of relationships between variables, inability of the problem-solver to limit the number of variables, the impracticality of fragmenting the problem, dynamic nature of the problems (constant change), difficulty of establishing cause-and-effect relationships due to complexity, and the fact that past experience may not be applicable to the current problem. Similar characteristics for complex problems come from a study conducted by Swinth (1971), where he studied how organizations jointly should solve complex problems, which he defined to be a high degree of interdependence between parts. The solution must serve many organizational objectives, too complex to be understood by one individual, and one must also combine knowledge and information with others. The presence of change in the external environment and change in the goals of the system is also characteristics of a complex problem.

Another thread of complex problems is the concept of *wicked problems,* proposed initially by Rittel and Weber (1973). They used the term wicked to describe problems which are inherently complex. In their 1973 paper, they present ten major characteristics that wicked problems possess:

1. There is no definitive formulation of a wicked problem.
2. Wicked problems have no stopping rule.
3. Solutions to wicked problems are not true-or-false, but good-or-bad.
4. There is no immediate and no ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a "one-shot operation;" since there is no opportunity to learn by trial-and-error, every attempt counts significantly.

6. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another problem.
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution.
10. The planner has no right to be wrong.

Having described the characteristics of wicked problems, problems that cannot even be defined, Rittel and Weber further state that different groups of individuals contain different perspectives and values; where a solution to a problem for one group or individual may not be a solution but an additional problem for another group or individual. They note that they have no simple solutions or tactics for these dilemmas; for these dilemmas are wicked conditions themselves. The important point to make here is that in the midst of all this wickedness, the problem and problem-solving literature now has a way of identifying these problems. Despite the lack of empirical, or non-empirical for that matter, foundation behind this perspective, wicked problems have been a part of many disciplines, from software engineering to systems engineering, which is proof that these problems do indeed exist, and many studies are being conducted to find a way of approaching them.

Beers et al. (2006) conducted a study at the organizational level, and looked at the need of forming multidisciplinary teams. Their purpose was to look at how to bridge the gap between different perspectives. Studies like this are the reason why looking at the predispositions and worldviews of different individuals becomes important. They observed that decision support tools for problem-solving were not enough and they used Rittel and Weber's (1973) description in defining complex societal problems as wicked. In complex problems, decision makers "can no longer follow a single claim about the nature of the problem at hand and its solution, but instead have to consider several problem perspectives, and search for solutions accordingly" (Beers et al., 2006, p. 531).

The individual perspectives in complex problem-solving become important because, as Tuan and Ryan (2002, p. 274) states, "complexity is meaningful only when a human observer intends to comprehend, or expound on, the observed phenomenon...it depends on each observer's capacity and talent." They compared the Western culture and the Eastern culture with respect to the way both sides approached complex problems. Their conclusion was that the Western culture worked more "outwardly," and it tends to focus on the complexity itself, whereas the East tends to focus on the problem itself, thus, they worked more "inwardly."

Srinivasan and Te'eni (1995) researched on how individuals modeled complex problems. They used Greeno and Simon's (1984) view of problem representation, which includes the variables of the problem, the goal of the problem, the actions performed, the strategies developed, and the knowledge constraints. This definition includes the use of knowledge to solve a problem and strategies to apply this knowledge under changing constraints, which ties with the epistemological dimension of the PPI. Saarni (1973, p. 342) observed in her study that "if the problem-solver is limited to considering the concrete empirical situation at hand, he will be less able to hypothesize solutions which satisfy the constraints of the problem and transcend the empirical given....on the other hand, the formal operational individual can consider problems involving several variables and their interaction; [therefore] he can entertain hypotheses and deduce inferences from them and systematically evaluate alternatives."

This argument also takes support from Mumford (1998), where he argued that how problems are solved depend both on the nature of the problem itself, as well as the beliefs, values and assumptions of the problem solver. Problem-solving is never a simple task, and there will always be uncertainties involved, affecting the decision-making process. He describes three important skills for problem-solving as capability, competence and coordination. The steps in solving a problem consist of: seeing the big picture, developing strategies, and taking action.

Zaccaro et al. (2000) conducted a study on leadership capabilities and effective leadership on problem-solving. Previously (Mumford et al., 1991), they had identified eight problem-solving skills. These include problem construction, information encoding, category search, category specification, category combination and reorganization, idea

evaluation, solution implementation, and solution monitoring. Although they have not provided a definition for what complex problems are, they mention that these problems have multiple components, and the generation of an effective solution would depend on the consideration of each of these components.

These approaches provide additional support to the argument that there will be different ways of solving a problem, and these different approaches will both depend on the type of complex problem and also on the individual who is attempting to solve the complex problem. Therefore, different individuals will deal with complexity in a different manner, either more easily or not. There have been many studies on the domain specificity or domain generality of epistemic beliefs (see Hofer, 2006, for a review). Addressing not only epistemic, but also ontological and teleological beliefs of individuals in reference to complex problems will be a contribution to this literature as well.

Table 5 is a summary of the arguments discussed above about what complexity is, and how complex problems have been characterized and explained by different researchers, studies and bodies of knowledge.

Table 5. Variables for Complex Problems

Author/Discipline	Level of Analysis	Characteristics for Complexity
Systems Theory and Cybernetics (1950's)	Systems	Equifinality, Feedback, Homeostasis, Multiple Goals, Complementarity, Self-Organization, Emergence
Rittel and Weber (1973)	Problem	No definition, no stopping rule, no unique/optimal solution, no test for solution (time), no trial and error learning, no all possible solutions, no truth, just improving
Lloyd (1978)	Problem	Many variables, complexity of relationships, impracticality of fragmenting problem, dynamic nature, difficulty of establishing cause-and-effect relationships
Steinberg (1983)	Problem	Number of components, problem solver's familiarity
Funke (1991)	Problem	Intransparency, Polytely, Connectivity of Variables, Dynamic Developments, Time-delayed effects
Bar-Yam (1993)	Systems	Components, relationships among components, information needed
Flood and Carson (1993)	Systems	Large number of parts, significant interactions, nonlinearity, asymmetry, nonholonomic constraints
Hood et al. (1993)	Problem	Severity, Complexity, Resource Availability
Barrows (1994)	Problem	Nature is unclear, not enough information, more than one way to solve, no single right answer
Berthon, Pitt and Morris (1998)	Problem	Structured, Unstructured, Strategic, Operational
Augier et al. (2001)	Problem	Unstructured, time availability
Biggiero (2001)	Human Systems	Logical, relational, Gnosiological, semiotic, chaotic computational
Quesada et al. (2005)	Problem	Dynamic, time-dependent, complex (variable interaction)

2.5 Summary of Background Research

This main objective of this section was to provide a background and context for the current research. This was also done for the purpose of bounding the research, as well as for presenting the relevant bodies of literature, so that the significance of this study could be better understood. The background research was divided into three main sections.

The first part, which was related to the individual, provided an overview of the past personality theories that were developed. Since any one of these theories could be a dissertation topic on its own, the purpose of presenting this body of literature was not so much to give detailed discussions on each theory, as to provide the reader with the limits of personality research. When a good understanding can be established on where the personality theory literature is, the better this research can be placed within that literature. Following this brief overview of personality literature, the concept of worldviews and relevant studies were discussed. This was done to provide an alignment of worldviews with the predispositions concept discussed in this research.

The second major part of this section was about philosophy. Since the proposed profile of the individual is based on philosophical predispositions, it was crucial to elaborate and argue the existing philosophical paradigms. An overview and brief discussions on each philosophical paradigm was presented.

The last part of the section dealt with problem-solving in general and complex problems in particular. The process of problem-solving and different studies related to personalities and problem-solving were analyzed. Following this, the issue of complexity was presented. Since complexity is a very broad term, and has implications on many different areas of research, the studies related to complex problems and complex problem-solving were presented and discussed in this section.

3 THEORETICAL FOUNDATION

Having established an understanding of the background literature that supports this research, this section's purpose is to develop, present and discuss the philosophical personality profile and relevant propositions. This is one of the most significant original contributions of this research, which is the development of the Philosophical Profile of the Individual (PPI) and analyzing how different profiles solve complex problems. The origin of the PPI presented in this section can be found in Bozkurt, Padilla and Sousa-Poza (2007). The content of this section is threefold. The first part will present the underlying dimensions of the PPI, the second part will present the actual model itself, and the last part is a brief summary of the entire section.

3.1 Building Blocks

As discussed in the previous section, the major personality theories that have been developed in the past have contributed to understanding an individual in different ways. Some theories have looked at the past events that have occurred in an individual's life, some theories have only looked at how an individual behaves at a particular moment.

Through worldviews and predispositions, the concept of personal philosophies have been introduced, albeit minimally. In this research, the concept of philosophy and its related paradigms are being used to develop a philosophical profile. Using philosophical paradigms as underlying dimensions for the personality profile will enable the PPI to be used as a generalizable profile for describing and understanding individuals. How an individual views the world around him or her, how the individual seeks knowledge and the purpose of the individuals' actions become the center questions that the PPI is set out to answer.

Previous research and theories relevant to this dissertation are used as building blocks for forming the initial theory of the PPI. The premises are extracted from previous literature, which is made explicit in a way that provides traceability, as well as ensuring that the premises are true. The premises that are not based on literature, or that are interpretations of extrapolations based on previous literature, are stated as assumptions.

3.1.1 Personality and Predispositions

Predisposition, according to the Free Dictionary (2009), is defined as a disposition in advance to react in a particular way. A tendency or an inclination to act a certain way, a choice of doing things a certain way, or leaning towards to a certain behavior are all synonyms of predispositions. Just as Midgley and Dowling (1993) state, a predisposition is not a post hoc classification of behavior. Stouffer and Toby (1951, p. 395) have considered personality predisposition to be "the extent that an individual is consistent, in varying types of situations, in reporting one type of role obligation rather than another." Continuing on the research done by Stouffer and Toby, Scarr (1964) has noted that predispositions of individuals describe the tendencies to be guided by criteria that they choose, or a predetermined and generalized criteria. One other specific definition of predisposition comes from Neff and Sherman (2002), which states that a predisposition consists of previous information an individual has. This may include the information gained through a lifetime. As Taggart and Robey (1982) state, studies on the *dual nature* of human beings have shifted from looking at differences *among* individuals, to differences *within* each person. This duality within individuals is the predisposition.

Almost all personality theories that have been previously discussed in Section Two deal with predispositions. The dichotomies that have been proposed by Jung, and have further been developed in personality type studies, such as the Myers-Briggs Type Indicator, or the trait theorists who argue that personality traits come in forms of continuous dimensions, are all examples of the predispositions individuals possess.

According to Caspi and Moffitt (1993), the differences between dispositions of individuals become increasingly explicit when an individual is in an ambiguous, uncertain environment, and wishes to transform these circumstances into familiar and clear conditions. This is what an individual dealing with a complex problem would tend to do. Therefore, it can be stated that the predispositions or certain tendencies tend to be more apparent in problematic conditions. However, not all predispositions are converted into action (Cole, 1969). This is the reason why there is always a low chance that an individual may choose to act in spite of his or her predisposition. From these arguments, the following premises are obtained.

- **Personality and Predisposition Related Premises:**

Premise 1.1: Every individual has different predispositions (Scarr, 1964; Stouffer and Toby, 1951)

Premise 1.2: Each dimension consists of two major opposing views (Taggart and Robey, 1981)

Premise 1.3: The individual is capable of operating within both views; however, the individual will have an initial tendency to choose one over the other (Midgley and Dowling, 1993; Neff and Sherman, 2002)

Premise 1.4: The tendencies will affect how a problem is solved (Caspi and Moffitt, 1993)

3.1.2 Philosophical Dimensions

It is argued in Bozkurt et al (2007) that a framework for establishing a profile of an individual in terms of philosophy is long overdue. People present strong tendencies in the way they deal with problems; therefore, every individual will have a certain way of how they see reality and how they seek knowledge in order to understand that reality. Philosophy presents a very advantageous perspective here, since is not only a field of study, but more importantly it is a mode of thinking and offers a framework for thinking (Paul, as cited in Ruona and Lynham, 2006).

Throughout history, philosophy has been the dominant topic of discussion among scholars and scientists alike. It is interesting to see how discussions of philosophy and scientific method have drifted so apart that we no longer even think of philosophy when it comes to the matters of science. Rychlak (as cited in Fransella, 1981, p. 4) has said that "human beings *must* begin making certain assumptions in order to reason, and whether they are aware of it or not, these assumptions influence what can and will then be learned, discovered, or 'known' about that which interests them." It is proposed in this research that philosophy is the means of doing this.

In Section Two, the main philosophical paradigms, namely Ontology, Epistemology, Teleology and Axiology were discussed. The paradigms that are used as dimensions for the PPI are chosen as *Epistemology*, *Ontology* and *Teleology*. There are various reasons for these choices, as argued below:

- **Argument 1: Coherence**

Immelman (1993, p. 726), when describing conceptual systems on political personality, states that these systems need to be "anchored to a comprehensive, integrative, theoretically coherent framework..." He uses Millon's (1986, p. 643) personality definition which states that personality, as a construct, should:

- not be a mix of unrelated traits and behaviors
- be a tightly-knit organization of stable structures
- be an integrated pattern of characteristics and inclinations

The *coherence* Immelman discusses is the main goal in not using certain philosophical paradigms, but using only the ones that are appropriate for the purposes of this research. Goal-orientation, for instance, a construct that is related with the Teleological dimension, is stated to be related to epistemological beliefs (Murphy et al. 2002). Goal formation has also been related to worldviews, knowledge, the experience of the individual, value systems and other variables (Luk'yanova, 2007). Locke and Latham (2002) have argued that goals mediate the effect of personality measures on work performance. This is another indicator that Teleology as a dimension should be part of the philosophical profile that is being developed. Skinner, in his paper on Operant behavior (Skinner, 1963), stated that the teleological problem of what an organism is behavior for, i.e. the purpose of behavior, could only be solved by answering questions such as "what gives an action its purpose, what leads an organism to expect to have an effect, how is utility represented in behavior?" (p. 503).

Taylor (2003, p. 308), for instance, argued that "ethics involves a range of "values" that are essentially understood to be on a different level, to be in some way special, higher of incommensurable with our other goals and desires." He has also stated that it becomes difficult to place values within the "ultimate furniture of the universe" (Taylor, 2003, p. 307). This is one of the reasons why Axiology was not included in the philosophical profile.

Coherence is also established through the consideration of Epistemology and Ontology together. Epistemology complements the Ontological paradigm in a way that one does not exist without the other. How we deal with knowledge has an effect on how we define things, and how we perceive reality depends on the ways we choose to reach it

(Bozkurt et al, 2007). Klemke (1960) discussed the universal and individual ontologies, and stated that for the individual to have any information or knowledge about universals, there needs to be another way other than direct acquaintance. This principle of acquaintance is the philosophical concept with which the term empiricism has been associated (Hochberg, 1965).

- **Argument 2: Personality Literature and Predispositions**

As established previously, there are numerous studies within personality literature that look at worldviews and philosophies as possible variables affecting personality. These studies greatly focus on epistemology and ontology, as well as teleology, as it will be shown in the following sub-section. This is an indication that these paradigms are already being considered within this body of knowledge. Ethics is also considered in various studies, e.g. ethical attitudes (Nardi and Tsujimoto, 1978), integrity (Schlenker, Weigold and Schlenker, 2008), virtue ethics (Jost and Jost, 2009), moral personality (Hill and Lapsley, 2009), belief in a just world (Wolfradt and Dalbert, 2003), formal axiology (Hartman, 1962; Hartman, 1967) and axiological psychology (Pomeroy and Edwards, 2005). However, these studies have been done in a different context. Unlike epistemology, ontology and teleology, axiology is not a paradigm where predispositions of choosing between certain approaches can be relevant. An individual, it is assumed, would surely always choose to be ethical, and have certain beliefs and values. This paradigm can be thought of as a meta-paradigm, when compared to the other paradigms. An individual's belief system is going to encompass all other tendencies. Axiology, in the past, has been considered with respect to various aspects, such as axiological naturalism, axiological emotivisim, axiological intuitionism and axiological Platonism (see Hart, 1971 for an overview). All of these paradigms, or schools of thought, have been based on different foundations, and all "engendered the quest for knowledge of reality" (Hart, 1971, p. 29). Therefore, it is a paradigm that is a common thread in all studies related to human beings, and it does not have any extreme or contradicting propositions with respect to how individuals live their lives.

Also, it could be argued that understanding individual values is similar to dealing with religion or morals in that it goes beyond what may be observable to the intimate personal being (Bozkurt et al., 2007). Hatzimoysis (1997), for instance, when discussing

ontology and axiology, states that the value properties of objects can be determined through ontological and epistemological capabilities, rather than trying to separate value from ontology.

- **Argument 3: Generalizability**

The underlying dimensions of the philosophical profile created are intended to be generalizable so that they can be applied to any individual in any context. The methodology paradigm, as discussed previously, tends to get overly specific. The generalized version is the epistemology, which is already included in the profile; therefore, in order to eliminate redundancy, the methodological paradigm is not included. Once the epistemological predisposition is made explicit, and a certain choice is made, the methodology needs to follow that paradigm. This is similar to the research hierarchy concept that was argued in the previous section. Therefore, because methodology is dependent on epistemology, it is not considered within the personality profile.

This also applies for the Axiology paradigm. Taylor (2003) has discussed ethics with respect to Ontology, with the following introductory question in his paper: "What are we committed to ontologically by our ethical views and commitments?" (p. 305). Hamm (1970) was hesitant to merely discuss values, and he stated that there is a need to consider the term "value," and this need is beyond any semantic and lexicographic perspective. According to him, the study of values belongs, technically, to ontology, but the specific area that deals with values is referred to as axiology. Therefore, he presented a hierarchy in which axiology is considered to be a part of ontology.

Hatzimoysis (1997) also discussed the ontology of values, where he differentiated between the phenomenology of values, or how values are experienced, and the nature of the values. While Hart (1971) stated that ontological and valuational questions were "divorced," he still argued that "inquiry into the claims, truth and validity of value judgments is a necessity of life itself" (Hart, 1971, p. 29). Bertland (2009), when discussing virtue ethics, makes the argument that virtue ethics is part of a teleological basis. He discusses arguments starting with Aristotle, all the way to modern scholars on ethics such as Solomon (1992) and Whetstone (2001). Guyer (2002) makes the argument that Kant's moral theory is also teleological in a way that loyalty to moral laws should serve an ultimate end and purpose, which is the teleological stance.

- **Argument 4: Solving Complex Problems**

As part of literature that covered complex problems, it was noted that solving problems have common steps in many studies. These steps include the identification and acknowledgment of a problem, collecting information about the problem, and making decisions about the problem and possible alternative solutions in order to reach a desired goal state (Frederiksesn, 1984; Lohman, 2004; Middleton, 2002; Simon and Newell, 1962; Tallman and Gray, 1990; Tallman et al, 1993). These major phases are aligned with the philosophical dimensions that are chosen to represent the personality profile. The ontological dimension is related to what reality is according to the individual, which includes the definition and description of the complex problem under consideration. The epistemological dimension deals with how and what kind of information and knowledge is available to solve this problem; and finally the teleological dimension indicates the presence of a purpose, and is related to the goal or the end state of the problem. Taking support from these theories, the following premises are obtained:

- **Philosophy Related Premises**

Premise 2.1: The profile of the individual can be explained through philosophical constructs (Babbage and Ronan, 2000; Costa and McCrae, 1992; Johnson et al., 1988; Paul in Ruona and Lynham, 2006).

Premise 2.2: The overall philosophical profile of an individual contains three main dimensions (Arguments 1, 2, 3 and 4): Epistemological, Ontological and Teleological.

Assumption 2.1: The Epistemological, Ontological and Teleological dimensions do not impact each other. The arguments made above provide support for the justification of using these three dimensions. It has been stated that these dimensions are coherent with each other, they complement each other in a manner that consideration of all three as a foundation for the personality profile was necessary. However, this does not (or should not) imply that these dimensions affect each other. For instance, one of the two epistemological predispositions does not necessitate the choice of either ontological predispositions, etc.

3.1.3 Epistemological Predisposition

Pollock (1983) makes the assumption that epistemology plays a fundamental role in epistemic justification, leading both to the adoption of newly justified beliefs and the rejection of previously justified beliefs. Reichenbach (as cited in Siegel, 1980) introduces the context of discovery and context of justification to illustrate the distinction between determining the psychological origin of a claim and determining the epistemic status of the claim. According to Reichenbach (as cited in Siegel, 1980), the context of discovery is irrelevant to epistemology, and epistemology is only occupied in constructing the context of justification and concerned with the evaluations of claims for which the psychological origin is irrelevant.

In the past, psychology was a sub-component of philosophy, "its major function was to tidy up the household of epistemology" (Turner, 1968, p. 1). Therefore, it is only normal that epistemology and personality have been considered together in many studies, namely studies on personal epistemologies. Within the personality body of knowledge, personal philosophies -personal epistemology, in particular- have been addressed by various researchers. The *need for cognition*, proposed by Cacioppo and Petty (1982) has been a dominant theme within areas such as information processing, problem-solving, intelligence, locus of control and motivation, among others. According to Cacioppo et al (1996), individuals that have a high need for cognition tend to seek and acquire information to gain insight on certain events. However, on the opposite end, individuals who do not need cognition in such a high level tend to rely on other individuals (such as experts), heuristics, or comparison processes. Even though not directly related, it could be argued that the need for cognition construct does involve issues on personal epistemologies, since it is related to seeking and gaining information and knowledge. Individuals who differ in terms of their need for cognition tend to have different tendencies on how much they seek detailed information about the world and the problems with which they are dealing (Cacioppo et al, 1996). Therefore, regardless of their ways of seeking information (i.e. empiricist or rationalist), each individual will have a need for cognition on a scale.

The duality within reasoning processes has also been analyzed, albeit in a different way, by other studies (Klaczynski, 2001; Klaczynski and Daniel, 2005;

Stanovich, 2003). Klaczynski and Daniel (2005) name these different processes as *experiential* and *analytical* processing systems. Both of these systems may operate simultaneously, however one will be predominant over the other, which is similar to the predisposition premise that was discussed in the previous section. The experiential system is the more dominant system, since it is mostly automatic, requires minimum effort, and is triggered by processing which is adaptive. On the other hand, the analytical processing system requires effort since it works with abstract rules of inference, and is triggered when the response required by the task is precise, and the environment requires certain logical analysis.

In a recent study, Stanovich suggested the construct of Master Rationality Motive (MRM), which he defined as "the motive that drives the search for rational integration across our preference hierarchies" (Stanovich, 2008, p. 119). In the scale that is constructed to measure the MRM, he includes items such as "I like to gather many different types of evidence before I decide what to do" and "I like to think that my actions are motivated by sound reasons."

These constructs demonstrate the place of epistemologies within different domains of literature. As a construct, like any other intangible construct, personal epistemology comes with its own baggage; therefore, there have been many studies to clarify the concept and address its relation to psychology and relevant areas (see Perry, 1968; Perry, 1981; Schommer-Aikins, 2004). Joseph R. Royce, who addressed the main questions about personal epistemic styles, argued in his research that if, indeed, there are different ways of knowing, and then it can also be argued that people will combine these different ways in a particular preference order (predisposition) which can be described as an hierarchical structure. This structure can be explained through different worldviews. In the Psycho-Epistemological Profile (PEP) which he developed with his colleagues (Royce and Mos, 1980; Royce and Powell, 1983), each person is labeled according to a particular epistemic belief system and cognitive preference. The conceptual model they developed has three classes of knowing: Rationalism, Empiricism and Metaphorism. This belief system also has an influence on how a person interacts with the environment. The *empirical* style involves the individual relating to the external world through senses, and defining reality through reliable and valid observations. Therefore, knowledge is reached

a posteriori, through experiences. The *rational* style describes an individual that sees and defines the world through rational and analytical skills, and reality is described thorough logical thinking. Therefore, it can be said that knowledge is acquired *a priori*, without the use or need of experience. Finally, the *metaphoric* style deals with symbolic/metaphoric experience, and awareness about reality is reached through constructive representations of generalizable experience.

Lyddon (1989) used the PEP to analyze whether there was any correlation with one's epistemic style and the preference for counseling approaches. From the results he obtained, he concluded that the counseling approach and the epistemological style of the participant was a direct match. It is interesting that despite the interest in personal epistemologies in personality and psychology literature, the Psycho-Epistemological Profile has not been revised in current research. However, the dissertations that have recently used the PEP (Burkemper, 1997; Draze, 2000; Evans, 2002; Senese, 1997; Simpson, 2003), and a personal note to the author from Dr. Mos, stating that there have been many requests for the PEP manual, indicates a resurrecting interest in this specific profile.

Unger, Draper and Pendergrass developed the Attitudes About Reality (AAR) Scale in 1986. This scale was used to measure "implicit causal assumptions about the relationship between persons and their physical and social reality" (Jackson and Jeffers, 1989, p. 353). The scale assesses a single dimension of personal epistemology, with a range from a social constructionist view of reality (person constructs the reality) to a logical positivist view of reality (reality constructs person). Baxter Magolda's Epistemological Reflection (ER) model, which was a result of a 16-year longitudinal interview study, includes "assumptions about the nature, limits and certainty of knowledge, and how these epistemological assumptions evolve during young adulthood" (Baxter Magolda, 2004, p. 31).

The Epistemic Preference Indicator (EPI) developed by Eigenberger, Critchley and Sealander (2007) looked at two different ways of processing information related to problem-solving and judgment. The first style was defined as *Intellective*, which relied on inferential processes that included deductive and inductive rules; whereas the second style was defined as *Default*, which was defined as to be a more reactive processing style,

restricted in inferential processes. With respect to problem-solving, they state that the possible actions taken to solve a particular problem should be based on an individual's theory of knowledge, and on the requirements of one's epistemic disposition.

These studies provide much support for the use of epistemologies (within the philosophical framework they were discussed) as a dimension for the philosophical profiling of individuals. The personal epistemology literature shows us that this construct has strong implications on how individuals deal with knowledge, which is why it is appropriate for epistemology to be used as part of the profiling. The two different approaches used to construct the PPI are Empiricism and Rationalism. This is perhaps one of the oldest debates in the history of philosophy, which makes this an interesting dimension because no conclusive results have been presented throughout history. Being one or the other does not equate to being right or wrong; however, having an either empiricist or rationalist predisposition will prove to be beneficial according to the situation. Empiricism is associated with hard facts, data and observation; whereas Rationalism is associated with deduction, logic and reasoning. Nickerson (2004) lists tools for problem-solving that can be used through rationalist reasoning as logic, mathematics and heuristics. The heuristic tool includes many steps, such as understanding a problem, analyzing the ends and means, making explicit assumptions about the problem, breaking down the problem into simpler parts, and finding a similar problem for comparison purposes. As Benjamin (1942) notes, some individuals are satisfied with the existence of hard data and explanation of that hard data; however, some individuals believe that there is more to be known outside the boundaries of hard data, in terms of hypotheses and soft data. Facts, hard data, observations, numbers are all tools of knowledge that increase the confidence level in some individuals. In order to increase knowledge and understanding of a situation, an empiricist may wish to initially gather facts and data; on the other hand, a rationalist individual, believing that knowledge does not always depend on observable facts, may choose to use valid and justified arguments to reach a conclusion. Some individuals may rely on reports and other individuals may prefer conducting brainstorming sessions in order to understand a situation.

Engineers and scientists, for instance, tend to be empiricists by nature. The foundation of the scientific method is based on testing hypotheses based on observations.

Mathematicians, on the other hand, can be considered as rationalists. No empirical testing or observation is involved in mathematical applications. Therefore, the way an engineer and a mathematician approach a problem would inherently be different. The same situation is present within the business world. Managers, for instance, may have a tendency to rely on facts and data when making a decision or when obtaining knowledge about a particular situation, whereas leaders may follow a different path when dealing with situations. Especially when dealing with complex situations, observable facts and data may not always be present to increase knowledge and gain understanding. When facing a dynamic and constantly changing environment, being an empiricist may not always be the appropriate route to take. From these discussions, the following premises are obtained.

- **Epistemology Related Premises**

Premise 3.1: Epistemological predisposition is an indicator of how, or through what means, an individual chooses to acquire knowledge.

Premise 3.2: Epistemological predisposition consists of two paradigms; Empiricism deals with hard data, observation and active perception, whereas Rationalism deals with reasoning, logic and deduction.

3.1.4 Ontological Predisposition

Ontology, as defined earlier, is the paradigm that is related to the nature of reality, or nature of things. The Ontological predisposition an individual may hold is a result of *what* the individual perceives the reality to be. Feibleman (1949) has stated that all individuals posses an implicit and dominant ontology, which he defines as "a private set of beliefs respecting what is primarily real" (p. 47). He notes that these beliefs are often deeply embedded within the individual to the degree that the individual is not aware of it, but acts instinctively, and this ontology becomes a crucial part of the individual's decision-making process. When discussing scientific theory, Wisdom (1972) states that in addition to empirical content, the embedded ontologies need to be considered for the theories to be scientific, since this would help establish boundaries. The same argument is made here in terms of underlying dimensions of a personality profile for an individual.

Ontology is a paradigm that complements epistemology in the sense that one does not (or should not) exist without the other. Kakol (2002) proposed a theory of worldviews based on process philosophies. He stated that "worldviews can be classified according to their approach toward the ultimate conceptual contrasts, such as being and becoming" (p. 209). Koepsell (1999) has stated that by conducting careful studies on the ontologies of the social world, and clarifying these ontologies, many real world problems can be solved.

In this research, contrasting ontologies (Process Philosophy vs. Substance Philosophy) are being used as the main perspectives of the personal ontologies that an individual may possess. As discussed in the background research section, Rescher (2000, p. 11) stated that "a substance-ontologist is committed to seeing the physical world (nature) as a collection of *things* and *objects*," whereas the process-orientation deals with continuous flow, movement and change. He further states that processes are connected to each other as integrated wholes; however, it is the individual who chooses to separate these connections and processes into certain aspects for convenience purposes. Process-oriented dispositions of individuals cannot be considered in isolation; these dispositions characterize an individual as part of certain social interrelationships and activities (Rescher, 1996). This becomes an important aspect, since all of the philosophical dimensions and the related predispositions and orientations will provide certain traits to the individual when dealing with complex problems. From these arguments, the following premises are presented.

- **Ontology Related Premises:**

Premise 4.1: Ontological predisposition is an indicator of how an individual approaches, shapes and defines the world.

Premise 4.2: Ontological predisposition consists of two paradigms; substantive-orientation focuses on individual entities, passivity and discreteness, whereas Process-orientation focuses on overall flow, activity and continuity.

3.1.5 Teleological Predisposition

Teleological dimension relates to *why* an individual does the things he/she does. Teleologies, by definition, deal with the purpose of actions. As discussed previously in

Section Two, the teleological framework of Stacey (Stacey et al, 2000) contains two main components. The first is the Predictable or Known state of the future, which deals with how the individual sees the future. We are well aware that in no case can the future be fully known, but we believe that certain situations are stable enough to lead to a high level of predictability; and certain individuals will have a tendency to see the future in a more predictable, stable manner. On the other hand, in the second component, due to different factors such as the dynamics of the environment, the state of the future can be Unpredictable or Unknown, and certain individuals see the future in an unknown and unstable way.

Similar to personal epistemology studies, teleology has also been a part of personality research, albeit in a different sense. Research from personality literature show us that teleologies have been dealt with not as one single dimension, but rather as an either/or/dual case together with "causality." A personality theory would either consider causality, or teleology, or sometimes both. Rychlak (1994) stated that human beings are teleological organisms. Therefore, according to Rychlak, it would not make much sense to view them as mechanistic individuals, functioning on a purely cause-and-effect basis. Rychlak (2000) further states that teleology presents an accurate description of individuals, and mechanical models cannot capture certain behavioral aspects.

According to Rychlak (1994), there are three different teleologies. Deity teleology, which is based on the assumption that entities and events are determined by purposes of a deity, a higher power such as God; *Natural teleology*, in which nature itself is directed in accordance with its purposes; and *Human teleology*, in which humans can behave for the sake of their own intentions, where people have the capacity to formulate goals and behave for the sake of them. In terms of personality theories, the reflection of Natural teleology can be seen in works of Piaget and Rogers. Jung, Adler and Kelly are supporters of the Human teleology, where individuals are responsible for their own goals and relevant behaviors. Human teleologists assume that humans are agents of their actions, and behaviors are not determined by the environment, as opposed to the studies of Skinner for instance, who argued that humans have no purpose or free will. According to Ewen (2003, p. 63), Freud focused on "the childhood determinants of personality (causality)," whereas Jung argued that behavior needs to be considered together with its

purpose or goal (teleology). Similar to Jung and Adler, Allport also concluded that human behavior is not exactly determined by prior causes; but rather, intentions. The purposeful actions that teleology represents are not due to a causal chain of events that precede them (Slife and Williams, 1995).

Teleologists view goals and actions as being "simultaneously connected." Goals are not just futuristic concepts, they have implications on our present behavior (Slife and Williams, 1995). Ewen (2003, p. 63) stated that "personality is shaped by our past and by our intentions and plans for the future." These studies provide useful arguments when discussing teleologies. Being goal-oriented and having that orientation are characteristics which reflect that one's personality is indeed a crucial argument. Locke and Latham (2002) describe a goal as the object or the purpose of an action. Similarly, Austin and Vancouver (1996) define goals as representing a desired state, where these states may be outcomes, events or processes. Assuming the state of the future as being predictable or unpredictable is also a part of the teleological dimension. It can be argued that this also fits in with the goal-orientation approach as well. Goal-oriented individuals can be seen as individuals who have a certain expectation from the future, therefore, will have a predisposition towards seeing that future as being predictable. Whereas, when a person does not act for the purpose of reaching a certain goal, it can be said that the individual perceives the future in an unpredictable manner.

Stacey et al. (2000, p. 18) have stated that when predictability is questioned, all of the management beliefs need to be questioned as well. When dealing with complex situations, the predictability component will fail to exist. Locke (1978) describes purposeful action as a requirement for individuals to survive. This requirement, however, is not guided by any environmental factor of any instinctual factor; rather, it is a matter of choice. Sweller and Levine (1982) discuss the effects of goal specificity on problem-solving, and they state that the goal is an important factor for the problem-solvers, and it provides guidance through the problem. However, Locke (1978) has stated that setting goals is not always beneficial; in certain situations, goal setting may lead to performance being neglected. Therefore, goal orientation may not always provide good capabilities to an individual. The following premises are related to the teleological predisposition.

- **Teleology Related Premises:**

Premise 5.1: Teleological predisposition is an indicator of the purpose of the actions of the individual

Premise 5.2: Teleological predisposition consists of two paradigms. Goal-orientation focuses on action towards a specific goal and it assumes the future to be predictable, whereas non-goal orientation focuses on no specific goals being set and assumes the future is unpredictable.

3.1.6 Complex Problems

Problem complexity proved to be an intersection of many different bodies knowledge, including problem-solving, complexity and systems theories. As discussed in the Background Research section, many different characteristics of complex problems were defined by various researchers. Rittel and Weber (1973) defined wicked problems as having no definition, no unique or optimal solution, no time-constraints for testing a solution, no trial and error learning and no truth, meaning that there would be just improvement. Lloyd (1978) described complex problems as having many variables, complex relationships between entities, impracticality in fragmenting the problems, the dynamic nature, and difficulty in establishing cause-and-effect relationships. Steinberg (1983) presented two main characteristics as the number of components, and the problem solver's familiarity with the problem, which also is related to the availability of information on the problem. Funke (1991), who was one of the leading scholars of the German school of complex problems, attributed complexity in problems to the lack of transparency (the ambiguous nature), the presence of multiple goals, the connectivity of variables, the dynamic developments within the environment and the problem, and the effects of time constraints. The time issues were also discussed by Augier et al (2001) and Quesada et al (2005). Bar-Yam (1993), providing a more systemic perspective, described complexity as the number of components, the relationship among the components, and the information needed on these components. Another perspective in terms of systems complexity came from Flood and Carson (1993), where they stated that the nature of complexity would arise from a large number of parts, significant interactions, nonlinearity, and nonholonomic constraints. Barrows (1994), when

discussing complex problems stated that the nature of a complex problem is unclear, there is not enough information, there is more than one way to solve a problem, and channeling Rittel and Weber, there is no single right answer.

From these studies (and from the more elaborated discussions provided in Section 2), the most common variables that define complex problems were chosen, which are information availability, ambiguity, time-sensitivity, stability and the number of entities. Information available in a problem (Bar-Yam, 1993; Barrows, 1994; Duncan, 1972; Hood et al, 1993) represents any information about the problem that is currently and potentially available to the problem solver. This may be available resources, available hard data, historical data, etc. In complex problems, some information (but not enough) is provided to solve the problem; therefore, available information is low, whereas in simple problems, the available information is high. Number of entities in a problem (Bar-Yam, 1993; Flood and Carson, 1993; Lloyd, 1978; Steinberg, 1983) is the number of components that come together to formulate the problem. Usually, this means that the more components a problem has, the more complex it gets. Therefore, in complex problems, the number of entities is high, whereas in simple problems the number of entities is low. Ambiguity in a problem (Barrows, 1994; Funke, 1991; Lawrence and Lorsch, 1967; Lloyd, 1978; Rittel and Weber, 1973) involves uncertainties. Instead of having a clearly defined problem, there are gray and black areas within the boundaries of a problem. In some cases, the ambiguity may even surface due to the vagueness of the boundaries. The less ambiguous the problem is; a more clear definition exists. This may initially seem related to available information. For instance, can a problem still be ambiguous even though there is a lot of information available about the problem? Yes. The individual may have/or acquire information about a problem, but may not know how to use it, how or where to apply it. Also, when a problem is dynamic, the information an individual has may not be useful after a while, after the problem has changed states. Stability in a problem (Funke, 1991; Lloyd, 1978; Quesada et al, 2005; Swinth, 1971) deals with the initial and final states of the problem. A problem may be considered to be stable if the conditions of a problem do not change. Complex problems have a tendency to evolve from one state to another. When time = t, the characteristics of the problem may have changed. The desired end-state gets continuously redefined, which means the

problem is dynamic. A high level of stability indicates that the problem is simple. Time-Sensitivity in a problem (Augier et al, 2001; Funke, 1991; Lawrence and Lorsch, 1967; Quesada et al, 2005) is focused on whether the solution of the problem is attached to any deadlines, time restrictions or limitations. For certain types of problems, time may be the most important component. For other problems, even though finding a solution is the ultimate goal, the way in which solutions are found, other emerging aspects of the problem while this process is in effect, may also be significant improvements. This argument can also be supported by whether the problem has a long-time horizon (which in this case, the key concern is effectiveness) or a short-time horizon (in which the key concern is efficiency). This variable also becomes important when all the other factors are put in, for instance, when trying to collect all possible data about a problem may help with accurate problem definition. If the problem has time constraints, this may not be desirable.

Other variables used in other studies are also valid within the context they were defined; however, for the purpose of this research, the variables outside of the five above discussed variables are not taken into consideration. The interactions or interrelationships between the entities was not chosen, for instance, because it is assumed that the more entities a problem has, the more interrelationships will there be. The issue of Polytely (multiple goals) is covered within the time-sensitivity variable. This means that when the problem has a temporal component, it is constrained by certain deadlines, which is in alignment with the problem having certain goals. The *ambiguity* variable chosen includes the issues of reducibility and irreducibility. It can be argued that the more ambiguous a problem is, the more irreducible it becomes. From the above arguments, the following premises are obtained.

- **Complex Problem Related Premises:**

Premise 6.1: A complex problem is defined by the following properties: Information available, Ambiguity, Time-Sensitivity, Stability and Number of entities.

Premise 6.2: According to the different properties, the problem ranges from simple to complex (Davis, 1969).

Premise 6.3: Individuals with different profiles deal with problems differently (Mumford, 1998).

Assumption 6.1: The complexity that is under consideration is assumed to be an inherent part of the problem, and not the individual.

3.1.7 Predisposition-Problem Interaction

In this section, it is argued that certain predispositions present certain capabilities to individuals. These capabilities may or may not be useful or appropriate when dealing with issues of complex problems discussed above. The predisposition, problem-interaction premises elaborate on how certain tendencies within individuals would provide certain kinds of capabilities when dealing with complex problems. Therefore, combining the above premises and additional literature, certain assumptions, inferences and conclusions are made on how different predispositions of individuals change the capabilities of dealing with complex problems. The following premises are divided into five categories, which describe the interaction of each dimension with the complex problem variables:

- **Problem Variable 1: Available Information**
  - Complex problem: available information is low
  - Simple problem: available information is high
  - **Empiricist**: When available information about the problem is high, this individual will deal with the problem better, because the capabilities he has are stronger, since the tools he has makes him predisposed in a way such that he will first want to collect information on the problem. This may take a longer time (which becomes important when the problem is time-dependent), but this way makes sure that the problem is correctly identified. When available information about the problem is low, in other words, when the problem cannot be defined properly, the Empiricist will deal with the problem poorly. The individual will want to collect information, but will fail to do so. This will lead to an incomplete understanding of the problem. Cooper et al (1995) found

that entrepreneurs with relevant industry experience will still perform more information search on a problem.

- **Rationalist**: When available information about the problem is high, the Rationalist will still not care about this. Even though there may be hard data and facts available about the problem, the rationalist will tend to use reason and logic to deduce conclusions about the problem. There have been various studies (e.g. Kahneman, 2003; Stanovich and West, 2002) which show that even though certain information about a problem or a situation is available, certain individuals will tend to ignore it, and come to a decision through reasoning. As discussed before, Campbell (1968) argued that selecting the relevant data to the problem, among many other amounts and types of information that is not required is an issue when dealing with problems. Even though a rationalist approach may take less time, it may also lead to a wrong definition and understanding of the problem. If there isn't much information about the problem, then the tools and the capabilities the Rationalist individual has is useful. For instance, a brainstorming session may prove to be a better way of dealing with such a problem, rather than trying to collect more information (which, in this case, does not exist).
- **Substantive**: When there is much information about the problem, the substantive-oriented person will tend to go through all of this information. This is a better way of knowing and understanding the problem, however it may (similar to Empiricist) work against the individual as well, if there are time-sensitive issues. If there is little information about the problem, the substantive individual will fall short in trying to learn more about the problem, however, it may be in a timelier manner.
- **Process**: This individual tends to have a continuous, whole approach to the problem, so even if there is much information about the problem, the capability may work against this individual, important information may get overlooked, when trying to come up with a more functional, active way of knowing about the problem. However, when there is little information available about the problem, this approach may be more efficient and useful.
- **Goal-Oriented**: When there is a lot of information about the problem, this predisposition will provide better capabilities to the individual, in the sense that the goal-orientation of the individual will help him/her find the information and better identify the

problem. This structured approach and perception of predictability will be better justified when all of the information is put in place. When there is little information about the problem, this tendency works against the individual. Assuming predictability becomes dangerous when there is much unknown about the problem. Sweller and Levine (1982) state that if an individual is not given sufficient information or a description of a specific problem, including a specific goal, the individual is not able to solve this problem because there will not be a condition where the goal will control and direct the problem-solver. However, Locke and Latham (2002) have also stated that individuals who face certain task goals tend to use the knowledge and skills that are already in their possession, which they have acquired through experience. Therefore, there is a chance that even though there is not much available information on a problem, the goal-oriented individual may still be able to solve this problem.

- **No-Goal Oriented**: Even when there is much known about the problem, this predisposition will not be of help to the individual. Since everything will be perceived as being unpredictable, there will be no structure to actions, and the available information about the problem will be disregarded, and will be thought of as being not useful. If there is very little known about the problem, this is already in line with thinking that the future is unpredictable. The no-goal oriented person will be a better problem-solver here, since the approach in dealing with the problem will not be constrained with pre-conceived goals. Locke and Latham (2002) have discussed that when dealing with a complex task, setting goals may backfire in the sense that individual may be anxious to succeed when goals are being set.

- **Problem Variable 2: Number of Entities**
  - Complex problem: number of entities is high
  - Simple problem: number of entities is low
  - **Empiricist:** When number of entities is high, the empiricist tendency will provide better tools to the individual, since obtaining hard data and facts about each of the entities will provide more solid information, but it will take more time, and in some cases, may not be always possible. So, it is a better tool, but slower. This will also depend on the amount of information available for each entity. When there are not many entities that

make up the problem, it is easier to come up with data and information about the entities (if possible). Either way, fewer entities lead to faster and better understanding of the problem.

- **Rationalist:** This predisposition will not provide good tools when dealing with problems with a high number of entities. More entities lead to more interrelationships, and knowing everything about these may not be possible by using logical arguments and deductions. Nickerson (2004) have stated that the tendency to reach a conclusion without giving the appropriate attention to the evidence available could be a reason to improve an individual's reasoning process. Even though it will be an informed guessing game, it will take a shorter time. When there are not many entities within a problem, the Rationalist approach will be the right approach.
- **Substantive:** When there are more entities, the substantive-oriented person will want to look at each of the entities and learn about the problem. This provides a better understanding of the problem, since complex problems with a high number of entities need to be considered from all angles (Beers et al., 2006), but it may not be the most efficient way. The most efficient way is when the number of entities is low.
- **Process:** This approach when the number of entities is high will not provide a good understanding of the problem, since the Process orientation tends to look at the whole. Unless you understand how each entity works, it will be very difficult (and sometimes wrong) to take a look at the whole. But it will take a shorter time when diving right into a situation, instead of trying to understand every component. When the number of entities is low, this is the better and faster one.
- **Goal-Oriented:** When there are many components to a problem, future events may not be so predictable, so this approach does not provide appropriate tools for this condition. The more components a problem has, the less predictable things become. However, when the entities are few, the goal-oriented approach becomes much more useful since each component can be examined and results can be predicted.
- **No-Goal Oriented:** When the number of entities is high, seeing the future as unpredictable is an advantage. Out of the high number of entities and interrelationships, emergence is expected, and this predisposition has the capability to deal with that. When there are fewer entities, this tendency works against the individual. It may be easier to

predict the future, but the individual may not do so, and this may lead to providing solutions to non-existent problems.

- **Problem Variable 3: Stability**
  - Complex problem: dynamic
  - Simple problem: stable
  - **Empiricist:** When the problem is stable, this means that the conditions do not change over time; the entities of the problem remain the same. This makes possible for the Empiricist tendency to have more capabilities for the individual, since variables such as facts, experience, perception etc. will provide adequate definition of the problem. However, if the problem is dynamic, the empiricist will have a hard time identifying these factors, thus dealing with the problem less effectively.
  - **Rationalist:** If the problem conditions are stable, the Rationalist will have appropriate tools. When there is stability, reason and logic will provide good understanding of the problem. When the conditions start changing, the Rationalist will still have better tools than the Empiricist. The effect of changing conditions on the entities may be better understood by the Rationalist. Reasoning is defined as "the process of drawing conclusions" (Leighton, 2004, p. 3). Therefore, it will be easier for the individual who has a Rationalist tendency to gain information on a problem that may not always be stable.
  - **Substantive:** If the problem is stable, the Substantive orientation will be more successful in solving the problem. The divide-and-conquer approach will work better if the initial conditions of the problem aren't changing. If the problem is dynamic, the substantive approach may still be beneficial, since the components of the problem are still seen as individual entities, and the new conditions may be better perceived.
  - **Process:** When the conditions of the problem are stable, the overall state of the problem may be better understood. However, when the conditions start changing, the overall holistic approach may miss the changes. Even though the foundation of the process philosophy lies in change and continuity in order to fully grasp the changing conditions, a different approach may be necessary. Rescher (2000) points out that a process is "a unity of distinct stages or phases…a matter of now this, now that" (p. 24).

Therefore, when the problem is dynamic, each different stage may not always be as apparent as necessary.

- **Goal-Oriented:** When the problem is stable, the individual who sees the future as predictable will have a better understanding of the problem. The goals may be better defined under these conditions. When the problem becomes dynamic, it may be more difficult to keep the goals in sight, and the predictability of the future is no longer valid.
- **No-Goal Oriented:** If the problem is stable, but the person still sees a certain degree of unpredictability in the future and therefore sets no goals, the stability of the conditions are not being used to the full advantage. However, when the entities of the problem start changing, this individual will have a better capability of solving this problem. The unstructured behavior towards solving the problem may work as an advantage, since it provides more flexibility and adaptability.

- **Problem Variable 4: Ambiguity**
  - Complex problem: ambiguity is high
  - Simple problem: ambiguity is low
  - **Empiricist:** When the problem is clear, empiricist will have good capabilities to solve the problem. The difficulty of the problem will decrease, and empiricist will gain more capabilities due to its success. When the problem is ambiguous, the empirical capabilities will not be helpful. Since the problem will lack clarity, the empiricist individual will not be able to find any tangible variables to measure and analyze data.
  - **Rationalist:** When the problem is clear, the rationalist will tend to make decisions with intuition, which may not always work for the best. Seth (1893, p. 555) notes that "the particularity which individualizes the universal is not to be deduced *a priori*; it can only be induced, learned by experience or empirically." If the problem is clear, then there should not be a need to make intuitive decisions. Therefore, this will work against the problem. However, if the problem is ambiguous, this is where rationalist thought will be beneficial for the problem.
  - **Substantive:** If the problem is clear, the substantive approach will be more capable of solving the problem, since dividing the problem into its individual elements will not be an issue because there will be no grey areas in a clear problem. But if the

problem is very ambiguous, this approach works against the problem. The ambiguity will not disappear when it is divided and will likely increase more, because we do not know how everything works within the problem. Reducing the problem into concepts will be a formalization, and the concreteness of this problem will be substituted for abstraction (Seth, 1893), which is not desirable.

- **Process:** Either way (regardless of whether the problem is ambiguous or not), the process-oriented approach is useful. It will help better to solve the problem, and increase the capabilities of the profile.
- **Goal-Oriented:** If the problem is clear, then a goal-oriented individual is going to have better capabilities to solve the problem, since certain goals can be set, and achieved, since the problem is clear. However, when the problem is highly ambiguous, the individual will not have a clear idea on all of the components within the problem and how they function together; therefore, setting goals for most of the situations is not a good approach. However, Locke et al (1989) have stated that goal specificity sometimes reduces variation in performance by reducing ambiguity about what the main purpose is. Therefore, the goal-orientation may sometimes be useful in ambiguous situations.
- **No-Goal Oriented:** This may be a more appropriate way to deal with a highly ambiguous problem. When the problem cannot be defined very clearly, taking one step at a time, adapting a more trial-and-error type approach may be useful. There will always be the ultimate goal of solving the problem. However, when more specific and detailed goals are set, not being able to reach them in a desired manner may create more unintended complexity.

- **Problem Variable 5: Temporal Component**
  - Complex problem: time is constrained
  - Simple problem: time is not constrained
  - **Empiricist:** When the problem is not constrained by temporal issues (meaning that when the solution of the problem is not immediate), the empiricist approach will be a better tool in providing a solution since there will be time to gather and analyze the data. However, if the problem is attached to a deadline (which is usually the case), then this approach, even though it may be a more solid one, will be a disadvantage. This is due to

the fact that under time pressure, individuals tend to collect lots of information on various alternative solutions, but analyzing only a small subset of these solutions (Verplanken, 1993). In this case, some parts of the problem will remain unsolved or unknown.

- **Rationalist:** When problem is time-dependent, the rationalist predisposition would provide better capabilities, considering the fact that within a time-constrained environment, there may not be time to go out and collect data, analyze this data and make a decision. As Cacioppo et al (1996) stated gathering information is a time consuming expensive and difficult activity. If there are no temporal constraints, the rationalist approach may or may not be of significant help because this depends on other conditions.
- **Substantive:** When the problem has temporal constraints, this predisposition may have disadvantages. When there are deadlines associated with the solution of a problem, a more continuous, holistic approach would be more useful. When the problem does not have any temporal constraints, still the substantive approach would not be of significant help because conceptualizing in a discrete fashion will take a long time. Therefore, even if there are no time-dependencies, it will not be efficient. Johnson (1974) states that inferences from experiences based on perception within a temporally discrete space are valid only for some (not all) of the observations. This relates to the empiricist predisposition as well, and means that the observations made through a discrete lens are not always correct.
- **Process:** Rescher (2000) has stated that a process is not only a collection of sequential stages, but also demonstrates a "spatiotemporal continuity." Therefore, when the complex problem presents time-dependent conditions, the process orientation will bring significant capabilities to the profile. If there are no temporal constraints, it could still be argued that this predisposition would still be useful to the individual in the sense that the problem may have been solved.
- **Goal-Oriented:** This predisposition would generate the most advantageous capability of the profile when there are time-constraints involved. The future is assumed to be predictable, and towards this, certain goals are specified. Rescher (2000) states that individuals tend to see themselves as sources of teleological (i.e. purposive) activities shaped to satisfy wants and needs of the situation. However, if there are no time constraints involved, this orientation would not be able to deal with the complex

problems in a useful manner. As La Porte and Nath (1976) state, when an individual has control over the time that is spent on a task, that is, when the task itself does not have any temporal constraints, hard goals prolong this effort.

- **No-Goal Oriented:** If the problem has temporal constraints, then not being goal-oriented, and assuming that the future is unpredictable would reduce the capability of the individual, since the presence of deadlines should be the ultimate goal. However, when the situation is not time-dependent, then the individual without a specific goal would not lose significant capabilities.

3.2 The Philosophical Profile of the Individual

Following the general and specific premises and assumptions discussed above, the general theory of PPI and the specific propositions are described below. The purpose of this is to provide a general statement for the philosophical profile of the individual, and formulate the specific propositions for each of the profiles. These statements are not in the traditional hypothesis format, since no statistically significant correlations are being hypothesized. Instead, following the rationalist deductive methodology and the coherence theory of truth paradigm, the specific theories for the PPI (i.e. the individual profiles) are going to be stated in a proposition format. These propositions cannot contain any predictive content, since the PPI is a combination of three different dimensions. Even though from the detailed individual-problem related premises certain assumptions and expectations could be inferred, one cannot at this point of the research hypothesize that one profile will deal with complex problems a certain way, and another profile will deal with them another way, etc. These types of statements will be made in the results section, as part of interpreting the results obtained through the simulation.

General Statement for PPI

The Philosophical Profile of the Individual is a model which states that three underlying philosophical predispositions, namely Epistemology, Ontology and Teleology, are present within an individual as embedded values that guide how the individual

approaches reality, chooses to acquire knowledge, and deals with the future. The constructs of the PPI are useful when individuals tend to solve complex problems.

Following the discussions presented above, the PPI is built and represented using a three-dimensional graphic, shown below in Figure 3 and Figure 4. A three-dimensional representation is used to better address the philosophical profiles. Eight profiles are obtained out of the combination of the paradigms by going through the following steps:

1. Establish the main categories for the axis
    a. x-axis: Ontology
    b. y-axis: Epistemology
    c. z-axis: Teleology
2. Establish components for each category
    a. Ontology: Substantive-Process
    b. Epistemology: Empiricism-Rationalism
    c. Teleology: Goal Oriented-No Goal Oriented
3. Construct all possible combinations using all three categories

The x-axis represents the ontological assumptions, with the substantive vs. process approaches on either side of the axis. The y-axis is the full scale of epistemology with empiricism and rationalism on opposite sides. The third and final axis is represented by the teleologies, and the individual is identified as being either goal-oriented or not-goal oriented. Therefore, from the above set-up, a total of eight profiles are obtained. The three main dimensions are Epistemology, Ontology and Teleology, and the different profiles are shown by the individual boxes. Each box represents a different profile. Depending on the dimension, the characteristics and capabilities of the PPI will change.

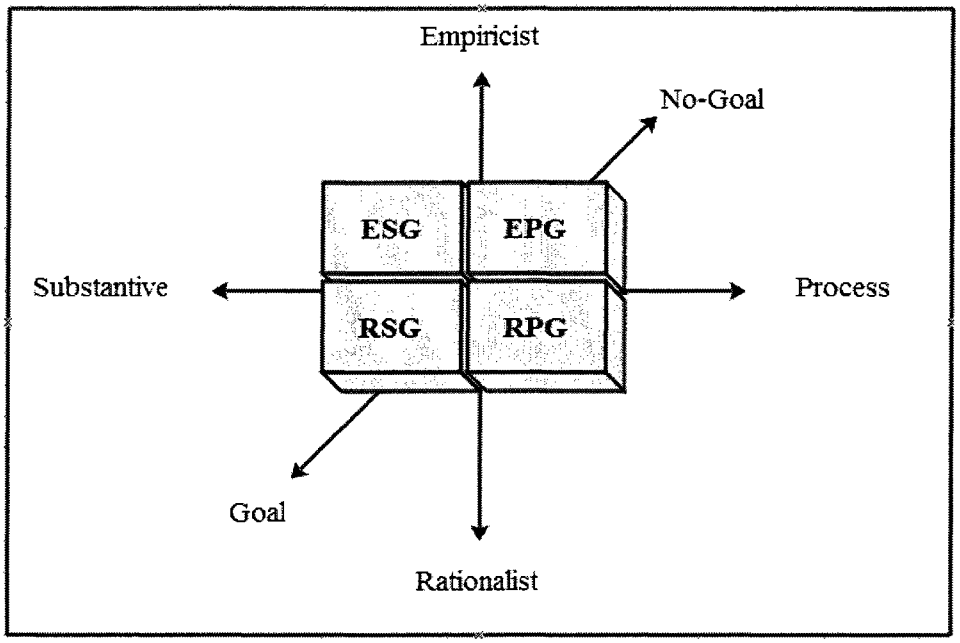

Figure 3. The PPI structure 1

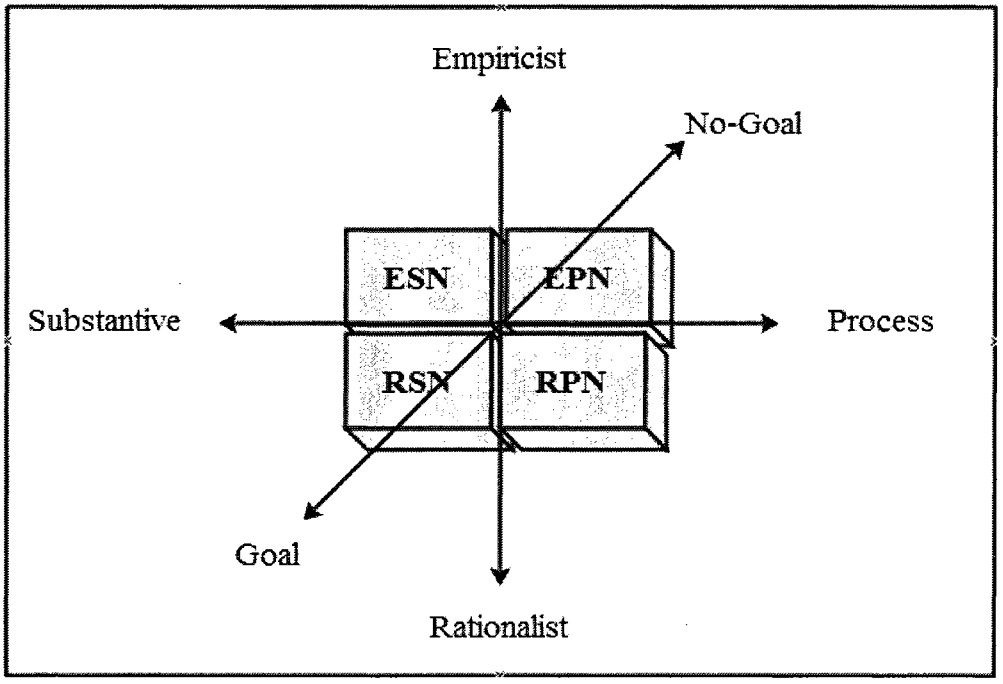

Figure 4. The PPI structure 2

Each of the three dimensions is present within an individual, since the dimensions complete each other in an inseparable way. An individual, at any point in time, will have

a representation and definition of reality, or the things around himself or herself. The individual will have some means of acquiring information and knowledge about the world surrounding him or herself, and the individual will act or behave in a certain way for different purposes. Context becomes a crucial matter when it comes to personality psychology (Winter and Barenbaum, 2001). Therefore, it is important to establish how differently and effectively each of these different profiles will deal with complex problems. Once the general structure of the PPI has been established, the focus is now on identifying each profile, and stating the capabilities of each dimension and predisposition which add to the specific profile.

Specific Statements for the PPI

- *PPI1 represents the Empiricist-Substantive-Goal (ESG) profile.*

In this first profile, the epistemological predisposition of the individual is empiricism, the ontological predisposition is substantive, and the teleological predisposition is goal orientation. The individual who fits this profile needs to observe facts, make use of sense data and hard, tangible constructs in order to acquire knowledge about a certain problem. The way the individual sees and shapes the real world around him/her is through a substantive philosophy approach. The individual sees the future as being predictable, and the actions of the individual are towards achieving a certain goal. Engineers are a good example for this type of profile. The highly observant nature of engineering is very fitting here, along with the reductionist, predictable and goal-oriented approaches.

Proposition 1: An individual with a PPI1 relies on observable facts, sees reality as being divided into individual components, assumes the future is predictable, and is expected to have a certain ability to deal with complex problems.

- *PPI2 represents the Empiricist-Process-Goal (EPG) profile.*

In the second profile, the epistemological tendency of the individual is again empiricism, where knowledge is acquired through observation, data and facts. The

ontological predisposition is from a process philosophy perspective, where the reality is seen as a continuum, and accordingly, the approach of the individual is a process-oriented approach, meaning that the individual will have a tendency to consider things as a whole, one following the other, as part of a process. The future is seen as predictable and the individual is goal-oriented.

Proposition 2: An individual with a PPI2 is goal-oriented, relies on observation and holistic approaches to deal with predictable issues, and is expected to have a certain ability to deal with complex problems.

- *PPI3 represents the Rationalist-Substantive-Goal (RSG) profile.*

An individual with this type of profile seeks knowledge using reasoning and deduction, which is representative of a rationalist epistemological predisposition. From the ontological perspective, substantive philosophy is the dominating tendency. The individual sees the world as divided into its elements in a very reducible way. Goal-orientation is an important factor in this profile and the teleological predisposition is to have certain goals within a predictable future, and strive to achieve them. Mathematicians would be a good example for this, since a purely theoretical approach to reality and knowledge is dominant in this profile, especially in terms of epistemological arguments.

Proposition 3: An individual with a PPI3 uses reason, logic and deduction to obtain knowledge, sees the future as being certain, and has a substantive and individual approach to reality, and is expected to have a certain ability to deal with complex problems.

- *PPI4 represents the Rationalist-Process-Goal (RPG) profile.*

The fourth profile describes an individual who has a tendency towards seeking and gaining knowledge from a rationalist perspective, and therefore, believes that a priori knowledge is possible. This individual works well within predictive environments, has a goal-oriented teleological predisposition, and also has a capability of seeing himself and reality as part of a continuous process. Managers, for instance, may be a good example for this type of profile. The managers often need to work with deadlines; therefore,

keeping up with certain goals would be an appropriate choice for them. Also, they often may need to make decisions when empirical data is lacking; therefore, a rationalist predisposition would be seen in managers and leaders, since they would follow certain reasoning processes to reach decisions.

Proposition 4: An individual with a PPI4 is goal-oriented, may see the future as being predictable; and rather than waiting to reach and observe facts, he/she uses reason and logic to establish an understanding of the big picture, and is expected to have a certain ability to deal with complex problems.

- *PPI5 represents the Empiricist-Substantive-NoGoal (ESN) profile.*

This fifth profile presents an individual who has an empiricist tendency from an epistemological stance, meaning that reliance upon observable facts plays an important role for this individual. The future he/she deals with is assumed to be unpredictable; from a teleological predisposition, the behavior and actions of this individual are not oriented towards achieving any pre-determined goals. The ontological predisposition of this profile has a substantive nature, which may not always be ideal when dealing with unpredictable and unstable events. One needs to have a certain holistic approach in order to better deal with unknown states.

Proposition 5: An individual with a PPI5 relies on hard facts and observations to gain knowledge, assumes reality to be formed of individual things and objects, is not goal oriented and is expected to have a certain ability to deal with complex problems.

- *PPI6 represents the Empiricist-Process-NoGoal (EPN) profile.*

In the sixth profile, PPI6, the individual is an empiricist who tends to rely on sense data, observations, measurements, etc. From an ontological perspective, the individual sees reality as a process, as a whole. There is no goal orientation in terms of the future; therefore, a certain level of unpredictability is present. Some levels of military may be an appropriate example for this. When the future is unpredictable, one needs to look at the big picture, but also to rely on observations. The decisions made need to be

based on certain facts, since the implications and consequences of these decisions would be severe, especially in an unpredictable future.

Proposition 6: An individual with a PPI6 works in an uncertain environment; takes a holistic view and also relies on facts to deal with the situations, and is expected to have a certain ability to deal with complex problems.

- *PPI7 represents the Rationalist-Substantive-NoGoal (RSN) profile.*

This profile seeks knowledge through a deductive approach, using processes such as reasoning and logic to acquire and also create knowledge. An individual with this particular profile feels comfortable dealing with high levels of uncertainty while using discrete concepts that can be generated via imagination, creativity and not necessarily facts. The lack of goal orientation and the rationalist view may complement each other in certain ways, whereas the substantive predisposition may work against the other two dimensions due to its individualistic nature.

Proposition 7: An individual with a PPI7 relies on deductive and logical reasoning to deal with an unpredictable future more than he/she relies on observed facts, does not have a goal-oriented perspective, and is expected to have a certain ability to deal with complex problems.

- *PPI8 represents Rationalist-Process-NoGoal (RPN) profile.*

The last profile describes an individual who is a rationalist from an epistemological perspective. The ontological predisposition is process-oriented, and the teleological tendencies are towards not setting any specific goals, since the future is assumed to be unpredictable by nature. Leaders and politicians may be good examples for this. When dealing with uncertain situations, one needs to be able to see the big future and make rationalist decisions.

Proposition 8: An individual with a PPI8 uses reason and logic to reach knowledge, and has a process approach towards reality, which enables him/her to deal

with uncertain situations without specifying goals, and is expected to have a certain ability to deal with complex problems.

3.3 Summary of Theoretical Foundation

In this section, the elements and concepts that were discussed in the background research section have been tied together to form a theoretical foundation that provides the basis of this research. As mentioned earlier in the introduction, the purpose of this research is to gain insight on how different individuals with different personality profiles deal with complex problems. The personality profile that is being analyzed in this research is the Philosophical Profile of the Individual. It has been argued that the traditional personality theories, however popular and extensively used they may be, have found to be inadequate when addressing certain issues, such as dealing with complex problems. This section has provided the discussions on the philosophical dimensions that were chosen, and their relation to personalities. Following the dimensions, the PPI itself was presented, together with propositions of different individuals within the PPI.

4 RESEARCH METHODOLOGY

This section is an elaboration and discussion on the higher-level research methodology that was used in this study. The idea of a *research hierarchy* is proposed (as seen in Figure 5) and executed in this section.

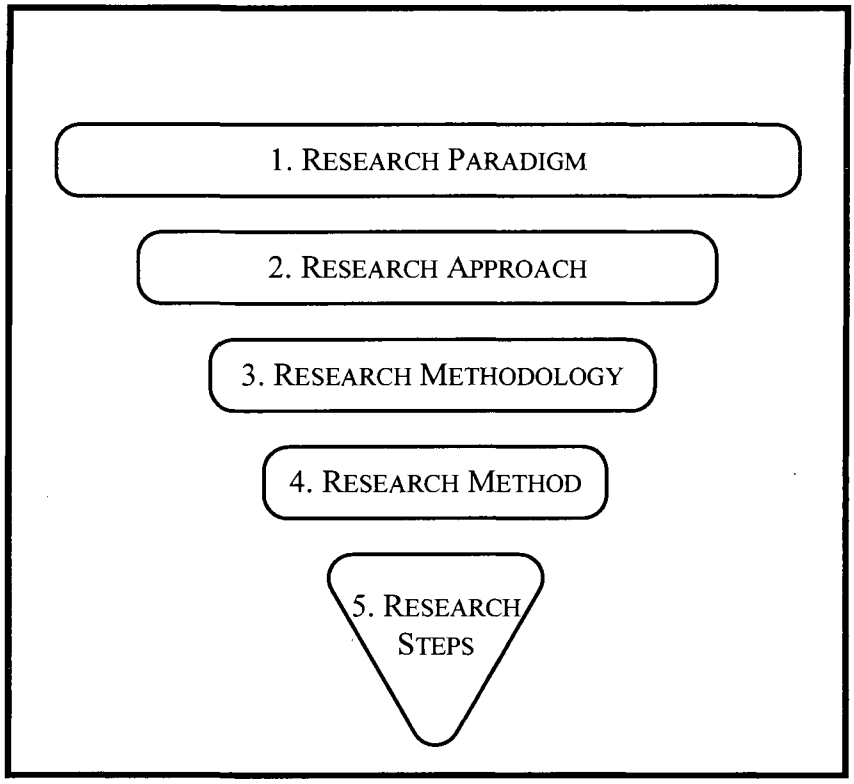

Figure 5. Research hierarchy

As Bozkurt and Sousa-Poza (2005) stated, there is always a debate on whether the research methodology follows the research question, or the research should be designed according to the major philosophical beliefs and assumptions of the researcher, or whether the only force guiding the research should be the specific research problem to be solved or the gap to be filled. It is argued in this section that every research should begin

with a paradigm, and everything else should be a reflection of this paradigm and should remain within the boundaries of this specific research paradigm.

The *first* part of this section presents a discussion on the *Research Paradigm* that is the underlying foundation of this research. This can be considered equivalent to a research philosophy to which one adapts while starting any research. This section provides an overview of the main premises that are used to construct the main research method. Arguments and discussions are presented on the theory of truth that is appropriate for this research, namely the coherence theory of truth, as well as the argument structure used in this research, namely deduction.

After the research paradigm, in the *second* part of this section, the *Research Approach* is presented. This approach is the bridge that connects the higher-level paradigmatic concept of doing research with the more refined research methodology. What the starting point of this research is, as well as where the research intends to go, and how this is going to be implemented is discussed through the research approach.

The *Research Methodology*, which is the *third* part of this section, is an overall representation of the type of study being done in this dissertation, namely a Rationalist Deductive Methodology. This step is where most studies tend to focus within the Research Methodology chapter; however, it is the firm belief of the author that the foundation for a methodology should be laid out initially by the research paradigm.

After going through these steps of the research hierarchy, a summary is presented at the end of the section. The last two phases of the research hierarchy, the research method and the research steps, are discussed in the latter sections of the dissertation.

4.1 Research Paradigm

Scientific research philosophies are overall conceptual frameworks within which researchers work; that is, a philosophy is a worldview or a set of linked assumptions about the world, which is shared by a community of scientists investigating the world (Healy and Perry, 2000). There are many classifications and terminologies for research philosophies. They are sometimes referred to as "research paradigms," "knowledge claims," "paradigms of research inquiry" etc. In this research, the term "research paradigm" is being used to describe this higher-level worldview adapted by the author.

A paradigm is a general perspective or way of thinking that reflects fundamental beliefs and assumptions (Kuhn, 1970). The research paradigm is therefore the specific perspective the researcher must take that is a reflection of his/her assumptions and beliefs towards research. As Gioia and Pitre (1990) correctly state, grounding a theory through appropriate paradigms and related assumptions prove to be helpful to researchers in terms that the common tendency of forcing theory-building techniques into one single approach is avoided.

In a research that deals with asking questions and why questioning is crucial, Sintonen (2004, p. 251) states that "the method of questioning may have been the first explicit view of how knowledge is acquired, as well as how it can be transmitted in both science and in everyday life." Research, which is what follows after questions are asked, is the systematic acquisition and justification of knowledge. The main purpose of doing research is, therefore, creating knowledge. In order to establish that which is being created is actually knowledge, the question "what is knowledge?" must be answered. The answer to this age old question comes from Plato. Plato, as far as we know, stated that knowledge is a *justified true belief (JTB)*. What JTB entails is shown in Figure 6.

The *justification* process of the truth is the crucial component in any research. Therefore, establishing the underlying research paradigm will start with an elaboration on the processes of justification, which is through Rationalism in this research.

Following this section, the *true belief* component will be addressed via discussion of the theories of truth. For the purposes of this research, through the rationalist arguments, Coherence Theory of Truth is the appropriate foundation; therefore, a discussion on this theory and how it relates to the present research is presented.

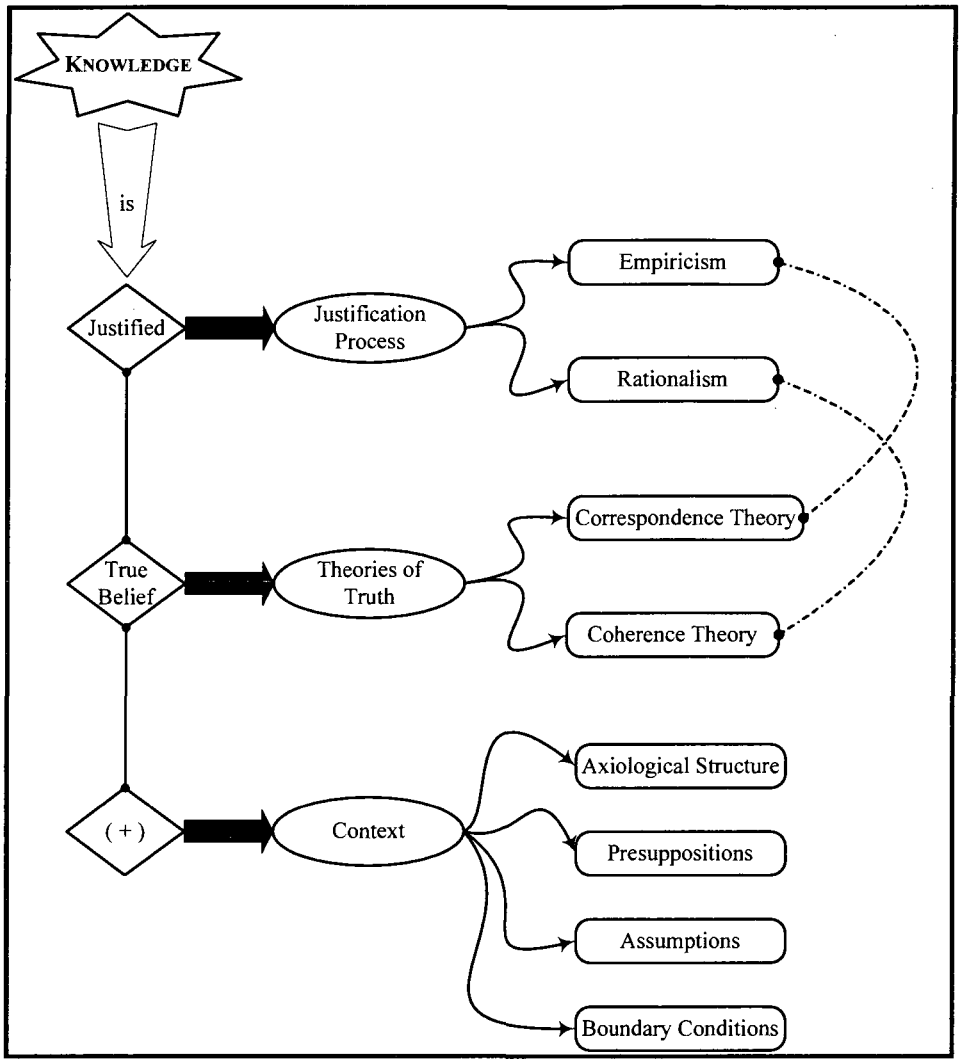

Figure 6. Research paradigm

4.1.1 Justification Process

The justification process of a true belief is at the heart of creating knowledge. Without justification, one can only state that all the statements and the conclusions made are *knowledge claims*, rather than *truths*. At the heart of the justification process lies the core premise of acquiring and generating knowledge. It is crucial to note that it is not the results but the *process of justification* that should be replicable in any research.

In general, there are two routes that can be taken; the use of Empiricism or Rationalism. Empiricism provides justification through observation of elements in the

real world. Rationalism provides justification through the use of previously generated and justified knowledge without having a tie to reality. Since Section 2 of this study has provided an extensive discussion on Empiricism and Rationalism, this section will provide a brief recap on the important aspects of the two justification processes.

Empirical justification is achieved through the use of observation and hard data. The data collection method, the type of data collected, and the contents of the data are included in this definition. Therefore experimental methodologies, statistical analysis etc. are part of this justification. In an empirical model, the premises are based on observations.

Within a rationalist justification, previous theories, knowledge claims, and statements known to be true are used in terms of data. The concept of data is still present, albeit in a different format. In the case of rationalism, sensory data that is collected through observations is not used. Argument structures such as Agent-Based Modeling, System Dynamics, formal logic or mathematical models, or mathematical equations are used. Within these different arguments, the way in which the conclusion is reached is different. In formal logic, for instance, the conclusion is defined as such: (a = c). The study done by Kunkel and Nagasawa (1973) is an excellent example to this. In an effort to develop a "model of man" that can be used as a general model by sociologists, they have used previous studies from literature as higher-level propositions and lower-level hypothesis. These building blocks are, then, used as axioms. Through a formal deductive argument, they develop a theorem from the formalized axioms. Tallman et al. (1993) have also followed this methodology, and have developed theorems and axioms (both verbal and mathematical) in order to develop a theory of problem-solving behavior.

When using ABM or multivariate type studies; however, the conclusions will be interpretative. The lack of empirical (or sensory) evidence does not undermine the rationalistic arguments that have replaced these evidences. Fumerton (1980, p. 599) emphasized that "though theoretical entities are themselves unobservable, their defining properties may be such that we have observation of other things having those properties." It is interesting to see how studies that are intended to be generalizable discussions on research tend to stay on the empirical side. For example, Hill (1993, p. 46) defines a research method as "a way of collecting and analyzing empirical evidence." This

empirical tendency is not uncommon when dealing with issues relating to research design. This is why the research paradigm described above is important, so that it becomes apparent to researchers that the justification process can include different approaches, not limited to empirical evidence.

4.1.2 Theories of Truth

Sellars has stated that "a specific and significant theory of truth must tie up with all sorts of analyses of the knowing process and of its presuppositions and implications" (Sellars, 1941, p. 645). Theories of truth are the central piece of the arguments of which is known to be knowledge and truth. The decision of which theory of truth is going to be used as base for a research paradigm has implications throughout the rest of the research. The research approach, the research methodology, the research method and the canons of science to be used take their cue from the theory of truth that is chosen.

Similar to all intangible, abstract concepts, there are different classifications for theories of truth, depending on the author and the school of thought. These various theories of truths include Correspondence Theory of Truth (starting from Socrates, Aquinas, Sellars, and Ratner), Coherence Theory of Truth (Spinoza, Leibniz, Hegel, and Bradley), Consensus Theory of Truth (Habermas, Rescher) and Pragmatic Theory of Truth (Pierce, James, Dewey). Among these, Correspondence and Coherence theories are going to be discussed here. According to these theories, truth can be established either through correspondence or coherence. As Schmid (2005) stated, these theories of truth are not right or wrong; they represent different perspectives to study the problem in question.

According to the *correspondence theory*, truth consists in a certain agreement or correspondence between a statement and the so-called "facts" or "reality;" while according to the coherence theory, truth is a possible property of a whole system of statements, i.e. a certain conformity of statements with each other; in extreme cases, truth is even identified with the mutual compatibility of the elements of such a system (Hempel, 1935). The correspondence theory of truth, according to Sellars (1941, p. 654), is a theory "which fits in with a theory of validation, since both involve the cognitive value of sensory presentations." In this case, the "sensory" component of the

correspondence theory implies the acceptance of empirical propositions as knowledge, and by studying the mechanics of the act of "knowing," this implication is shown to be justified (Sellars, 1941). In the correspondence theory, a proposition is accepted as true if it corresponds or agrees with its facts; however, if the proposition fails to correspond or it disagrees with the facts, it is considered to be false (Ratner, 1935). According to Ratner, the essential process of determining correspondence (or agreement) is the act of comparison. He argues that the degree of precision of the comparison corresponds to the degree of precision attained in arriving at the truth. Camilleri (1962, p. 171) stated that the "empirical truth of a theorem refers to the judged correspondence of its interpreted assertion with the observed state of affairs."

Coherence theory of truth is usually accepted to be the opposite of correspondence theory. However, contrasting the coherence theory of truth with the correspondence theory is, at the least, misleading, according to Walker (1985). The coherence theorist can accept that there are facts, and that true beliefs correspond with them. The correspondence ultimately consists in coherence. This is along the same line of thought that was mentioned in the previous section, where rationalists do not deny that knowledge can be obtained through sensory experience and observation. Their argument is based on the premise that this way is *not* the only way.

The coherence theory of truth claims that the truth of the statement consists in its coherence within a system of statements, or a relationship of coherence between beliefs (Dauer, 1974; Walker, 1985). Dauer goes on to state that two major coherence theorists, Bradley and Neurath, agree on two points: 1. Truth is characteristically judged in terms of coherence where even the most elementary synthetic statements or beliefs are subject to correction in light of other statements or beliefs. 2. The idea that statements or beliefs correspond to facts (experience, reality, etc.) is illusory or non-sensical. The coherence theory of concepts is the doctrine that all our concepts are related to one another in such a way that we cannot be said fully to have grasped any one of them unless we have grasped all the others (Firth, 1964).

According to Ratner (1935), the criterion of truth is the coherence of a proposition within a system of propositions. According to Walker (1985), this theory does not view coherence as a likely guide to truth, but rather it maintains the perspective that coherence

is all there is to truth and all that truth amounts to. He asks: "Our standards of rationality and justification are *our* standards, after all, and what assures us that our standards are such as to lead us to the truth about the world, and not just reflections of our psychological habits?" (Walker, 1985, p. 3) This is somehow in the same line as Ratner's reasoning to reject the criterion for coherence. He argues that this criterion of truth as coherence should be rejected, since "false propositions can also form a coherent system, and any false proposition will be coherent with other false propositions constituting that system" (Ratner, 1935, p. 142). In order to avoid this trap, one needs to have a firm understanding of the coherence theory of truth before using it as part of a methodology. To generate theory based on coherence, two conditions must be met: the propositions must be true and the arguments need to be correct. This assures the soundness of the methodology.

According to Cartwright (as cited in Hedrich, 2007, p. 273) reality can only be "captured approximately, by a patchwork of effective theories which have only a limited reliability for a specific context." In order for a claim to be accepted as true and be developed into a theory, it does not need to have any empirical ties. Reality, as described by Hedrich (2007, p. 274) could "be something which can not be described with an empirical adequacy by means of coherent, unified, fundamental physical theories, but rather by a collection of effective theories which could find their relevance in a direct and close coupling to specific phenomenal areas."

These theories of truth are crucial for any research, since they are the factors that determine whether the attempt to produce truth, and therefore knowledge has been successful (Stahl, 2007). The underlying theory of truth determines whether the research has any value or not.

4.1.3 Context

Gettier, in his 1963 paper, asked whether justified true belief could be considered as knowledge (Gettier, 1963). He stated (and demonstrated, through his "counterexamples") that a person could be justified in believing a proposition, which could in fact be false. There are those who support and defend the argument Gettier has put forward (Kirkham, 1984; Lowy, 1978; Sturgeon, 1993; Zagzebski, 1994), and there are those who criticize it

(Coder, 1974; Hooker, 1973; Levi, 1995; Thalberg, 1969; Weatherson, 2003), and those who argue the value of both sides and propose that more research needs to be done on the arguments, as well as the general concepts such as knowledge (Creath, 1992; Greene and Balmert, 1997; Le Morvan, 2005; Margolis, 1972; Riggs, 2002; Williams, 1978).

It is not within the scope of this research to provide a solution to the Gettier problem. It is suffice to say that Gettier provided something additional to the definition of knowledge as justified true belief, and that something us denoted as (+). Therefore, the definition of knowledge being used here is JTB (+). This definition includes the addition of *context*. Knowledge can only exist within a context. If the context cannot be defined and substantiated, the statement that "I created knowledge" becomes invalid. Without context, knowledge is merely information. Context includes the axiomatic structure, the assumptions, presuppositions and the boundary conditions. The concept of context is also important from a methodological as well as a methodical sense. Lundberg (1976) states that replication of a study in a different context may lead to new interactions and conditions of general findings.

The context in which the research is being conducted in this dissertation is provided by the initial research purpose, and the bounding of the research problem and the research questions. As demonstrated in Section Two, Background Research, research involving personalities and profiles can be applied across a field of different bodies of knowledge. In this research, this context is given as complex problems and engineering management. This eliminates the issue of having to think about a personality profile in a vacuum; looking at personality profiles and how they deal with complex problems is one of the major contributions of this research to the body of knowledge of engineering management.

4.2 Research Approach

The Research Approach, shown in Figure 7, represents the author's thought process. The importance of establishing a general understanding of the overall approach is crucial for the reader to fully absorb and understand the details of the research methodology. This section explains the reasoning behind choosing the particular research methodology.

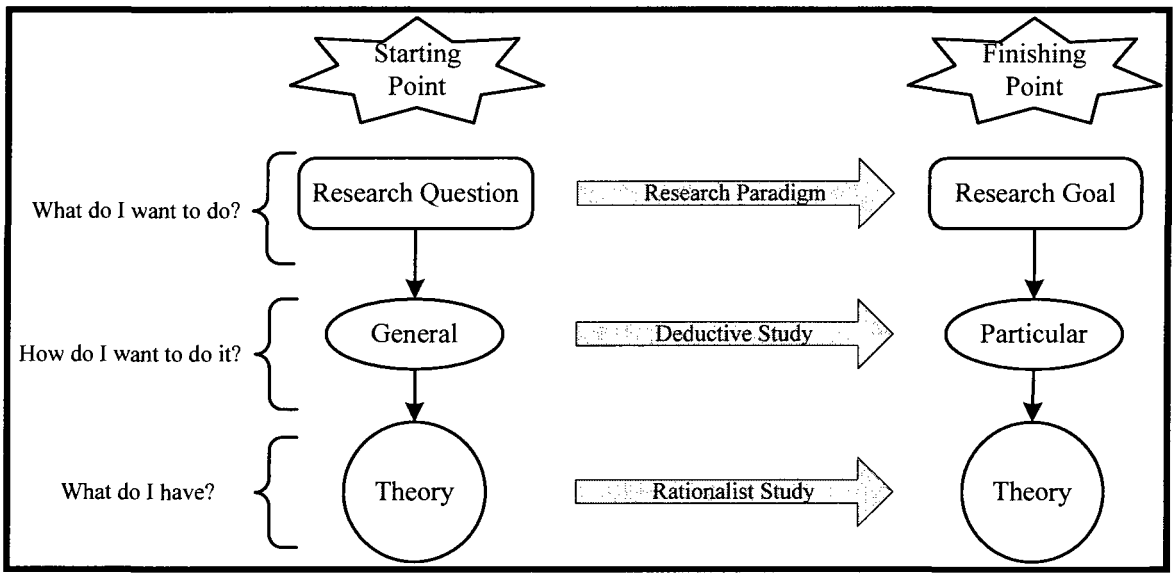

Figure 7. Research approach

The research questions stated in the first section of this dissertation established the starting point of the study. These questions and the research problem lead to the formulation of the research purpose, or the research goal. The route from the questions to the purpose, in other words, how to reach that particular research purpose by answering these research questions is shaped by the research paradigm, which will be discussed in the following section.

- **Why Deductive?**

The second part of the research approach looks at the current situation and at what is available to the researcher in the beginning. For the purpose of this study, through certain theories that have been tied to literature, *a general theory* in the form of a statement and certain propositions will be stated in the *beginning*. The finishing point will be reached when these propositions have been explored and analyzed, and certain results are obtained and interpreted, which means that this research will be a *deductive* research. This general theory and propositions are in the form of premises and other theories that come from literature, observations, other studies, etc. The end result of this research is going be another theory, which is going to be a specific case of the original starting point.

Therefore, in this research, a proposed model and related propositions comes first, and then the research moves towards establishing the specifics of this model.

Reasoning, as defined by Fritz Jr. (1960. p.127) refers to "the general process of arriving at conclusions from evidence." The main goal of *deduction*, shown in Figure 8, is to draw valid consequences from a series of premises. In other words, deductive reasoning starts with given beliefs, and arrives at others that necessarily follow from them (Rips, 1990). In order for a conclusion to be true in a deductive argument, two conditions need to be satisfied (Baggini and Fosl, 2003):

1. The argument needs to be valid
2. The premises need to be true

Researchers generally find it more satisfying to understand how underlying entities interact to produce some phenomenon of interest than to account for the phenomenon by showing that it is an example of some more general statistical regularity expressed as a typical relationship between variables (Smith and Conrey, 2007). This way ensures that the general law applies to all the cases, as seen in below figure.

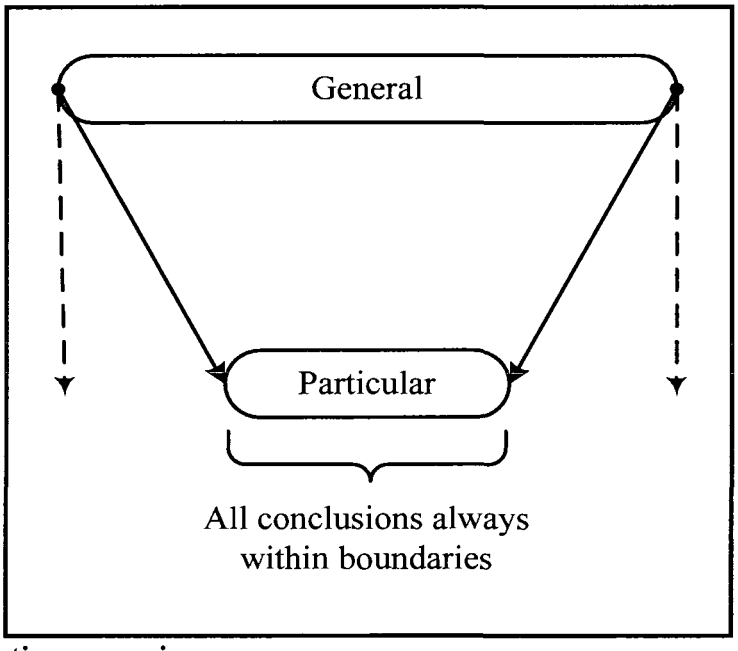

Figure 8. Deductive reasoning

Karl Popper, the founding father of the "scientific method," which is often closely linked to deductive theory testing, states that a new, tentative idea, which hasn't been justified yet, should be the starting point (Popper, 1968). This new idea can be a hypothesis, a theoretical system, or whatever one wishes to call it. This is followed by conclusions which are reached by means of logical deduction. After this step, the conclusions are then compared with other relevant statements in order to find certain logical relationships, such as incompatibility, equivalence, etc. The hypothetico-deductive method, therefore, involves "putting together two or more common sense principles or empirical findings, and deriving from their conjunction some predictions of interest" (Lundberg, 1976, p. 9).

Popper (1968) proposes four different approaches to theory testing:

1. *Logical comparison of conclusions among themselves*: the main purpose of this is to gain insight on the internal consistency of the system.
2. *Logical form of the theory*: the objective of this is to determine whether the theory has the characteristics of an empirical, scientific, or tautological theory.
3. *Comparison with other theories*: this line of testing is also similar to coherence theory of truth, in which the final theory obtained is compared with other theories to determine whether it would constitute a scientific advance. This is also desirable in terms of any research, since the main purpose is to contribute to the body of knowledge of the discipline on which one is working.
4. *Empirical applications*: the last kind of testing is to determine "how far the new consequences of the theory…stands up to the demands of practice" (p. 33)

Inductive reasoning is the other route that the research can take. Induction, as Lee and Baskerville (2003, p. 224) state, is a process of reasoning that "begins with statements of particulars and ends in a general statement." This inductive reasoning is the opposite of deductive reasoning, in the sense that it starts from the particular, and moves towards the general, shown in Figure 9. In the case of inductive reasoning, the starting point is again given beliefs, however the resulting beliefs are supported, but are not entailed by the given ones (Rips, 1990). According to Feibleman (1954), induction serves three main purposes: discovery of hypotheses, offering evidence for generalities, and giving information about the future. Through induction, a new proposition is

discovered as a hypothesis to be tested. Goldstone (2004) provides a historical explanation for this, when he states that Francis Bacon, who was one of the front advocates of the inductive method, argued that one could be able to accumulate and organize facts and evidence, and reach an explanation that would cover all means of specific phenomena and events.

Induction, according to Bara and Bucciarelli (2000, p.96), is "a thought process that aims to draw a plausible conclusion from particular observations or premises." Induction increases "semantic information," which is to say that the conclusion goes beyond the premises by excluding at least some additional possibility over and above the circumstances that the premises rule out. This is done in order to reach a plausible conclusion. This particular aspect of inductive reasoning has become an issue since the conclusions arrived by inductive reasoning not necessarily have the same degree of certainty of the initial premises.

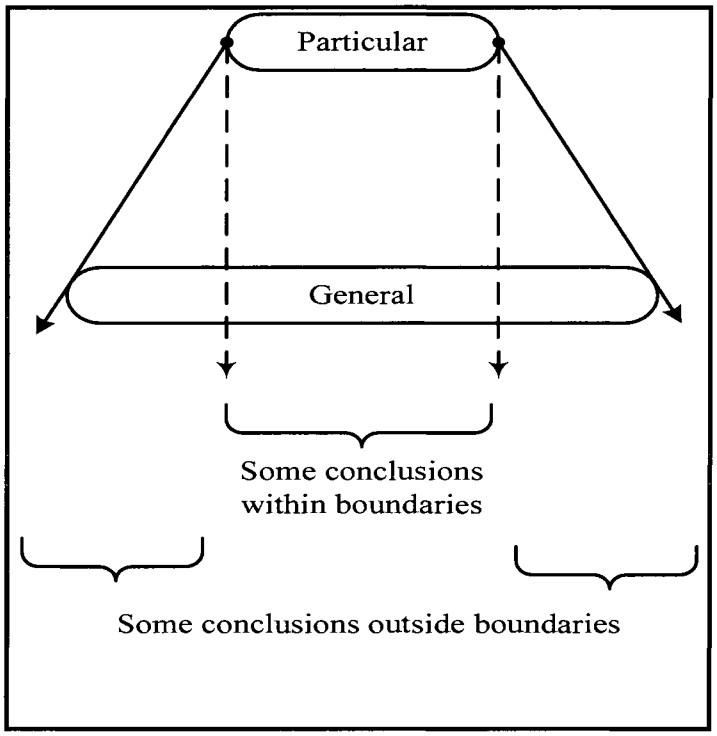

Figure 9. Inductive reasoning

Camilleri (1962, p. 177) states that "often research is undertaken not to test a theory, in the sense of trying to reject it, but to extend it, to determine its scope of applicability or to enlarge this scope by the introduction of modifications in the theory." This is where the conclusions outside the boundaries may come into place. There may be certain inferences, certain "leaps of faith" so to speak, when arriving at conclusions within inductive research. However, this does not reduce the usability or dependability factor of inductive research within certain disciplines, especially in social sciences where non-measurable, non-repeatable and stochastic situations are the majority.

When starting an inductive research, the researcher should not have any preconceived ideas on the subject matter. Naturally, some form of pre-research is necessary in any type of study; however, the distinction in this case is the result of an inductive study which is a pattern that *emerges* out of all the research that has been conducted. A researcher can start out by gaining information through many sources, and as this information is being built on, and knowledge is acquired, it is possible that there may be common threads running through this collection of information. These common threads are then modified into a general theory, or a proposition, or a hypothesis by the researcher, which concludes the inductive study. Unlike the deductive approach, there is no testing required. The main purpose of an inductive study is to reach a general statement through a collection of specific instances. This type of research may continue with a deductive approach, where the theory that was previously researched could be tested through empiricist or rationalist means; however, this additional deductive loop is not a necessary condition of an inductive research.

The use of philosophical constructs as dimensions for a personality profile has been the initial starting point of this research, rather than emerging as a pattern as a result of extensive exploratory research. The PPI has been argued, proposed and presented as a concept (see Bozkurt et al., 2007), and is now being fully developed in this research. Therefore, in the author's mind, the theory was already present during the initial stages of this dissertation, making this research a deductive research.

Another reason why a deductive approach is appropriate for this study is the boundary conditions. When conducting an inductive study, the researcher is not supposed to have a pre-conceived boundary to make a general statement from the start. Instead, the

boundary should emerge towards the end of the study. In this research, however, the boundary and scope conditions are determined from the start, making this study well-bound. Considering all of these factors, the deductive approach is the appropriate approach to conduct the study.

- **Why Rationalist?**

Since the research is based on the Coherence Theory of Truth, this leads the current study into a rationalist medium; however, this is only one of the various reasons on why a rationalist study was appropriate for this research. Fumerton (1980, p. 599) advises that individuals "should not choose our epistemic principles with the realist's ontological commitments as our guiding light." This is an important point, which is in line with the proposed research hierarchy concept. An individual's research paradigms and philosophies should be aligned with each other, and these choices should be reflected in the lower levels of the hierarchy as well. This is why if this research is based on a coherence theory of truth, adopting an empiricist position would be a mismatch of underlying paradigms.

The second major reason why a rationalistic approach was chosen is the subject of this research. Mostly in social sciences, intangible concepts such as motivation, satisfaction, and leadership styles have been operationalized in some way or another, usually by means of proxy variables, and have been measured by using instruments such as questionnaires. However, more often than not, there is always a caveat with this approach. Firstly, the use of proxies means that one can never fully be sure that what is being measured by the instrument is actually the same concept that one wants to measure. Secondly, when certain techniques are being applied (such as semi-structured interviews) canons such as traceability and repeatability start becoming an issue. As Riemer (1954, p. 552) states, "the social sciences meet with unique methodological difficulties due to the unavailability of experimental devices." He also states that "with our insistence upon "operationalism" and methods of empirical verification, we tend to neglect the importance of sound interpretive reasoning" (Riemer, 1954, p. 553).

The availability of empirical knowledge to the researcher of personality may sometimes be scarce, often due to the complexity of the subject at hand; therefore, it should not be surprising that "personality theories are not based completely on empirical

knowledge" (Maddi, 1996, p.9). Winter and Barenbaum (2001) discuss three strategies that personality psychologists have used to study personality traits. The first strategy is factor analysis and related mathematical techniques (such as the Big Five), the second is rational or a priori theorizing (such as the California Psychological Inventory, developed by Gough, 1957), and the idiographic approach, which states that there is no need to search for an underlying basic trait. Saunders (1964) has stated that one of the most important characteristics of what he calls "rationally derivable facts" is that the rational derivation "is always allowed to have precedence over empirical derivation" (p. 265).

Based on this, the use of rationalistic methods is not uncommon in personality research. Certain limitations of empiricist-based research are also presented in Sousa-Poza, Padilla and Bozkurt (2008):

- Traceability is lost between observations and abstracted generalizations within emergent conditions.
- When attempting to address complex problems, the contexts that are established are divergent.
- In case of non-ergodic, non-linear problems (which most complex problems are), teleological constraints also arise.

The choice of a rationalist study gives the researcher the option of using true premises, knowledge claims assumed to be true, and sound arguments to provide the necessary accuracy when working with the intangible, abstract concepts, such as philosophical dimensions. As discussed previously in Section Two, there have been empirical studies that were conducted on worldviews, and personal epistemologies. However, the proposed philosophical profile in this research is also connected to complex problems. Using a modeling and simulation paradigm enables the researcher to not only explore certain propositions, but also gain insight on matters that would not have been otherwise possible. The empirical route would have been desirable if the proposed theory were established within more solid boundaries.

4.3 Research Methodology

The main purpose of a methodology is to provide a solid foundation so that a robust research method can be developed. The discussions and the arguments provided in the previous steps (through the research paradigm and the research approach) have set the grounds for a research methodology. The following conclusions that have been reached so far through the above-mentioned discussions will provide the basic premises that will support the choice of the research methodology applied in this study:

- ✓ *This research is going to be a Deductive study*
- ✓ *This research is going to be a Rationalist study*
- ✓ *Therefore, the appropriate Research Methodology is the Rationalist Deductive Methodology*

This section will elaborate on the particular research methodology that was determined to be appropriate for this research. After identifying the main steps for the research methodology, each step will be elaborated and a discussion will be presented with respect to the current research purpose and the scope of the research. Methodology allows for the development of the research method, and it is generated through the relationship between the situation under study, the researcher, and the theory being drawn upon for the research (Kay and Halpin, 1999).

It is important to establish the boundaries of the research methodology that is going to be adapted in this study, so that proper guidelines can be presented. This will serve two main objectives. The first objective is to establish *repeatability* and *traceability* of the present research. Even though the results cannot be repeatable, it is the duty of the researcher to layout the specific steps taken in order to establish methodological repeatability. The second objective of the research methodology serves a more high-level purpose, which is to introduce a more *formalized Rationalist Deductive* approach. This approach has been used in various studies, and has many advocates (Bara and Bucciarelli, 2000; Goldstone, 2004; Lundberg, 2005). Taking support from these and other studies, presenting a more formal, repeatable and traceable method is one of the contributions of the current study.

4.3.1 The Rationalist Deductive Methodology

The Rationalist Deductive Methodology (RDM) is a modification of the traditional hypothetico-deductive (or the scientific) method, that was initially proposed by Popper (1968). According to Goldstone (2004), the main goal of the rational-deductivist method is to formulate logically coherent and rational principles, then deduce from them how nature works. Experimentation therefore becomes secondary; rational investigation and the working out of logical principles on the basis of inherent rationality form the secure foundation of knowledge.

Kunkel and Nagasawa (1973), in their study on building a "behavioral model of man" within sociological research, have used the following steps in their rationalist deductive research for the purposes of description, explanation and prediction:

1. Use current and previous studies as major sources of data (building blocks)
2. Summarize the studies in generalizations
3. Turn these into higher-level propositions (axioms)
4. Derive lower-level hypotheses
5. Formally develop the model

A similar approach was taken by Tallman et al. (1993) when developing a theory of problem-solving behavior. In their study, they have developed a formal, testable theory of problem-solving behavior with respect to individuals and small groups. Instead of one single theory, they provide 14 theorems that cover different aspects of the problem at hand, while staying within the scope conditions. The following steps represent the method used in their research:

1. Provide definitions for main constructs
2. Establish scope conditions under which the theorems of the theory can be tested
3. State axioms (both verbal and mathematical)
4. Derive general theorems from the axioms

Both of these studies will be taken as examples when providing guidelines and canons for the research methodology and the research method used in this research. Figure 10 is a representation of the three major steps within the Rationalist Deductive Methodology, starting with Identification & Development, followed by Structuration, and

ending with Conclusion. This representation provides a meta-structure of the research methodology.

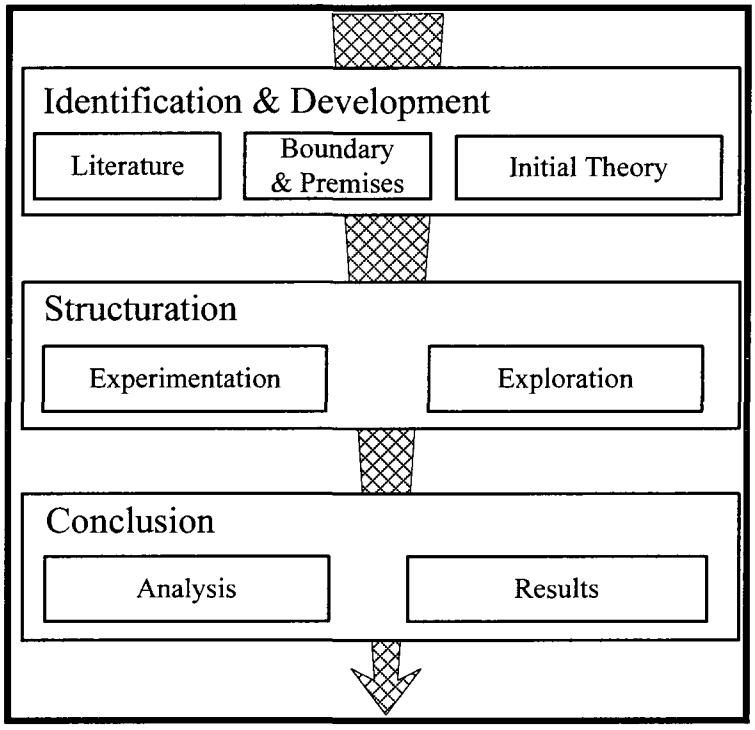

Figure 10. Rationalist deductive methodology

(Representation adapted from Sousa-Poza, Padilla and Bozkurt, 2008)

4.3.1.1 Identification and Development Step

According to Lundberg (1976; 2005), there are four pre-requisites for question and hypothesis creation:

- Familiarity with the phenomena
- Possessing thorough knowledge on the subject
- Possessing an embedded paradigm
- Avoiding strict goal-orientation

Acquiring knowledge on the subject matter is a crucial aspect in this first step, which is Identification. The deductive reasoning process starts from a general statement, and then looks at the particulars of this statement. The starting point of the RDM is a knowledge claim, which is a statement known to be true. This may be in a form of an hypothesis, a theory, or any other form of statement. In order to reach this, however, the identification step is necessary.

In order to make a general statement, or a knowledge claim, the researcher needs to have sufficient grounds to support this statement, or how this statement was reached. Unless this is an *Abductive* process, where the generation of the general statement cannot be traced to previous research, observations, data etc., but to a "Eureka!" moment, it is important to establish how the general statement was formed. The research problem and research questions can be identified via different means, such as literature reviews, case studies, etc. This can be considered as an *inductive loop* within an overall deductive process.

First part of the identification step was covered in Section Two, which presented background information on the disciplines that provide the context and the boundaries for this research. The purpose of this research is to develop a theory of the philosophical profile of the individual and analyze how different profiles can deal with complex problems. How the general statement and the relevant propositions are developed is part of the Development Step. In this research, a single theory is being formulated (with related propositions) during the development step. This is done through defining the general premises which form the foundation of the rational argument. The premises are used as foundational blocks to develop the coherent theory, which is then going to be explored.

Riemer (1954, p. 551) provides a useful definition for what premises are:

> Premises are statement of facts. They may either be assumed or proved to be true...[in] the social sciences, premises are exactly the instrument by which the scientist eliminates those conditions from his consideration which might interfere with the observation upon which his inquiry is to be focused. The statements contained in the premises

> are not necessarily based upon previous empirical research. Premises may be no more than a hypothetical device to hold certain factors constant and to allow others to vary for purposes of empirical observation (p. 551).

This is in direct relation with the *rationalist* aspect of the methodology, as well as the *coherence theory of truth* being used as the foundation for the research paradigm. Having based the research on coherence of the premises, rather than direct correspondence to reality, the canons of empiricist research are no longer being considered within the scope of this research. This is what Reimer is saying in his above statement. The rational premises provide the necessary support for the whole research. Premises are the most important components when building an argument. They are the stepping stones towards a meaningful conclusion. All assumptions and premises needs to be made explicit before reasoning can take place as series of arguments (Fritz Jr., 1960). In deductive arguments, the truth of the premises is necessary to provide complete evidence for the truth of the conclusions. Through the premises, the context is set, which also provides the axiomatic foundation of the research. It is stated in Sousa-Poza, Padilla and Bozkurt (2008) that the two main conditions for truth to be reached through coherence are: the premises must be true and they must hold together. For this, the axiological structure of assumptions and pre-suppositions by the inquirer must be clearly established. The axiological structure establishes the context of the study, and under this axiological structure the proposed theory must be true based on a coherent system of beliefs achieved through the deductive process. This, in turn, placed under a methodological structure, can be used to formalize the theory or model.

Using premises that were developed through existing previous research that could be traced back to the literature review, as described in the Identification section, a general theory is developed as a result of this second phase, hence the Development section. The general theory may be in form of a general statement, a knowledge claim, hypothesis, or a model.

Walker and Cohen (1985) define a theory as "a set of logically interrelated propositions or arguments that make assertions about the nature of relationships between theoretical constructs" (p. 290). This definition is important for two reasons. First, the

logically inter-related statement is a direct emphasis on what is considered in this research as *coherence*, hence the use of coherence theory of truth. The propositions that form the theory need to be coherent, or logically related to each other, in order for the theory to hold together. The second reason why this definition makes inherent sense is the use of *theoretical constructs*. Walker and Cohen, through a footnote, specifically state that the word *construct* was used instead of *observable concepts*, and they support this by stating that theoretical progress and development of knowledge occurs when using constructs. Walker and Cohen (1985) further state that theories (or theoretical formulations) need to be considered with respect to their scope, and need to be tested, or falsified, within this scope. Therefore, the boundaries and the scope of the research become even more crucial. The conditions under which the model is developed and executed are also identified in the Structuration step. These conditions are similar to the scope conditions that Tallman et al. (1993) have included in their method.

Eysenck (1987) presents an argument for the strength of scientific theories according to their relation to the changing criteria that science deems acceptable (Figure 11).

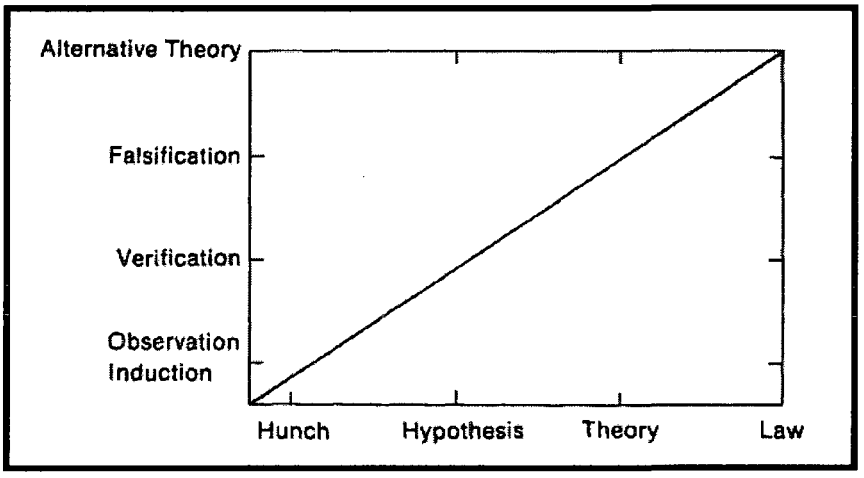

Figure 11. Stages of developing scientific theories

(From Eysenck, 1987, p. 52)

In early stages of theory development, observations and induction lead to only hunches. When these are verified, they become hypotheses. These hypotheses are then developed into more specific theories, which is when Popper's falsification criterion is the appropriate evaluation mechanism. Following these theories, a stage is reached when general laws are being stated, and these can only be challenged by alternative theories. It is important to note that these stages cannot be as clear cut as their definitions. The differences between these constructs are as clear as the individuals defining and determining what they are.

In the case of this research, the PPI is stated as a theory, while stating that the conditions and assumptions under which the theory is developed and analyzed are only valid within the scope in which they are created. A model for the philosophical profile of the individual is represented in graphical format, a verbal format and through detailed propositions, similar to Tallman et al. (1993).

4.3.1.2 Structuration Step

The Identification and Development step is then followed by the Structuration step. In the hypothetico-deductive method, which is the empiricist form of RDM, structuration is done through observations and experiments. This is where the individual goes out to the "real world" and observes, or tests the knowledge claim. In the case of RDM, this is done via a rationalist format.

The structuration step is the heart of the coherence theory of truth process, in which a coherent formulation of the theory being built is presented. Bounding becomes an important phase of structuration as well. The coherent formulation is strengthened by this bounding, which includes fine tuning the system of beliefs and premises. In other words, the coherence is retained between the theoretical structures. These premises can be formulated throughout the whole research methodology, or may be a part of the final results. Either way, the important point that should be addressed here is that the premises should be coherent with each other, and to establish the final coherent model, the premises used within this coherent structure may be modified through the whole research.

The rationalistically developed general model is going to be explored using Agent-Based Modeling in this research. The exploration in this research is not in the

same realm as *empirical testing*, where a statistical significance is sought. Since this research is based on coherence theory, and is rationalist by nature, the experimentation, exploration and analysis in this step is more towards gaining understanding on how different profiles deal with different complex problems. Looking at the specific propositions that constitute the PPI model and analyzing the patters and the data obtained through the simulation are the steps conducted for the decision-making process about the general theory and the related propositions.

4.3.1.3 Conclusion Step

The last building block of the RDM is the Conclusion phase. There are two components in this step, which are *analysis* and *results*. The results are representative of the final, specific theory. Therefore, the conclusion includes an array of analysis, from very deterministic statistical analysis to the more interpretative analysis.

4.3.2 Canons for Rationalist Deductive Methodology

In any discipline, researchers need to follow certain accepted and appropriate canons rigorously and vigorously (Bozkurt and Sousa-Poza, 2005). Generalizability, applicability, consistency, reproducibility, precision, verification and validation are examples of canons that a research, through its research design, must provide sufficient depth (ibid). The *appropriateness* of the canons used with the type of research that is being conducted is the key point in the research design. This is why the research hierarchy was proposed, developed and discussed in the previous section of this dissertation.

It is crucial for the research design to be aligned with the research canons used; otherwise, the resulting mismatch would make any research questionable in terms of its value and scholarliness. As Racher and Robinson (2003) point out, congruence between philosophical positions and research approaches is a necessary condition of scholarly research. For instance, not every research needs to be, or even could be, generalizable from a sample to a population. When case studies are being used, for instance, to support a research, the value of generalizability is not relevant. The importance of depth as opposed to breadth should be under discussion in such a research.

In terms of scientific method, for instance, Maslow (1946, p. 328) notes that the "laws of scientific method...have been crusted about with tradition and history; they tend to become binding upon the present day (rather than merely suggestive or helpful)." He further states:

> In the hands of the less creative, the timid, the conventional, these "law" become virtually a demand that we solve our present problems *only* as our forefathers solved theories. Such an attitude is especially dangerous for the psychological and social sciences. Here the injunction to be "truly" scientific is usually translated as "Use the techniques of the physical and life sciences." Hence we have the tendency among many psychologists and social scientists to imitate old techniques rather than to create and invent the new ones made necessary by the fact that their problems and their data are intrinsically different from those of the physical sciences (p. 328).

The appropriateness factor comes into play in Maslow's discussion as well. Even though the above quote is more than 60 years old, the point he so clearly makes is still valid and crucial in any scholarly research. While it is extremely important to follow certain rules (or canons) when conducting research, it is equally important that these rules are in alignment with the discipline, the research topic, the methodology, and the researcher's own perspective. Without these canons, the research is defenseless.

Canons of research, like any other subject within the research methodology and research design area, are open to discussion. In Bozkurt and Sousa-Poza (2005), canons used by positivistic and constructivist/naturalist research have been analyzed and compared (Table 6). In the same research, it has been argued that the canons used in these different research have their foundations in the research philosophies and methodologies. The positivist-constructivist argument has been made in parallel to the Quantitative vs. Qualitative debate. Without having the intention of addressing this debate that has attracted heavy attention throughout the decades (e.g. Guba and Lincoln, 1994; Lee and

Baskerville, 2003; Munck, 1998; Sale, Lohfeld and Brazil, 2002; Smith and Heshusius, 1986), it is important to show that different types of research dictate different canons.

Table 6. Canons for Positivist and Constructivist Research

(From Bozkurt and Sousa-Poza, 2005)

Positivist	Constructivist
Internal Validity	Credibility
Generalizability	Transferability
Reliability	Dependability
Objectivity	Confirmability

Any research that deals with social issues, that has a purpose of gaining insight on complex problems, and that has little or no empirical foundation or opportunity of observation of phenomena under question needs to establish the appropriate canons to be used, and follow them. Within the rationalist deductive research methodology, there were three major phases: identification and development, rationalist structuration and conclusion. Appropriate canons for these three steps are discussed and how these canons are adapted, their implications and threats to these canons are presented in the following.

1. **Identification and Development:** In the Identification and Development phase, the research problem is identified, along with the premises, rules and context. This step is mostly based on literature, past research, case studies, and other published scholarly material. Following this, the main knowledge claim, or the theory (PPI in this case) is developed, and the specific propositions are made explicit.

- **Bounding:**

Together with the identification and description of the research question, the research problem and the research purpose, the scope of the overall research is established, which addresses the issue of bounding. As discussed previously, literature on personality theories is immense; therefore background research is presented as an overall

view of major personality studies that were done in the past, followed by example research that are related to the topic of interest. The same approach is taken when discussing philosophy. The perspectives that are related to personality profiles are discussed. Both of these topics are tied together with the concept of complexity and complex problem-solving, which completes the bounding process.

- **Comprehensiveness:**

This canon ensures the completeness of the theories and knowledge claims presented in the past which are relevant with respect to the current research. Within the underlying context of this research (which is established through the *bounding* step discussed above), it is the author's aim to consider all existing and relevant bodies of knowledge that could impact the research. Goldstone (2004) states that the rationalist-deductive methods may have two flaws: The first is the possibility that the researcher may overlook certain phenomena that fall outside the scope of the rational postulates, but may still be relevant. The second is that the rational postulates may have been misframed, or the assumptions and the presuppositions may have been faulty. This is why this canon is extremely important because it ensures that the researcher has followed through on relevant research, and verifies that the boundary conditions are established in a meticulous manner. The second flaw – the misframing of the postulates – is addressed through the following canons.

2. Structuration: The second phase of the methodology, the structuration, is the main component of the coherence theory of truth, where a coherent formulation of the theory is being presented. This phase is important when looking at the internal consistencies of the premises and the theory that was built in the previous phase. Because Agent-Based Modeling is the specific research tool that is being used within the structuration phase, the canons in this step are related to the Modeling and Simulation paradigm, specifically ABM. Through the use of the Agent-Based Model paradigm, the verification and validation of the model supports the initially developed theory and identified premises and propositions.

- **Internal validity:**

For the case of rationalist inductive methodology, three types of traditional validities, internal validity, construct validity and external validity, have been discussed

under a different methodological umbrella in Sousa-Poza, Padilla and Bozkurt (2008). These canons can be applied within a rationalist deductive methodology. In the majority of definitions for internal validity, inferences on establishing casual or cause-and-effect relationships is the main premise, especially in experimental and quasi-experimental research (Trochim, 2006; Yin, 2003). From a rationalist perspective, this type of validity is a function of the coherence with which the participants' view has been successfully conveyed. This is similar to the premise of validity within qualitative research, with a specific difference in terms of format of "data." Qualitative research is mostly focused on soft or secondary data (obtained through case studies, structured or semi-structured interviews, etc.), while the rationalist deductive methodology uses premises from existing knowledge claims or truths.

For modeling and simulation, Sargent (1999) describes sixteen different validation techniques that include internal validation, face validation, traces, parameter variability, sensitivity analysis, predictive validation, historical data validation, among others. According to his description, internal validity is determined through several replications of the simulation model. The amount of variability (or consistency) is one of the measures used to determine whether the model is internally valid or not. In this research, verifying the model is a measure of whether the model is valid or not. In addition to the verification process, traceability will also be used as a measure for validity, which is also in line with Sargent's validation techniques. Tracing the behavior of different types of entities throughout the model is an appropriate way to determine whether the model is performing as expected. This is also an indication that the premises are coherent with each other, which is the main purpose of the structuration phase. Under various experimental conditions, a graphical representation of the behavior data of the model is also used to determine whether the output data of the model has sufficient accuracy for the purpose of the simulation model (Sargent, 1999). This graphical representation is also used in this research.

- **Construct validity:**

Construct validity is defined as "the degree to which inferences can legitimately be made from the operationalizations in [the] study to the theoretical constructs on which those operationalizations were based" (Trochim, 2006). In other words, establishing

construct validity makes sure that correct operational measures are used for the concepts that are being studied (Yin, 2003). When considered with respect to the rationalist deductive methodology, this type of validity is applicable during the structuration & development stage. Construct validity is relevant to the premises being made explicit. Similar to internal validity, construct validity is based on the coherent structure of the premises and the way they are formulated in order to describe and build knowledge claims. The way the premises can be traced back to literature and past theories is an indicator for this type of validity.

- **External validity:**

The main focus of this type of validity is extending the results of the research beyond the settings in which they were obtained (Sousa-Poza, Padilla and Bozkurt, 2008). External validity is related to the generalizability of the study, e.g. from a sample to a population, which is based on establishing the domain of a study. From the rationalist perspective, external validity is focused on the applicability to the context from which the premises were derived. In other words, the results should make sense when being considered from various bodies of knowledge that provide the basis for the background research. In the case for this research, for instance, do the insights that have been gained make sense? Does the way an individual with a certain PPI solves complex problems make sense? The answers to these types of questions, which were discussed in the previous section, support the external validity of this research.

For simulations in the social sciences, Kuppers and Lenhard (2005) argue that validity (in the classical, traditional sense) is not an adequate measure. As Bossel (1994) states, the construction of a model will always include simplifications, aggregations, omissions and abstractions. This is why, when arguing the truth value of simulation, Schmid (2005) discusses the philosophical truth theories, which were discussed in the Research Methodology section of this dissertation. He states that the application of the philosophical concept of truth enables the researcher to gain more insight and therefore acquire increased understanding on certain assumptions and parts of the simulation process. He argues that the notion of truth provides a sound base for understanding the epistemological complexities of simulation practice.

From a correspondence theory of truth perspective, a simulation model is true if and only if it corresponds to a matter of fact in reality; whereas the coherence theory of truth argues that a simulation model is true if and only if it is a member of a coherent system of beliefs (Schmid, 2005). The concept of truth has also been addressed by Becker, Niehaves and Klose (2005), in their study on developing a framework for epistemological perspectives on simulation. They have argued that epistemological, ontological and methodological assumptions need to be addressed when using simulation as a research method. The implications of these paradigms reach into the more specific details of modeling and simulation.

In terms of the coherence theory of truth discussion, Schmid (2005) argued that validity would refer mainly to the subjective part of a simulation that was based on certain beliefs on how a model should behave to meet the purpose. Sargent (1999) stated that developing a model should be based on a specific purpose, and the validity of that model needs to be considered with respect to that purpose. Bossel (1994) had argued the same point when he stated that a simulation model cannot be discussed in terms of its *correctness* but only in terms of its validity with respect to the model purpose. This teleological perspective resulted in four types of validity:

1. *Behavioral Validity*: The model system produces the same dynamic behavior as the original system under the same initial conditions and exogenous influences as the original system.
2. *Structural Validity:* The influence structure of the model corresponds within the constraints of the model purpose to the essential influence structure of the original.
3. *Empirical Validity:* The results obtained from the model need to correspond to the empirical results from the original system under the same conditions. Boero and Squazzoni (2005, p. 2) are strong advocates of this type of validity as well, arguing that within agent-based modeling, empirical data is necessary to "build sound micro-specifications of the model and to validate macro results of simulation."
4. *Application Validity*: The model and its simulation capabilities correspond to the model purpose and the requirements of the model user.

Computer simulation literature that is focused on technical issues and topics has used the concepts of *verification* and *validation* together to address procedures of rigor. North and Macal (2007) state that verification and validation are the most time-consuming process of building an agent-based model, however they ensure that the correct model is built, that the model is functioning as it was intended, and that the models can be used to support decision-making processes. According to North and Macal (2007, p. 222), verification is necessary from an operation and implementation aspect, which makes sure that the model "performs the correct calculations according to its intended design and specification." The primary goal of validation, on the other hand, is to ensure that the model is correctly representing the real-world system it is suppose to represent (North and Macal, 2007). Figure 12 below is the representation that has been used by North and Macal (2007) in order to explain the relation between the two constructs.

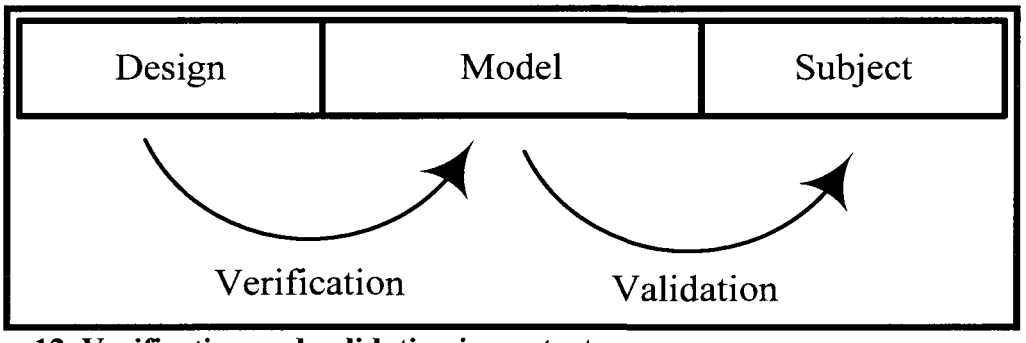

Figure 12. Verification and validation in context

(From North and Macal, 2007, p. 222)

Kleijnen (1999, p. 648) notes that "[i]f no data on the real system are available, then strong validation claims are impossible." In their effort to reach the goal of validation, North and Macal (2007) have provided an extensive list of practical validation perspectives:

- Requirements Validation
- Data Validation

- Face Validation
- Process Validation
- Model Output Validation
- Agent Validation
- Theory Validation

In addition to practical validation, they discuss other processes that could be used for validation purposes, such as establishing credibility, case approach, model calibration, parameter sweeping, multiple models and the use of subject matter experts. One of the questions they put forward in the beginning, however, does not have an easy answer, if any answer at all, as they state: How can the model be validated if no real-world examples or cases exist to make comparisons and estimations? Drawing from the various discussions provided above and below, certain inferences are to be made in order to establish appropriate canons for this type of research.

Model validation, on the other hand, is "substantiating that the model, within its domain of applicability, behaves with satisfactory accuracy that is consistent with the modeling and simulation objectives" (Balci, 1997, p. 135). Therefore, the validation makes sure that the right model is being built. Emphasizing on the teleological underpinnings of a simulation model, Sargent (1999) states that a model should be considered to be valid only for a set of conditions, which need to be within a certain range, which should be connected to the model's intended purpose.

As Kuppers and Lenhard (2005) correctly observed, there are various accounts of different strategies that consider validation in simulation methods. Kleijnen (1999, p. 647) very accurately has stated that "[a] whole book could be written on the philosophical and practical issues involved in validation." This was demonstrated in the previous discussion on different definitions and techniques for verification and validation. This is a problem that still does not have a permanent solution that dictates alignment between different kinds of validation approaches and different kinds of modeling approaches (Moss, 2008).

- **Verification**:

Balci (1997, p.1) defines verifying a model as "substantiating that the model is transformed from one form into another, as intended, with sufficient accuracy." In other

terms, it makes sure that the model is built right. According to Sargent's definition (Sargent, 1999), verification of a model ensures that the computer program of the model and the implementations are running correctly. According to Sargent (1999), model verification makes sure that the simulation language is error free, has been properly implemented, and has been correctly programmed. For some researchers, the verification phase is identical to the internal validity phase and includes debugging, which is done to ensure that the computer program is running as intended. There are certain steps that need to be taken in order to verify the simulation model. The following steps are described by Gilbert (2008), as well as Macal and North (2005):

- *Code elegantly*: This advice ties back to the core of modeling and simulation, where the coding needs to be as simple as possible, but not too simple that necessary details could be omitted.
- *Include output and diagnostics*: NetLogo provides a range of buttons, sliders and monitors to trace each step of the simulation, and to ensure that each output and outcome from the simulation is somehow captured through the many tools available to the modeler.
- *Observe simulation, step by step*: This step is tied together with the previous one. Setting up the correct trackers and monitors gives the user the advantage to observe what exactly is going on at any point of the simulation. Slowing down the simulation process is a useful approach that was adapted by the author. The movement of each agent and their interactions through a simulation run one time step at a time was observed. This way, any anomalies that occur during the simulation could be caught as soon as they occur.
- *Add comments and update them*: The Command Center feature that is available in NetLogo is used to track down every movement that occurred in the simulation. For instance, when an agent representing an individual cannot solve a particular problem, the Command Center reads "could not solve complex problem," and according to the rule assigned to that particular agent, the capability of the agent should decrease. Another example would be "could solve medium problem," where the capability is expected to increase. By reading this, and also looking at the agents, the researcher could see if what was happening was actually a match with what was coded.

- *Use unit testing*: In this research, this is done by separating the NetLogo program into sub-sections of code, transferring those particular lines of code into a separate file and making sure that each batch of code runs without any error.

- **Robustness**

The robustness of the research and specifically the simulation model is another crucial issue that needs to be considered. As described in previous sub-sections, **sensitivity analysis** is a step that is part of developing, running and analyzing a simulation model. The specific sensitivity analysis technique and steps are discussed in the results and analysis section of this dissertation.

In order to substantiate one's choices during the simulation modeling process, Bossel (1994) presents four important steps that need to be completed:

- Requirements of testability and reproducibility
- **Completeness** and precision in the use of facts
- Chains of conclusions have to be complete and correct
- **Complete documentation**, so that others can understand all assumptions, and so that the results can be replicated. Sargent (1999) also emphasizes the importance of this step, stating that documentation is critical to ensure the users that the model is valid and correct.
- **Finalization**

3. Conclusion: In this last phase of the research methodology, the modeling technique that ensures the coherence of the premises is also selected, which is agent-based modeling for this research. Following this selection, the simulated model is developed and executed. Within this step, the context and certain conditions are tested, which determine the coherence of the premises that are used as underlying rules. Finally, the general theory is tested; the results are analyzed, interpreted and reported.

The whole research has been conducted in a manner that is rigorous and can be replicated by other researchers who wish to continue certain portions of this research. Table 7 below is a summary of the specific canons that are appropriately used in this research.

Table 7. Specific Canons of Research

Methodology Phase	Canons of Research
Identification & Development	Bounding
	Comprehensiveness
Rationalist Structuration	Verification
	Internal Validity
	Construct Validity
	External Validity
	Robustness
	Finalization
Conclusion	Documentation
	Completeness
Overarching	Traceability

4.4 Summary of Research Methodology

The starting point for the research methodology section was the idea of a research hierarchy. The proposed research hierarchy explained the important and necessary layers by which any research should abide. The highest level of the hierarchy is the research paradigm. In order to determine the paradigmatic structure of this research, the research approach is first presented. The research approach is an indication of what is available to the researcher, and where the research needs to be. Following this approach, the research hierarchy is then explained. The definition of research as the systematic acquisition of knowledge, and stating that the main objective of conducting research is the creation of knowledge led the way of using Plato's definition for knowledge, which was stated to be Justified True Belief. Together with the addition of context, this definition was further improved as JTB (+). The justification processes is explained in terms of Rationalism. Following this, the theories of truth are discussed, namely Correspondence and

Coherence Theory of Truth. The next step in providing further elaboration to the research paradigm is forms of reasoning. It is argued that whether the research takes on an inductive or a deductive approach has important implications.

This is followed by the Research Methodology section, which provides the basic building blocks and a solid, robust foundation for the Research Method. After this, the Identification & Development, Structuration and Conclusion steps of the Rationalist Deductive Methodology are explained, and the canons of research are identified and discussed for each step of the research methodology.

5 RESEARCH METHOD

After presenting the research methodology, this section focuses more on the specifics of the methodology, which is the *Research Method.* As Bryman (1984) notes, *methodology* and *method* indicate two different levels of analysis, therefore, it is important to define and discuss the underlying foundations for both as separate sections. In this Research Method section, the main steps identified in the previous Research Methodology section are explained and discussed in detail, so as to provide a more granular level of analysis to this section. The purpose of this part is to provide a more formalized approach to the design of the research methodology. This serves two main purposes. The first is that it is important to explicitly state the assumptions and foundational concepts that are used in the research. This explicitation is in direct relation to the second reason, which is to make this current research methodology traceable, and therefore repeatable.

Staying within the research method phase of the research hierarchy, the next part of this section is an elaboration on the specific medium that is chosen to elaborate on the PPI model and its propositions. Modeling and Simulation as a paradigm brings numerous advantages to such a study, which is why Agent-Based Modeling is chosen as the specific tool. An overview of personality research that use modeling and simulation is presented, followed by an overview of agent-based modeling and the steps that are taken to construct the model.

5.1 Research Method

Any research method (or methods) must comply with the research methodology. The specific methods chosen and applied are mere executions of the methodology in various ways. As mentioned previously, the research methodology sets the building blocks, or the guidelines that should be followed throughout the research method.

Figure 13 presents the detailed research method for the current study.

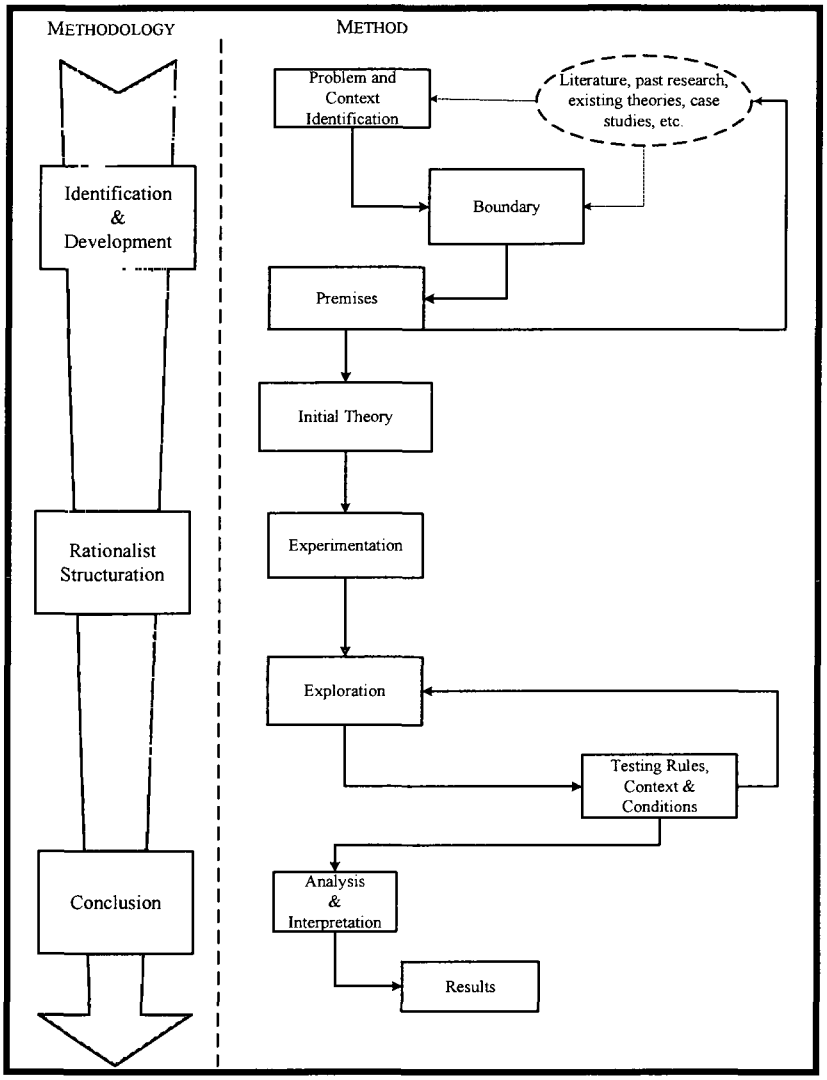

Figure 13. Rationalist deductive method

(Modified from Sousa-Poza, Padilla and Bozkurt, 2008)

Through extensive reading, literature reviews, looking at past research, the research problem was identified and discussed in Section One. Context is established starting from the beginning of this research, until the identification of the premises. Starting with the initial background research and the literature review, and taking into consideration the boundary and scope conditions identified previously, the context has been set. In terms of research methodology, *context* is used in the sense to define the setting in which something occurs; i.e., within the disciplines and bodies of knowledge used in the research.

When the problems that are being dealt with become more complex through time, due to many parameters, including a rapidly growing technology, dynamic environments and juxtaposing objectives and requirements, the need to examine and gain more insight on the personality of individuals has become more pressing. The current behavior and cognition-based theories have explained a great deal in relation to how individuals behave and why. However, it is argued in this research that looking at underlying personal philosophies is also necessary, especially when dealing with complex problems.

Boundary conditions are also established during the search on background information and the review of literature. Going through the personality theories that were previously developed, and analyzing various studies that were conducted using these specific personality theories have given this research certain boundaries as to how much to include and exclude when developing a personality profile. The addition of the philosophical constructs into the scope of this research has provided solid boundaries.

Once the need and context of research is established, the next step is to identify and select the appropriate and necessary premises that will formulate the coherent structure, which then leads to the final and formulized model. The premises that are presented in the last section have been established through the background research conducted and certain inferences and assumptions made by the author.

The initial theory is developed as a result of the premises that are argued within a certain context. This is similar to the *conditional theory* concept of Walker and Cohen (1985), in which they state that theories, especially the ones that are developed in social sciences (sociology in their case) should be considered, tested and falsified within their own scope. The philosophical profile of the individual, which is the initial theory developed, is presented in terms of a general statement and related specific premises.

These premises are used as individual rules for developing the simulation model. The implementation, experimentation and exploration of rules and conditions are part of the *rationalist* methodology, where the exploration of the general theory will be conducted in a non-empirical fashion. The use of modeling and simulation, agent-based modeling in particular, enables the researcher to analyze the theory and the propositions in such a way that the *experimentation* and *exploration* component will not be done in terms of *proving* (i.e. testing in the empirical sense), but more similar to inductively

analyzing the data obtained through the simulation. Certain analyses also need to be conducted to gain insight on the patterns that are obtained, on the robustness and the validity of the simulation. These analyses also provide insight and intuition on the original theory and the propositions that are introduced into the model.

Following the Rationalist Structuration step, the Conclusion step is reached. Data obtained from the simulation is analyzed and interpreted through different means. The results obtained cover the initial theory that is developed. The analysis and interpretation of the results provide the researcher insight on the theory developed.

5.2 Using Modeling and Simulation

This research does not attempt to develop a fully comprehensive and detailed model of how individuals think, behave and act. Such complexity is almost impossible to understand in real life, let alone in a simulated model. However, this research provides insight on a small portion of individual personalities, and indicates how individuals with different philosophical profiles deal with complex problems. As Schmidt (2001) points out, "[a] good, useable and useful model capable of providing valuable insights does not necessarily have to be insurmountably complex and difficult" (p. 11).

From topics such as leadership (Gigliotta, Miglino and Parisi, 2007), decision-making (Sun and Naveh, 2004; Wilson, 2007), teamwork (Overwalle and Heylighen, 2006), sociology (Gilbert and Abbot, 2005; Sallach and Macal, 2001; Todd, Billari and Simao, 2005), cognition and emotion (Bandura, 2001; Gratch and Marsella, 2005) to biological topics (Emonet et al., 2005; Krawczyk et al., 2003; Troisi et al., 2005; Wilensky and Reisman, 2006), ABM has been used extensively in many areas.

In relation to personality, cognition and psychology, there have been various studies that used modeling and simulation to gain insight and understanding on specific issues that are covered by these bodies of knowledge. Egges, Kshirsagar and Mognenat-Thalmann (2003) conducted a study where personality and emotion of individuals was simulated. Kikuchi and Nakamori (2007) used the Big Five Theory of Personality Psychology factors as rules for a genetic algorithm. In the study conducted by Ghasem-Aghaee and Oren (2007), the agents that are being used have certain personality traits, based on Big Five Personality Theory, and these traits could be dynamically modified

based on the changes of personality facets. They then studied how different personality traits are related to the individual's cognitive complexity, and the problem-solving capabilities. Martine-Miranda and Aldea (2005) have stated that the use of Multi-Agent Systems is beneficial, not only because of the autonomous properties the agents have, but because additional characteristics and agent can take, such as coordination and communication. Hendrickson and McKelvey (as cited in Silverman, Bharathy and Nye, 2007) state that there is a need for the theories of social science to be computationally formulized as agent models, in order to show that they are analytically adequate.

Epstein (1999) highlights some of the characteristics that make ABM a unique paradigm by addressing certain conditions that are pervasive in managerial conditions. Those conditions are: *heterogeneity*, where all agent populations, similar to individuals, are heterogeneous and may differ in various ways which can change or adapt over time; *autonomy*, where there is a lack of top-down structure, and therefore agents are autonomous in behavior; *explicit space*, which is the medium where all the events between agents take place; *local interactions*, where agents interact with each other, as well as the environment (or the space) itself; and finally *bounded rationality*, which is a concept that was initially developed by Simon (2000), which states that individuals cannot possess complete knowledge of reality. All of these concepts reflect the flexibility and openness of agent-based modeling when dealing with intangible, real-life constructs such as personality.

5.3 Analyzing Theory Through Simulation

5.3.1 The "Why?"

Especially when moving from the engineering to the management side of the discipline, more abstract, intangible concepts enter the picture, concepts such as trust, knowledge, satisfaction, experience, that become increasingly difficult to operationalize (Bozkurt, Padilla and Sousa-Poza, 2008). Peshkin (1993, p. 27) states that "*clarifying and understanding complexity* [italics from original quote], another outcome of interpretation, is important because most of what we study is truly complex, relating to people, events, and situations characterized by more variables than anyone can manage to identify, see in relationship, or operationalize." The simulation paradigm is equipped with tools and

techniques that help researchers address these complex relations, and analyze the situations where these relationships take place.

Axelrod (1997) has stated that simulation is "a new way of conducting scientific research" (p. 17). In addition to induction and deduction, he states that simulation is the *third research methodology*. Similar to deduction, the starting point of simulation is a set of explicit assumptions. However, instead of proving a theorem, data is generated through simulation that can be *analyzed inductively*. This property provides the simulation with the characteristic of aiding intuition and understanding.

Bossel (1994) provides two main perspectives for simulation of behavior:

1. *Description of behavior:*

This particular simulation model consists of an output that is a function of some input, which can be mathematical equations. This type of simulation can be considered to be a black box, where only the inputs and the outputs, can be observed. What happens within the box, such as "how" the inputs turn into the outputs cannot be observed; therefore, insight gained from this process is limited.

2. *Explanation of behavior:*

This simulation model is conducted for the purpose of modeling actual processes. Questions such as what parts, how are they connected, how do they influence each other, can be answered. The box in this case can be similar to a glass box, or an opaque box.

In the case for social sciences, the second approach, where a behavior is being explained in terms of the elements, and the relationships between those elements, are the more relevant and important approaches. Gilbert and Terna (2000) note that the reason why social sciences have not benefitted enough from computer simulation as a methodological approach may be that the main value of simulation in the social sciences is for theory development rather than for prediction. As Gilbert and Troitzsch (2005) have stated, building a model entails the researcher to understand the world.

A model is defined by Gilbert and Troitzsch (2005) as "a simplification-smaller, less detailed, less complex, or all of these together-of some other structure or system" (p. 2). They further state that through a process of abstraction, a model is built (either through a set of mathematical equations, statistical equations or a computer program) which could in turn be used to develop new theories.

For the purpose of this research, an understanding of how individuals with different philosophical profiles solve complex problems is going to be established through this type of simulation. Agent-Based modeling has been chosen as an appropriate tool for this research, because it possesses certain characteristics that are needed in theory exploration, and provides insight on complex situations. Because computer simulations provide the capability of sharing a methodology, experimentation and data, explicitly thorough inspection, *replicability* is also established (Abrahamson and Wilensky, 2005).

Gilbert and Troitzsch (2005) provide an explanation on why simulation seems to be a proper fit for social studies:

> The major reason for social scientists becoming increasingly interested in computer simulation is its potential to assist in discovery and formalization. The process of formalization, which involves being precise about what the theory means and making sure that it is complete and coherent, is a very valuable discipline in its own right (p. 5)

Kalick and Hamilton (1986) stated that the overall objective of using simulation was to develop models that would present researchers with the opportunity to look for overall patterns in the social system that were being produced by behaviors of individual characteristics.

Gilbert and Troitzsch (2005) describe three main uses of simulation:

1. *Understanding*: Simulation helps researchers obtain a better understanding of some features of the social world, as well as the relationship between the 'micro' level, which represents the attributes and behavior of individuals, and the 'macro' level, which is a representation of the properties of social groups. Together with investigation of emergence, this understanding is amplified.
2. *Prediction*: If we can develop a model that faithfully reproduces the dynamics of some behavior, we can then simulate the passing of time and thus use the model to 'look into the future.'

3. *Substitution*: Simulation may also be used to develop new tools to *substitute* for human capabilities. For instance, expert systems simulation can be used by non-experts to carry out diagnoses.

Gilbert and Troitzsch also state that the initiation point when using simulation as a method is that there is a real world phenomenon (the target) that the researcher is interested in investigating. The main purpose of the simulation, therefore, is to create a model of that target, which would be simpler to study. However, aside from this simplification, the model also needs to be dynamic, since in social sciences the target is constantly changing over time, and reacting to its environment. Having decided on what the model should comprise, a representation of the model as a specification needs to be formulated. This specification can be made in terms of a mathematical equation, a logical statement, or a computer program. In some instances, especially when this specification is not linear, analytical reasoning may be difficult, or even impossible. That is why, Gilbert and Troitzsch conclude, simulation is often the only way.

5.3.2 The "How?"

There are nine stages of simulation-based research according to Gilbert and Troitzsch (2005):

1. Identify the puzzle, which is represented by the research question.
2. Definition of the target for modeling.
3. Some observations are needed to provide the parameters and initial conditions for the model. The parameters and initial conditions for the simulation model need not be through observations only. Other theories, historical data, research present in literature and similar non-observable "data" can also provide the initial specifications for the model.
4. Make assumptions and design model in form of a computer program. They have also stated that it becomes increasingly difficult to decide what to leave out and what to include, especially when what is being modeled is a complex phenomenon. The more that is left out, the greater the conceptual leap required between the conclusions drawn from model and interpretations in relation to the target. The more that is put in, the more precisely the parameters have to be

measured or assumed. Each has effect in validity. Axelrod (1997, as cited in Gilbert and Troitzsch, 2005, p. 19) has noted that "accuracy is important when aim is prediction; simplicity is an advantage if the aim is understanding."

5. Perform simulation.
6. Verification (internal validity)-debugging: ensure that the model is correctly implemented and working as intended.
7. Test cases, extreme situations where outcome is fairly predictable.
8. Validation (external validity): ensure that the behavior of the model corresponds with the target's behavior.
9. Sensitivity analysis: this is conducted in order to see how sensitive the model is to changes in parameters and initial conditions. This last step also establishes the robustness of the simulation model.

Similar to the research steps described above, Bossel (1994) has provided four main steps for building and analyzing a simulation model, which will serve as basic guidelines for the research conducted in this dissertation as well: Development of the model concept, development of the simulation model, simulation of system behavior and mathematical systems analysis:

1. *Development of the model concept*:

During this initial phase, the model purpose should be clearly defined. This should include all of the assumptions, simplifications and aggregations used. Following the model purpose, the system definition should be made explicit. This definition needs to include the system boundaries and borders with the environment, so that the purpose of what the system does (and what the system is) will be clear. The last step of this initial phase is the structure and function of the system. This includes a verbal model, which consists of influence relationships. These relationships are necessary to layout an accurate verbal model.

2. *Development of simulation model*:

In the second phase, the simulation model is developed. This, similar to the initial phase, includes multiple steps, as explained below:

- *Dimensional analysis*: Elements identified before must be precisely specified in terms of their exact meaning and units of measurement

- *Determine functional relationships*: Relation between elements must be uniquely specified
- *Quantification*: Influence relationships are quantified
- *Developing Simulation Diagrams*: As a basis for the simulation program
- *Program Statements and computable model*: Default values must be specified and defined for initial values, system parameters, and exogenous influences. They may be later changed in the simulation runs.
- *Validity test for model structure*: Whether the "real" system is correctly represented in the model (and corresponds with the model purpose). This is, however, from an empiricist perspective, as demonstrated by the "real system" approach. The validity could also be tested through the coherence of the premises, from a rationalistic stance.
- *Development of alternative forms of representation:* Whether the simulation model could be made more transparent or comprehensible without loss of validity. One should check whether modularization is possible and permissible.
- *Attempting a compact representation*: Reduce the system structure to a simple elementary structure which simplifies the analysis and allows certain generalizations.

3. *Simulation of system behavior*:

When switching gears to the computer phase, the choice of simulation software becomes one of the most important issues. This choice depends on the type of model that is being developed, the type of computer that is being used, as well as the programming language in question, which is also related to the developer's personal preference. The actual programming of the simulation includes lines of program codes. Once the simulation is programmed, the run time parameters need to be considered, which includes the development of a function with respect to time. Usually, time at $t = 0$ is the beginning of simulation, and $t = t_1$ is the end of simulation. This becomes important for speed and precision of simulation. Initial conditions of state variables have to be set at the beginning of the simulation. Default values can be changed by users in the simulation runs. Exogenous influences are another step to be considered. The response of the system to

certain prescribed influences from the environment or to certain developments assumed for the future should also be specified before the simulation.

- *Scenarios*: In more complex systems, many parameters and environmental inputs have to be investigated simultaneously, since the possible number of combinations is large.
- *Presentation of results*: Tables, graphs and animated presentations provide the user with quick and reliable overviews.
- *State trajectories*: Presentation of dynamics of the state variables and system behavior (oscillations, points of equilibrium, collapse, chaos, etc/)
- *Sensitivity*: Sensitivity of the model to uncertainties in the formulation and to the changes in critical parameters.
- *Validity testing*: Simulation dynamics agree quantitatively and qualitatively with observed and expected behavior; model results and knowledge gained correspond to the model's purpose.

4. *Analysis of model system:*

Deeper insight with further analysis is gained. Bossel (1994) has stated that using computer simulation can be advantageous in the sense that it has the capability of dealing with complex non-linear systems that are not open to mathematical analysis. However, mathematical analysis may present with an advantage as well, which is the fact that this type of analysis may lead to solid proofs of certain system properties. These properties could only be inferred or extrapolated from a computer simulation. This is why it is crucial to conduct certain statistical analyses in order to establish a deeper level of formalization and rigor in the research. These analyses will be described in latter sections of this dissertation.

5.4 Overview of Agent-Based Modeling

Agent-based modeling and simulation has its own theoretical foundations, worldviews and philosophies built through its connection to other fields such as complexity science, systems science, systems dynamics, traditional modeling and simulation, and the social sciences (Macal and North, 2005). Epstein (1999, p. 56) describes ABM as a "powerful tool in the analysis of *spatially distributed systems of heterogeneous autonomous actors*

with bounded information and computing capacity [italics original]." Most social and psychological phenomena occur not as the result of isolated decisions by individuals but rather as the result of repeated interactions between multiple individuals over time (Smith and Conrey, 2007). Therefore, it is important to choose a specific method that will enable the researcher to observe these repetitive interactions and the patterns that emerge as a result of these interactions.

Smith and Conrey (2007) propose that ABM is an alternative approach to theory building in order to understand dynamic and interactive processes. "One hallmark of ABM is that it typically assumes that the overall system's complexity emerges from the interaction of many very simple components, rather than from great complexity in the behavior of individual agents" (Kauffman as cited in Smith and Conrey, 2007). Agent-based models are dynamic, expressive and afford immediate feedback (Abrahamson and Wilensky, 2005). ABM of human behavior is a growing research practice that has shed light on complex dynamic phenomena (e.g. Holland, 1995; Kauffman, 1995). Agent-based models are particularly useful for understanding *complex phenomena* (Abrahamson and Wilensky, 2005).

Another key advantage of ABM is that it does not restrict a theorist to a single level of analysis. The whole point of a multiagent model is to bridge theoretical levels (Smith and Conrey, 2007). Practicing ABM in psychology research can potentially support the development of richer theoretical models that coordinate complementary perspectives as viable complements of an integrated explanatory structure (Abrahamson and Wilensky, 2005).

Abrahamson and Wilensky (2005) present three main contributions of ABM to the advancement of theory:

1. *Explicitizing*:

The ABM environment demands an exacting level of clarity and specificity in expressing a theoretical model and provides the tools, structures and standard practices to achieve this high level.

2. *Emergence*:

Through the computational power of ABM, the researcher can mobilize a static list of behaviors and identify any group-level patterns that may arise through multiple

interactions between the agents who implement these behaviors. The concept of emergence provides simulation methodology with a unique advantage. The main idea that lies behind emergence is that simple, "preprogrammed" behavior of the individual parts may result in interesting, unexpected patterns of the system as a whole, which provides insight about how the whole system, as well as the individual parts, actually function (Kalick and Hamilton, 1986). The most important point about emergence within ABM is that it arises from simple rules and behaviors. Without any direction from a central authority, through simple rules and interactions between agents, a collective pattern or behavior that is unexpected may occur.

3. *Intra/interdisciplinary collaboration*:

The *lingua franca* of ABM enables researchers who otherwise use different frameworks terminology and methodology to understand and critique each others' theories and even challenge or improve the theories by modifying/and or extending the computational procedures that underlie the model.

To construct an agent-based model, the modeler assigns the agents real-world roles and rules, then studies the model through conducting simulation experiments in which the agents follow their rules, and observes real-time data (Abrahamson and Wilensky, 2005). The agent-based model is the researcher's idealized approximation of how things work in the world. The following steps are used:

1. Modeler creates agents
2. Assigns rules to agents
3. Creates virtual environment where agents operate
4. Conducts simulation experiments in which agents play out their rules within the environment

The NetLogo (designed by Uri Wilensky in 1999) environment was designed so that building simulations could become common practice for natural and social sciences scholars investigating complex phenomena. The scholars themselves, and not hired programmers, build, run and interpret the simulations. For this purpose, the NetLogo "language" has been developed so that it can be accessible, easy to write, read and modify. This makes NetLogo very much distinct from common general-purpose

programming languages like Java and C++. NetLogo is mostly appropriate for modeling complex systems, which are dynamic over time.

As a result of the vast amount of research that has been done on ABM, it can be said that there is consensus to some degree on what characteristics an agent should possess. Taking into consideration a sample of these researches (Bonabeau, 2002; Gilbert and Terna, 2000; Jennings et al., 1998; Kauffman, 1995; Macal and North, 2005), here is how an agent is defined:

1. Agents are identifiable, self-contained, discrete individuals, possessing their own sets of characteristics and rules. This means that an agent has its own boundaries, which helps determine whether something belongs to an agent, or is outside of the boundaries of that agent.
2. Agents are situated in an environment, which provides the medium for agents to interact with other agents. There are certain rules for agents' interactions.
3. Agents are goal-directed, meaning that each agent has a goal to achieve.
4. Agents are autonomous; they independently seek their own goals based on their own local information. There is no central authority, controller or planner. This makes self-organization possible.
5. Agents are interdependent. The actions of each agent influence the others.
6. Agents follow extremely simple rules, simplest and best supported assumptions about individual agent behavior.
7. Agents are flexible, meaning that they have the ability to learn and adapt their behaviors over time. This is reflected at the instances where an agent has a form of memory, and it may have some rules that modify its behavior according to these memories.

Following these and previously discussed steps, the Agent-Based model will be constructed in the following part.

5.5 Research Steps

This section builds the foundation for the Agent-Based model to be constructed. The section will start with the research steps taken to start constructing the Agent-Based model, which include the Conceptual Step, the Concept-to-Computer Step, and the

Computer Step. The premises discussed in the previous sections now become rules for the agents to interact with each other. The next section is an elaboration on how the ABM was set up, including details of all levels.

As Becker, Niehaves and Klose (2005) state, constructing a simulation model and interpreting the simulation results are dependent on the researcher, the research topic, the researcher's experiences and epistemological perspectives. The main research steps as shown in Figure 14 below start with the *Concept*. This is where the verbal model or the conceptual arguments are established and elaborated. In order to establish a valid and sound argument, followed by meaningful and *coherent* conclusions, it is crucial to make the premises explicit.

This is followed by the *Concept to Computer (C2C)* phase. In this step, the previously developed conceptual model and the premises are shaped and formalized in such a way that they can be used as input for the computer simulation model. This can be thought of as the pseudo code. Having established this, the final phase (*Computer*) consists of building the computer simulation model.

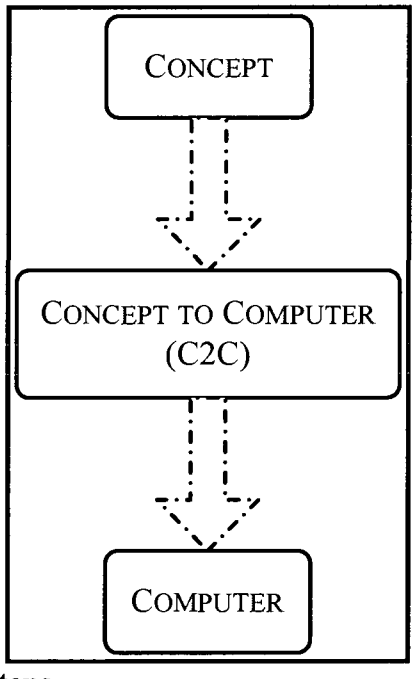

Figure 14. Main research steps

5.5.1 Conceptual Step

The conceptual phase consists of the previously developed, identified and selected premises, rules and the context.

Premises

1. Philosophical paradigms as underlying dimensions for personality profiles when dealing with complex problems
    a. The philosophical profile of the individual (PPI) contains three philosophical dimensions; Epistemology, Ontology and Teleology.
    b. Epistemological dimension contains Empiricist and Rationalist predispositions.
    c. Ontological dimension contains Substantive and Process predispositions.
    d. Teleological dimension contains Goal-oriented and Not Goal-oriented predispositions.
2. How these profiles deal with/solve complex problems
    a. What makes a problem complex?
        i. Justification from literature:
            1. Lack of information
            2. High number of entities
            3. Ambiguity
            4. Instability
            5. Temporal constraints
    b. Level of complexity
    c. How do the profiles deal with complex problems?
        i. Each predisposition will have a different way of dealing, i.e. different capabilities.
        ii. When they are combined, what happens?

5.5.2 Concept to Computer Step

The C2C Process:

The C2C process, presented below in Figure 15, involves taking the above conceptual/verbal theory, structuring it and formalizing it in a way that it can be put into

a simulation medium (ABM) using a particular tool (NetLogo). An important point to address here is that the below process is non linear. Iterations, trials and errors, and modifications have been present in every step. In addition to this, it should be noted that the C2C process is done on paper, meaning that before even touching a computer, this process has to be completed, to ensure that the actual agent-based model is logically consistent and coherent.

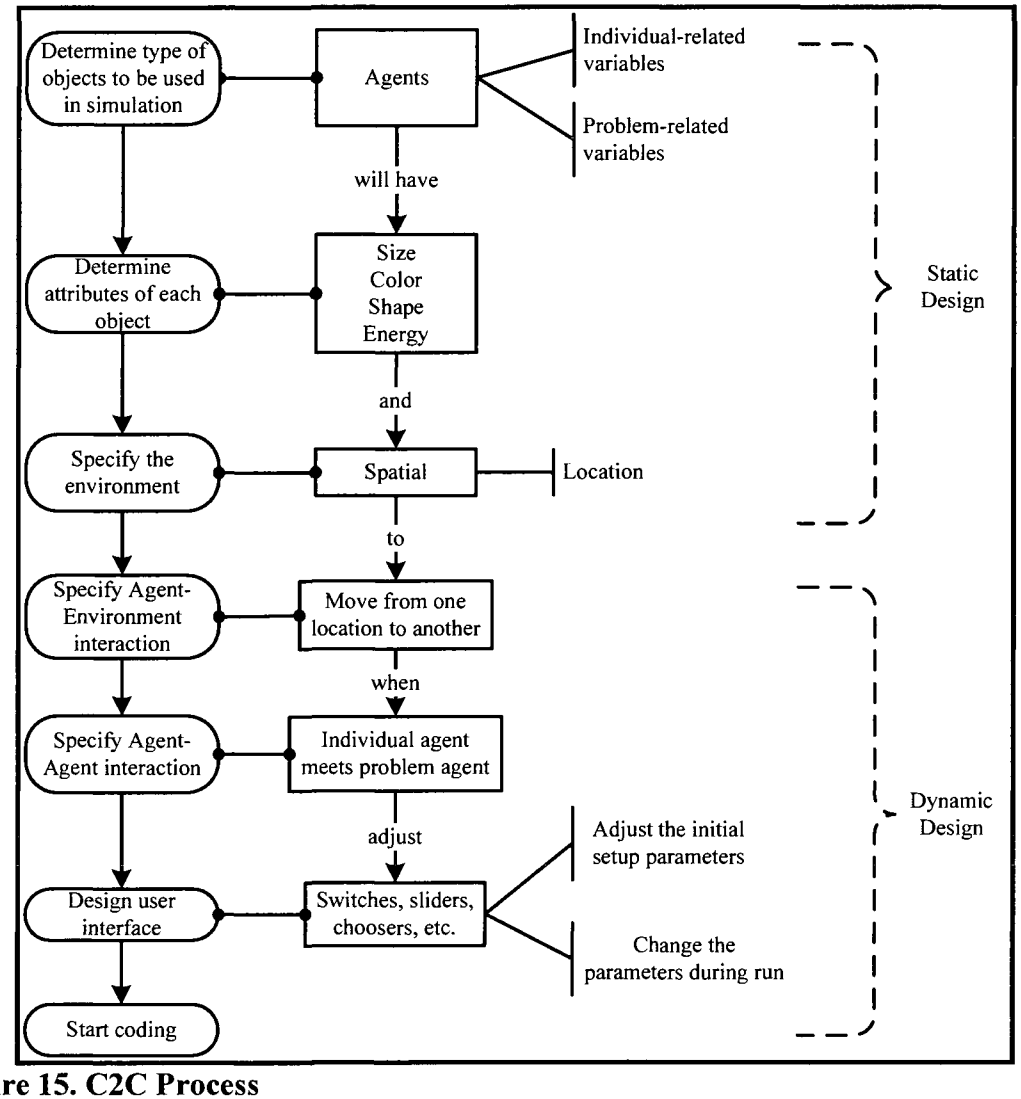

Figure 15. C2C Process

(Contents adapted from Gilbert and Troitzsch, 2005)

5.5.3 Computer Implementation Step

This last stage is where the agent-based model was built. Figure 16 is a general representation of the two main phases of this process. Phase 1 presents an explanation on how the user-model interaction takes place, and Phase 2 is a detailed discussion on the actual simulation model, and what is taking place inside the simulation run. Therefore, these two levels occur simultaneously. The user is responsible from the initial setup conditions, and the running of the program. While the simulation is being run according to the rules and interactions described in Phase 2, the user can directly observe the outputs identified. A more detailed analysis of this output takes place afterwards.

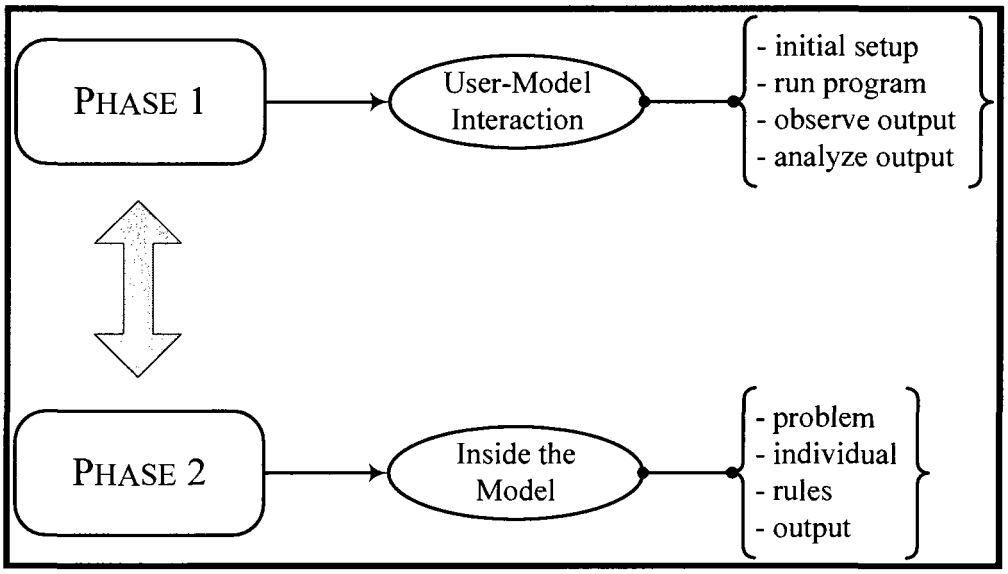

Figure 16. Phases for the computer section

Phase 1: User-Model interaction

1. Initial Set-up (User will determine):
    a. Number of Problem agents
    b. Number of Individual agents
    c. Problem Conditions
        i. Levels of complexity for

1. information
2. entities
3. stability
4. ambiguity
5. temporal

d. Predisposition Dimensions:
   i. Empiricist and/or Rationalist
   ii. Substantive and/or Process
   iii. Goal and/or NoGoal

2. Run the program
3. Observe Output
   a. Overall Profile Capability
      i. Initial
      ii. Final
   b. Overall Problem Complexity
      i. Initial
      ii. Final
   c. Individual Predisposition Capabilities
4. Analyze Output

Phase 2: Inside the model

Moss (2008) stated that the simulation model becomes more concrete when the contributing entities to the social process are captured in high levels of detail; whereas the model becomes more isolated when these entities are reduced for the purposes of concentrating on more specific causal mechanisms. This is why modeling is commonly described as an art, rather than as a science; that is, it is full of trade-offs and compromises in order to reach the most accurate representation *for the purposes of a research.* In this section, the construction of the agent-based model will be explained in detail, which will include the choices and the reasoning processes behind those choices.

This section has four main components: The first component is an elaboration on how the philosophical dimensions and the individuals' profiles are represented as agents.

The second component deals with the representation of the problem variable, including how the complexities are represented. The third component elaborates on the rules that describe how the previously identified agents will act on their own, and how they will behave when they interact. The final component is the output, where what kind of results will be obtained, and how they will be captured is explained. These four components are described below in detail.

5.5.3.1 Representation of the Individual

Type of representation:

The three dimensions of the profile for the individual (from now on "individual agents") are represented as separate agents.

Reasoning:

The main premise of the PPI is that the personality profile is composed of three philosophical dimensions, and these dimensions have two main components which represent the individual's predisposition. Building up on that premise, the second component of this research is to see how these predispositions, dimensions and profiles deal with problems of certain complexity.

As explained in the conceptual section, each of these components will have different ways of dealing with the problem variables. It is crucial for the purposes of this research to see how all of these components interact together. It will be elaborated in the latter sections that one-on-one interactions can be explained, deduced, observed or hypothesized. However, what exactly happens when these three philosophical dimensions and their related predispositions come together to form an individual's profile, is unclear. This is why these variables are represented as individual agents, so that the interaction with the problem agents can be tracked down and analyzed.

Below table (Table 8) represents the common attributes all agents posses.

Table 8. Common Attributes for Agents

Agent Type	Common Attributes
All Agents	Size Color Shape Number Location Movement

Details (in accordance with the "common attributes" table presented above):

1. **Shape:**

Each of the philosophical dimensions (epistemology, ontology and teleology) is represented by a different shape.

2. **Size:**

The individual agents have a size of 1.4. This value is different from the size for the problem agents not only because of visual purposes, but mainly because of certain tracking down and output plotting purposes, which is explained later in this document.

3. **Location:**

Each of the individual agents is randomly placed when created.

4. **Number:**

The initial number of individual agents is determined by the user and can be between zero and fifty, with increasing increments of 2 (i.e. 0, 2, 4, etc.). The reason for this is explained in latter sections.

5. **Movement:**

When asked to move, all individual agents move one step forward, then make a random 90° turn, and move one step forward again. The purpose behind the movement is to create a means of interaction for the agents representing a problem and an individual.

6. **Specific variable:**

All individual variables have certain "energy." For the individual agents, this represents the *capability* of the specific predisposition to solve the specific problem. This capability is a randomly assigned a number greater than zero, and smaller than 120.

The above details are summarized in Table 9 below:

Table 9. Details for Individual Agent

Dimension	Breed	Shape	Size	Location	Capability
Epistemological	Epist	Circle	1.4	Random	0-120
Ontological	Ont	Triangle	1.4	Random	0-120
Teleological	Tel	Pentagon	1.4	Random	0-120

7. Epist_id/Ont_id/Tel_id:

The individual agents own a specific "*identification (ID).*" This becomes an important point in the representation of the individual agents. So far, the above explanations have been in relation to the three philosophical dimensions. Now, the focus turns to the predispositions, which is what the ID represents. The Epistemological ID may either be Empiricist or Rationalist. The Ontological ID may either be Substantive or Process. The Teleological ID can either be Goal or No Goal. The main reason why this particular way of representation was chosen is that instead of having six different agents representing individual predispositions, only three agents are created in the model. Even though each of these predispositions *will* have a different representation in terms of the agent that they belong to, for the purposes and the specifics of coding, they are not different breeds of agents. Also, the starting premise of the PPI is the three philosophical dimensions. How the predispositions come together effect the type of the personality profile, but not what the underlying foundation of the profile is. The way the predispositions are reflected in the model and how they are determined is as follows:

Three scales, called the "*predisposition scales*" (Figure 17), have been created, which is controlled by a slider in the ABM. These scales represent the different

predispositions, more specifically, how much of those predispositions are present within the model interface. The scale is represented as a percentage, with increasing increments of 10. The reason for this is that the more granular the scale gets, the more difficult it becomes to explain the differences between the predispositions and the profiles. The percentage scale is also the reason why the number of individual agents was an even number, so that an odd number is not forced to be divided into two or four or six, etc.

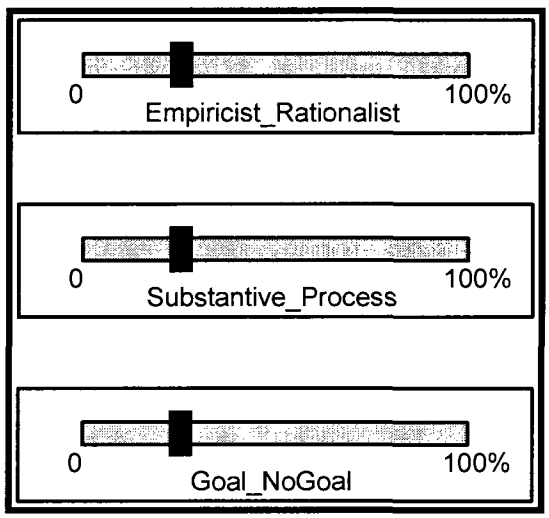

Figure 17. Predisposition scales

The first scale, related to the Epistemological dimension, is the *Empiricist/Rationalist* scale. The initial value of the scale is determined by the user. The extreme ends of the scale represent the two opposite predispositions. For instance, if the percentage is set at 0%, this means that all of the epistemological agents are "empiricist" agents. If the scale is set at 10%, this means that 90% of the epistemological agents are empiricists, and 10 % of the total epistemological agents are "rationalist" agents. If the scale is set at 100%, this means that all of the epistemological agents are "rationalist" agents. Since it has been discussed in the above sections (and further elaborated in the later sections) that the different predispositions will have different ways of dealing with problems, it was important to somehow differentiate the different predispositions in the

coding. This differentiation is also important for visualization purposes as well, and it was done by the use of different colors.

8. Color:

According to the specific predisposition scale determined initially by the user, the Epistemological agent will have the color "blue" or "sky;" the Ontological agent will have the color "magenta" or "violet," and the Teleological agent will have the color "brown" or "yellow."

The above two details are summarized below in Table 10:

Table 10. Color Rules for Individual Agent

Scale	Value (%)	if	then id	Color
Empiricist/Rationalist	0-100	> 50	Rationalist	Sky
		< 50	Empiricist	Blue
Substantive/Process	0-100	> 50	Process	Magenta
		< 50	Substantive	Violet
Goal/NoGoal	0-100	> 50	NoGoal	Yellow
		< 50	Goal	Brown

Figure 18 below represents the steps taken to create an individual agent. When an individual agent is created, the size and location are pre-set in the sense that the user does not have any control over these settings. The user, however, determines how many agents there will be through the use of the "number of individual agents" slider. The user can also determine which of these agents will be representing which predispositions. In other words, if the user wants to explore PPI1 (ESG), he/she will set the Empiricist_Rationalist scale to 0%, which ensures that all of the epistemological agents will be Empiricists. Similarly, the Substantive_Process scale is set to 0%, which means that all of the ontological agents are Substantive, and when the Goal_NoGoal scale is set to 0%, all of the Teleological agents are set to be Goal-oriented. Taking into consideration the type of

agents, the program determines the shape and the color of the agents. Each agent possesses a certain capability. This capability is also set randomly. According to all of these settings, a certain number of agents are created and located randomly throughout the spatial environment; in this case, the aggregate of individual agents are now representing PPI1.

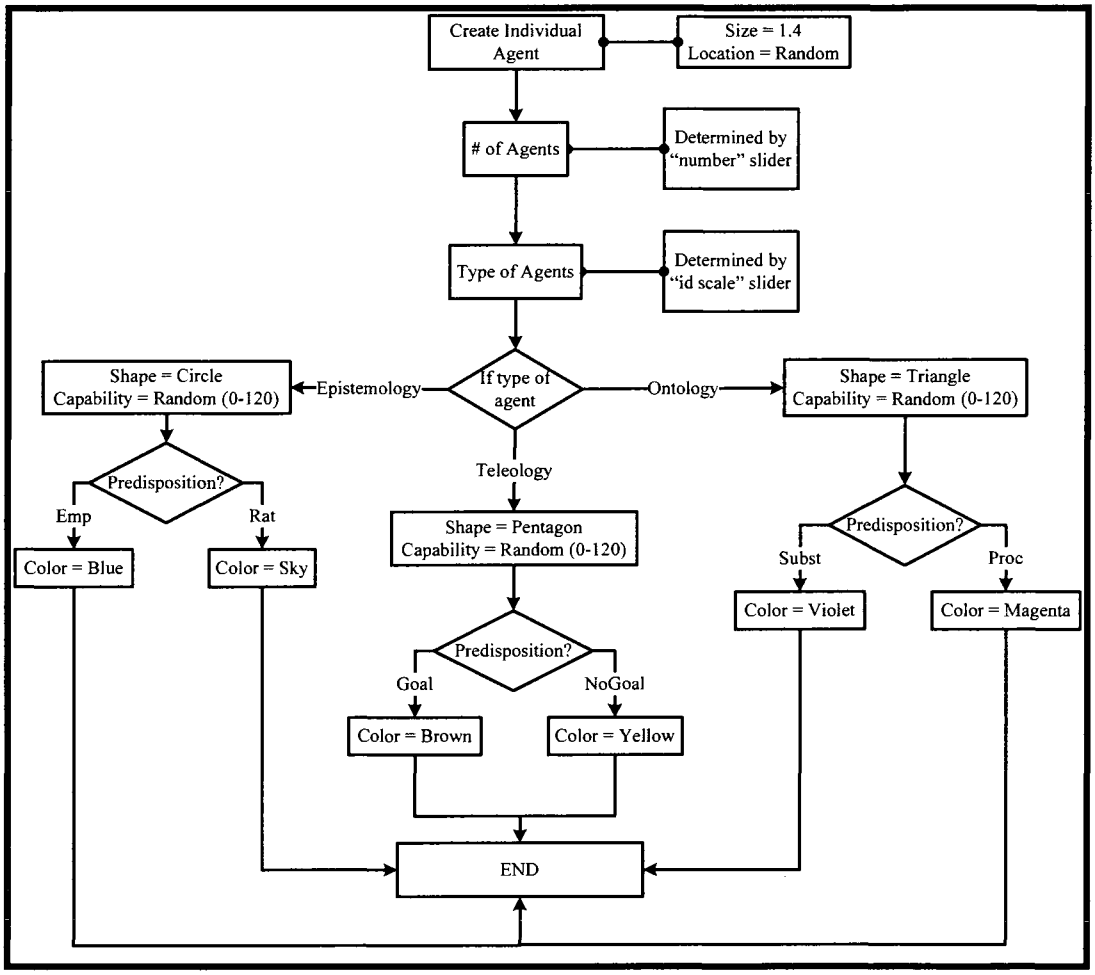

Figure 18. Setup for individual agents

5.5.3.2 Representation of the Complex Problem

Type of Representation:

Each of the five variables that constitute a complex problem is represented as a different agent.

Reasoning:

This option was chosen among the many representation possibilities in order to have a better understanding of what happens when an individual is trying to solve a problem. The literature (and experience) tells us that one of the main difficulties in anticipating complex problems is not being able to determine what the problem actually is, hence the use of multiple variables to better characterize a complex problem. Therefore, rather than aggregating these variables and representing the problem with one single agent, it was decided that each of these variables would be represented as different agents. Another benefit of this representation is that it gives the researcher (and the subsequent users) of the model the ability to effectively track down how different profiles deal with the different aspects of the problem. For instance, one particular predisposition may have better capabilities dealing with the dynamic characteristic, but may fail in addressing the high number of entities.

Details (In accordance with the "common attributes" table, Table 8):

1. **Shape**:

   All problem variables (from now on "problem agents") have similar shapes, for better visualization purposes. In this case, each problem agent is represented as a different type of die.

2. **Size**:

   All problem agents have a size of 1.5.

3. **Location**:

   When created, all problem agents are placed at a randomly chosen location.

4. **Movement**:

   When asked to move, all problem agents move one step forward, then make a random 90° turn, and move one step forward again.

5. **Number**:

The initial number of problem agents is determined by the user, and is between zero and 50. The number of agents can be increased at increments of 10 (i.e. 10 agents, 20 agents. etc.). The reason is explained in the latter sections.

6. Specific variable:

All problem agents have certain "energy," called *difficulty*. This represents the *level of complexity* of the problem agent. There is no consensus among various research within literature on how problems can be classified, as discussed previously. They have been classified as Complex/Simple, Structured/Unstructured, Well structured/Ill structured etc. This research uses the classification Simple-Medium-Complex. Just as an answer to a survey question can be divided up to a 7-level Likert Scale, the complexity of a problem can be divided into three. Having only Simple and Complex would be a useful simplification; however, problems do not change from complex to simple at an instant. It is important for the sake of this research that the middle ground be covered as well. The difficulty of a problem agent is randomly assigned when the agent is created. It can be greater than zero, and smaller than 120. The maximum limit could have been any number. After couple of tests of the setup, the execution and the graphical outputs, the number 120 was decided on. As long as all the problem agents have the same range of difficulty, this choice is valid. The level of complexity, as explained in the conceptual section, is divided into three (simple, medium, and complex), and is reflected in the "difficulty" attribute of the problem agent as such:

a. if >= 80 (difficulty of problem agent) < 120, problem agent: high complexity
b. if >= 40 (difficulty of problem agent) < 80, problem agent: medium complexity
c. if > 0 (difficulty of problem agent) < 40, problem agent = simple

All of the above details are summarized in Table 11 below:

Table 11. Details for Problem Agent

Variable	Represented by	Shape	Size	Location	Difficulty
Information	info	die 1	1.5	Random	0-120
Entities	ent	die 2	1.5	Random	0-120
Stability	stab	die 3	1.5	Random	0-120
Ambiguity	amb	die 4	1.5	Random	0-120
Temporal	time	die 5	1.5	Random	0-120

7. Color:

The level of complexity is reflected on the problem agent in terms of color, as seen in Table 12:

Table 12. Color Rules for Problem Agent

if Difficulty	then Color	Complexity
[80, 120]	Red	High
[40, 80)	Orange	Medium
(0, 40)	Green	Low

8. Overall Problem Complexity:

Even though each problem variable is represented separately, the overall problem complexity is relevant to the model, and is therefore represented as the aggregate value of individual problem variables (Table 13).

Table 13. Overall Problem Complexity Function

Overall Problem Complexity	Variables
Low	$info_L$ + $entity_L$ + $stability_L$ + $ambiguity_L$ + $time_L$
Medium	$info_M$ + $entity_M$ + $stability_M$ + $ambiguity_M$ + $time_M$
High	$info_H$ + $entity_H$ + $stability_H$ + $ambiguity_H$ + $time_H$

For a complex problem, the availability of information would be low. This indicates that the agent representing the availability of information ("info") will have a high complexity, therefore the user will choose "Low" from the "available information" chooser, which in turn would set a high level of complexity for the *info* agent. Through this setting, when the simulation is initially set up, all of the *info* agents will be red, and have a difficulty between 80 and 120. Similarly, for a complex problem, the number of entities would be very high, therefore, the user will choose "high" from the "number of entities" chooser, which will set the level of complexity for the *entity* agents as high, will make them red, and will set their difficulties at a random number between 80 and 120. The rest of the problem variables can be determined in a similar fashion.

Figure 19 represents the above steps for the creation of the problem agents. When a problem agent is created, similar to the individual agents, the size and location are pre-set. The initial number of agents is determined through the "number of problem agent" slider. The level of problem's complexity is determined. The color and the difficulty values for the agents are determined according to the initial settings the user chooses.

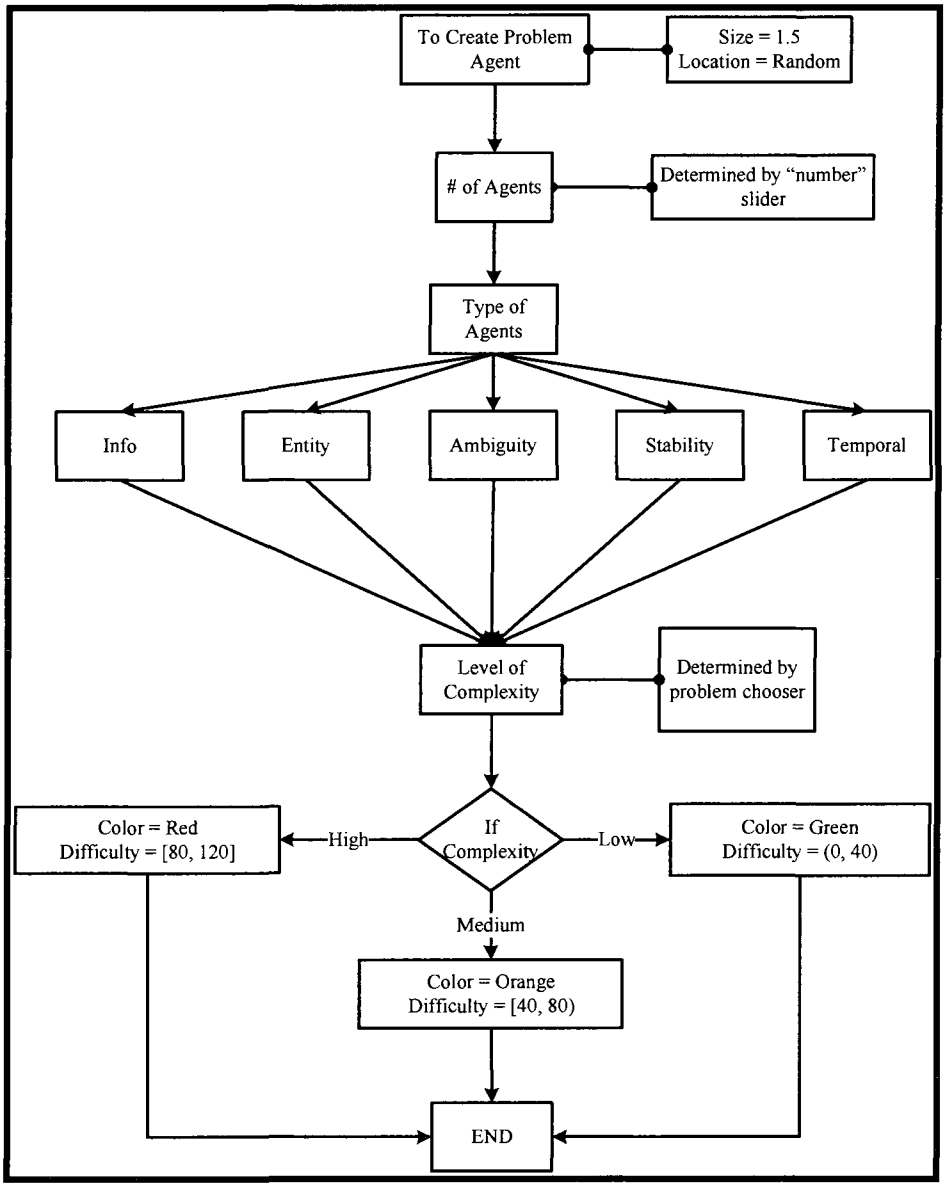

Figure 19. Setup for problem agents

5.6 Rules

After going through the general attributes for all agents, and specific attributes for the problem and individual agents, this section elaborates the rules that the agents follow.

There are three sets of rules that the simulation environment can contain:

1. *Rules (characteristics) of the Agents*:

This is considered to be "private" information, provided to each individual agent. These rules are stated such that they are ready to be input in the NetLogo environment, for agents to follow.

2. *Rules that are common to all agents*:

This is considered as "public" information. These rules are accessible and available to all of the agents.

3. *Rules for connecting the agents*:

This is considered as coupling. This set will provide the rules for agents to connect with each other, in other words, it will provide the conditions where one agent may hook up with another.

5.6.1 Public Rules

Public rules are specific rules, or instructions that are given to all of the agents. These rules are accessible by all of the agents at any time.

- ✓ All agents are created
  - size, shape, color
- ✓ All agents are placed
  - randomly
- ✓ All agents move
  - choose random direction, move one step
- ✓ All individual agents interact with all problem agents
  - Capability of the individual agent will change
  - Difficulty of the problem agent will change
- ✓ The individual agents do not interact with each other
- ✓ The problem agents do not interact with each other
- ✓ All agents die
  - for Problem: if difficulty <= 0, then die
  - for Individual: if capability <= 0, then die

5.6.2 Private Rules

These rules are customized for each agent, meaning that each type of agent will have a different set of private rules. They basically tell each agent what to do, and when to do it.

These set of rules can be thought of as goals, or purposes that are provided to the agents, for them to achieve it, which is in line with the requirements Abrahamson and Wilensky (2005) discuss. The private rules are divided into three levels; Level 1 and Level 2.

Level 1 Private Rules: These describe the more general, higher level rules that describe the behavior and action of the problem and individual agents. Both the individual and the problem agent are assigned a goal, as well as a criterion to establish whether that agent has met its goal or not.

Individual Agents (Purpose is to solve problems):

- ✓ look for problem variables
- ✓ if find a problem agent
    - o try to solve the problem: the capability that was assigned to the individual agent in the beginning will change.
- ✓ continue moving
- ✓ Criteria for individual profile: How do I know if the profile is effective?
    - o Success
    - o Consistency

Problem Agents (Purpose is to be solved):

- ✓ if met with an individual variable
    - o try to get solved: the difficulty that was assigned to the problem agent in the beginning will change.
- ✓ continue moving
- ✓ Criteria for problem: How do I know the problem is solved?
    - o Individual problem variable solutions
    - o Overall problem complexity

The above steps are summarized in Figure 20.

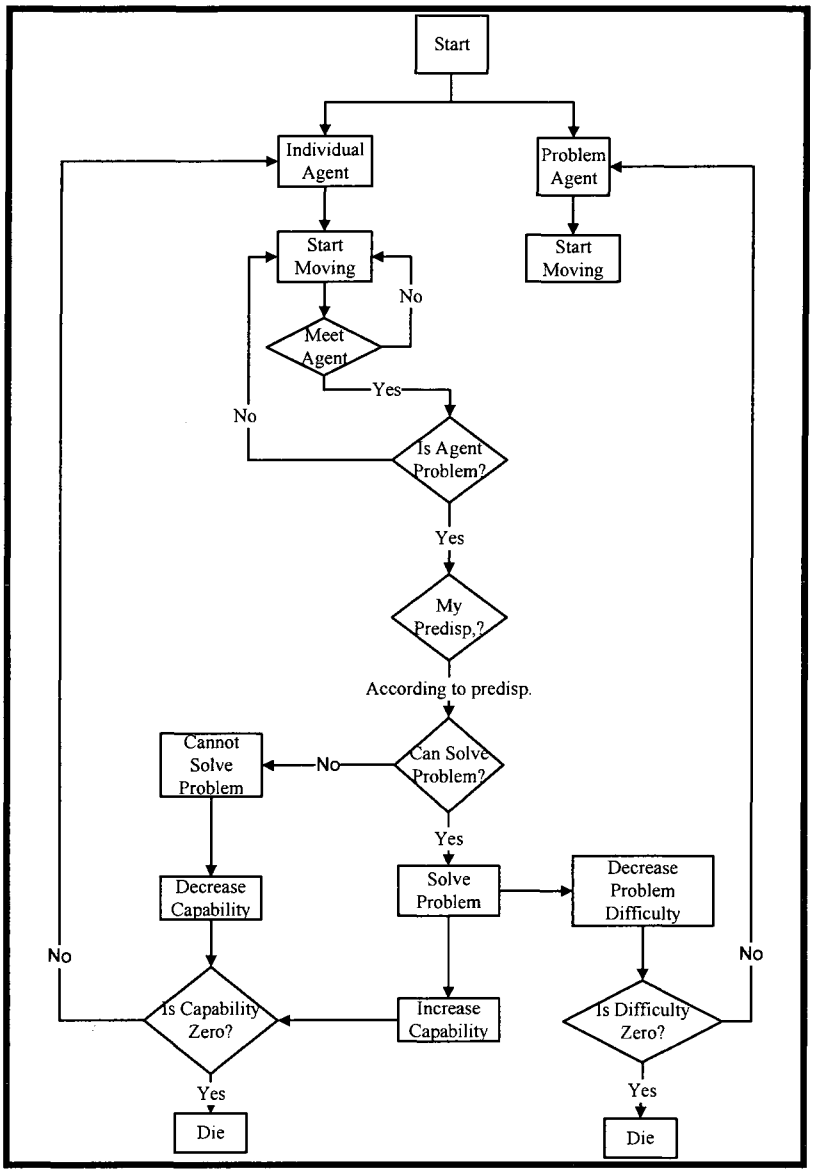

Figure 20. Common rule diagram for interacting agents

Level 2 Private Rules: These rules are the actual interaction rules for each of the individual agents with the problem agents. These interaction rules are the operationalization of the premises that were developed and discussed in Section Three. In below figure (Figure 21), an example of these rules is given. For all other rules, see Figure 42, Figure 43, Figure 44, Figure 45 and Figure 46 in Appendix A. The figure represents what happens when an individual agent who is an empiricist meets five of the problem variables. "C" denotes *complex*, and "S" denotes *simple*. A recap of what was

discussed in the premises follows. When available information about the problem is high, this individual deals with the problem better, because the capabilities are stronger, since the tools he has at his disposal makes him predisposed in such a way that he wants to collect information about the problem first. This may take a longer time (which becomes important when the problem is time-dependent), but this is the best way to verify that the problem is correctly identified. This is operationalized as "problem solved." When available information about the problem is low, in other words, when the problem cannot be defined properly, the Empiricist will deal with the problem poorly. This is operationalized as "problem not solved." The individual tries to collect information, but fails to do so. This leads to an incomplete understanding of the problem. Cooper et al (1995), for instance, found that entrepreneurs with relevant industry experience will still research a problem.

When the number of entities is high, the empiricist tendency provides better tools to the individual, since obtaining hard data and facts about each of the entities will provide more solid information, but it will take more time, and in some cases, may not always be possible. So, this results in a better tool, but within a slower time frame. This is operationalized as "problem is solved less," which indicates that there is still room for improvement on the problem, however not completely. This also depends on the amount of information available for each entity. When there are not many entities that make up the problem, it is easier to come up with data and information about the entities. Fewer entities lead to faster and better understanding of the problem, which leads to the problem being "solved."

When the problem is clear, empiricist has good capabilities to solve the problem. The difficulty of the problem decreases, and empiricist gains more capabilities due to its success, therefore the problem is "solved." When the problem is ambiguous, the empirical capabilities are not helpful. Since the problem lacks clarity, the empiricist individual is not able to find any tangible variables to measure or analyze data; therefore, the problem is "not solved."

When the problem is stable, this means that the conditions do not change over time, and the entities of the problem remain the same. This makes the Empiricist tendency provide more capabilities to the individual, since variables such as facts,

experience, perception etc. provides adequate definition of the problem, which makes the problem "solved." However, if the problem is dynamic, the empiricist has a hard time identifying these factors, thus he deals with the problem less effectively, and does "not solve" the problem.

When the problem is not constrained by temporal issues (meaning that when the solution of the problem is not immediate), the empiricist approach is a better tool in providing a solution, since there is time to gather data and look at the facts regarding the problem, meaning that the problem is "solved." However, if the problem is attached to a deadline (which is usually the case), then this approach, even though it may be a more solid one, is a disadvantage. This is due to the fact that under time pressure, individuals tend to collect a great deal of information on various alternative solutions, but analyze only a small subset of these solutions (Verplanken, 1993). In this case, some parts of the problem will remain "not solved," or unknown.

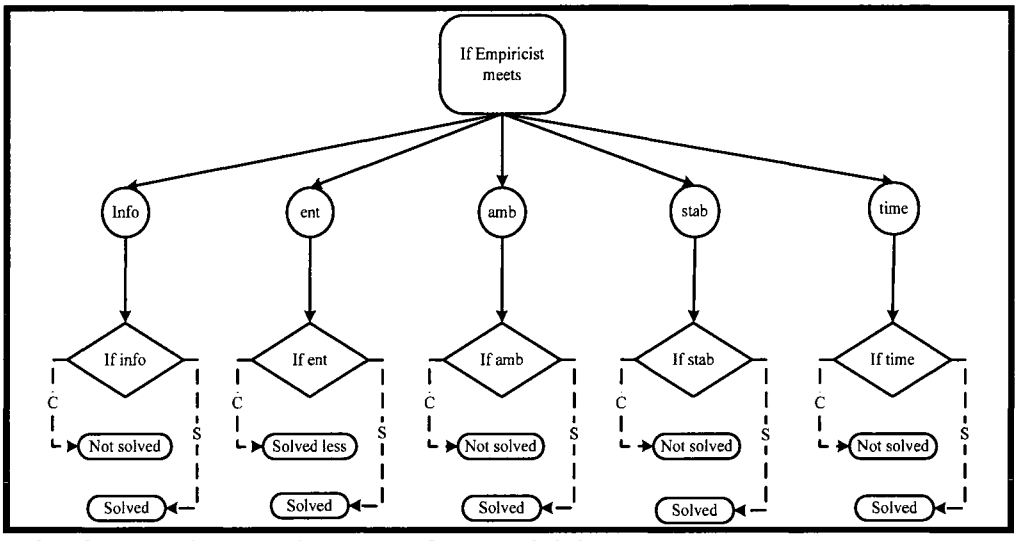

Figure 21. Sample interaction rules for empiricist agent

As seen from Figure 21, there are different ways a problem can be solved, or not solved. As previously discussed, there are two variables that change during these

interactions; the problem difficulty and the predisposition capability. The following rules are used for these changes in the variables (Table 14).

Table 14. Rules for Change in Values

	Capability	Difficulty
Problem Not Solved	-2	No Change
Problem Not Solved Less	-1	No Change
Problem Solved	+2	-2
Problem Solved Less	+1	-1

- *Problem Not Solved*: This rule indicates that the predisposition did not have enough capabilities to deal with that particular variable, therefore, lost capabilities with an increment of 2. The problem difficulty does not change.
- *Problem Not Solved Less*: This rule is a modification on the first one. The profile may still not have enough capabilities to deal with a problem variable, however in a slightly lesser degree. For instance, the disadvantage an Empiricist has over a lack of available information is not in the same extent that a Goal-oriented individual has with an ambiguous problem, hence the decrease in capability with an increment of 1. However, the problem difficulty still remains unchanged.
- *Problem Solved*: This rule indicates that the predisposition does have strong capabilities when dealing with that particular problem variable, e.g. an Empiricist agent facing an information variable with a high level of available information. In this case, this agent is able to solve that particular problem variable, and in turn increases its capabilities by +2. The problem difficulty decreases by 2.
- *Problem Solved Less*: This rule, similar to the second one, is a modified version of the previous rule. In this case, the predisposition is still capable of dealing with a particular problem agent, albeit in a lesser degree. Therefore the capability gain is +1, and the problem difficulty is decreased by 1.

These subtle differences are necessary in order to capture the nuances within predispositions, and the way they deal with each problem variable. Without these different rules, the emergent capability of the agent-based model would have been ignored, and the whole purpose of using this specific method would have been defeated.

The steps of how the computer simulation is going to take place are summarized in Figure 22.

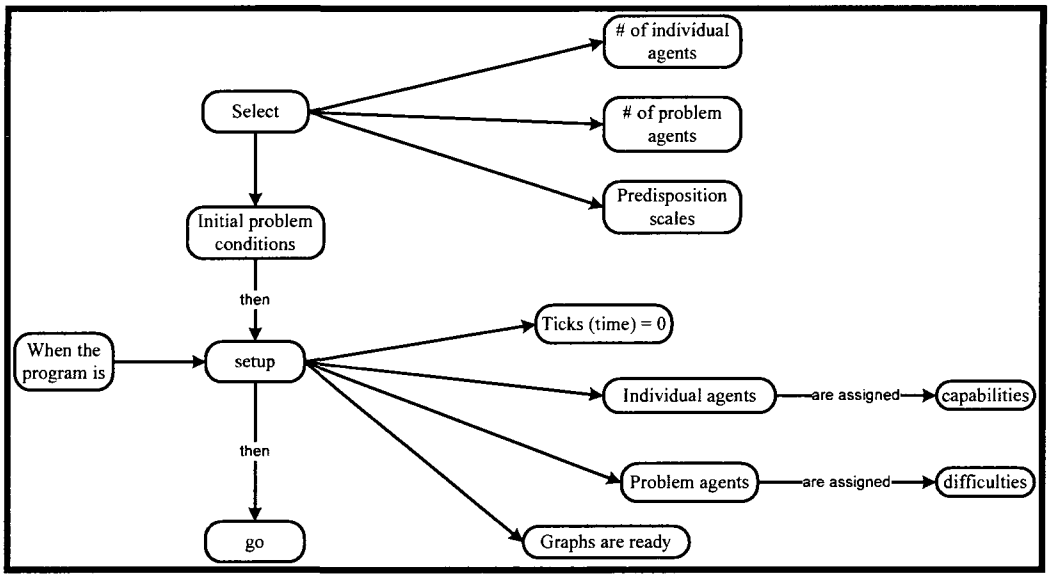

Figure 22. Overall rule chart

At the first step, the user selects the number of agents describing the problem variables, and the number of agents describing individual predispositions. Following this, through the predisposition scales, the user selects the profile to be explored. For instance, the two ends of the Epistemology scale are Empiricism and Rationalism. When the Epistemology scale is at 0%, this means that the Epistemological predisposition of that particular profile will be purely Empiricist. The user can adjust the Ontological and Teleological scales in a similar manner. The problem conditions can be determined by the user as well. Each of the five variables (available information, number of entities, stability, ambiguity and temporal) can be adjusted separately. Time for the simulation run can also be adjusted according to the needs of the user. The run can have no time limit; in

this case, the model is coded in such a way that it would terminate itself when there are no individual or problem agents. When the user hits the "setup" button, the predetermined number of agents will be created and randomly distributed on the interface, which is the environment in which the agents interact with each other. The individual agents are assigned certain capabilities, and the problem agents are assigned difficulties.

When the program is started with the "go" button, both the individual and problem agents start moving randomly. This means that there is now a problem that the individual needs to address. The individual agents look for problem agents to solve. Once the individual agent comes across a problem agent, the individual agent determines what type (e.g. "info") and what level (e.g. "high") that problem agent is. According to the characteristics of the problem agent and the individual agent itself, the individual will either solve the problem or not. If the individual agent can solve the problem, the capability of that agent will increase, and the difficulty of the problem agent will decrease. If the individual agent cannot solve the problem, the capability will increase, and the problem difficulty will remain the same. This process continues until there are no problem agents remaining, or individual agents remaining.

5.7 Evaluation Criteria

In order to accurately determine and interpret the results, certain criteria need to be established. After the computer simulation has been run, these criteria will be used to relate the outputs and outcomes of the simulation experiments with the final results of this study. Since one of the main objectives of this research is to examine and gain insight on how individuals with different philosophical profiles deal with complex problems, there are two criteria used in order to present the results with respect to the research objective. The first criterion relates to the individual and the individual's philosophical profile, and the second criterion relates to the complex problem that is being addressed.

- **Criterion for the Individual:**

This criterion is specifically related with the effectiveness of the PPI under question, and therefore, tries to answer the following question: How do I know if the profile is effective?

- *Success*: this can be determined/observed at every run
  - The better an individual agent is with a problem agent, the more capabilities it will gain when solving the problem. This may seem counter-intuitive in the beginning, however, the purpose here is to determine how the predisposition deals with the problem, and the way to do that is chosen as increasing the capability. Therefore, when an individual agent attempts to solve a problem agent that it is comfortable solving, the capability of the individual agent will increase. If not, the capability of the individual agent will decrease.
- *Consistency*: this can be determined/observed with more than one run
  - This will depend on how successful an individual agent is over time in different runs. It is crucial to look at whether or not the capability of the particular predisposition, as well as the overall capability of the profile increases or decreases in a similar fashion when different runs under the same conditions are tried.
- **Criterion for the Problem:**

This criterion is related to the problem that the individual is attempting to solve, and therefore tries to answer the following question: How do I know the problem is solved?

  - The problem is considered *solved* when the difficulty is equal to zero, which is when that particular problem agent "dies," or disappears from the model. The difficulty of a problem agent decreases if the individual agent is comfortable with dealing with that type of problem. If not, the difficulty will increase
  - Overall problem complexity

5.8 Output

The discussion of output will include two main factors. The first may be considered as an instant answer to the above question, it is what can be obtained directly from the model, right after a run, which consists of the graphical representations, and the values from the monitors that are being used for tracking purposes. The second is a more elaborate explanation, which involves the use of certain statistical tools (excel, spss, etc.) after the data obtained from the runs of the model are being extracted.

The model consists of different output graphs, which represent different aspects of the model. The plotted graphs are a way of seeing the effects of either the interactions between agents, or the impact of the changes that are being made by the user, or both. In this case, there are six main graphs, three graphs for the individual agents and three graphs for the problem agents:

1. *First individual-related graph: Overall Profile Capability*

This graph tracks down the capability of the profiles, depending on the Predisposition Scales and time. As time passes by (i.e. as ticks increase), the capability of the PPI(s) will change, and in the endpoint, the question of "what happened to the capability of which profile?" can be answered.

2. *Second individual-related graph: Individual Predisposition Capabilities*

This graph is a basic line graph that shows the capabilities of the individual predispositions. Since the number of agents for each predisposition is more than one, the sum of all capabilities for each predisposition is being plotted (i.e. Σ $\text{Capability}_{\text{Emp}}$ vs. time, Σ $\text{Capability}_{\text{Rat}}$ vs. time, etc.).

3. *Third individual-related graph: Individual Dimension Capabilities*

This graph shows the capabilities of each dimension, i.e. the Epistemological capability, the Ontological capability and the Teleological capability for the profile that is under exploration.

4. *First problem-related graph: Individual Problem Complexity*

This is a basic line graph that is similar to the Predisposition Capability graph described above. This time, however, the interest is in seeing how the complexities of individual problem agents change over time, while being solved or not solved by the individual agents. This is done by looking at the sum of difficulties for each problem agent (i.e. Σ $\text{Difficulty}_{\text{Info}}$ vs. time, Σ $\text{Difficulty}_{\text{Entity}}$ vs. time, etc).

5. *Second problem-related graph: Overall Problem Complexity-Histogram*

Together with the initial setup, this histogram is set as well. As explained in the previous sections, the overall problem complexity has three levels; therefore, the graph is made of three blocks. This graph, therefore, represents 1) what the initial starting complexity of the problem is, 2) what the final complexity level of the problem is, and 3) how it evolves over time.

6. *Third problem-related graph: Overall Problem Complexity*:

This graph shows the overall problem complexity, which is the summation of the difficulties for each individual problem variable. The individual difficulties will be tracked down as well, but it is important to look at the overall complexity of the problem, and how it changes with time.

Figure 23 below is a snapshot of the agent-based model that was constructed as discussed above.

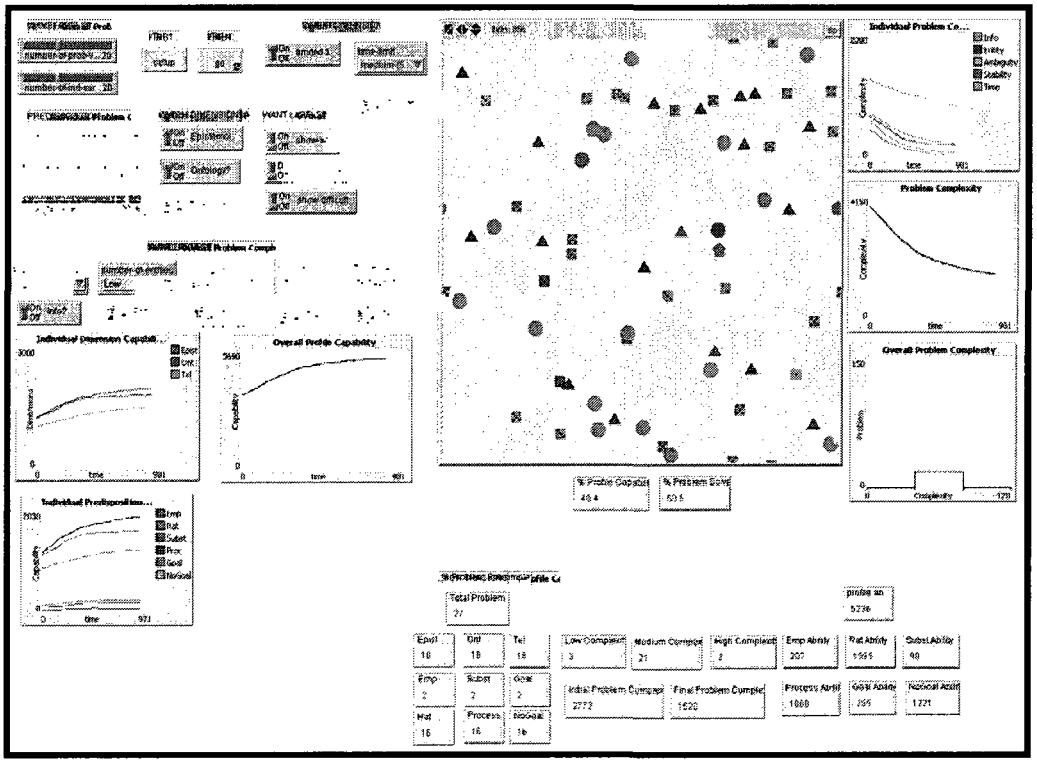

Figure 23. Snapshot of the PPI model

5.9 Experimental Setup

Before conducting any type of analysis, appropriate ways on how that data is going to be obtained should be considered. Design of Experiments (DoE), combined with sensitivity analysis is the type of analysis necessary when no real data is available on the system being modeled (Kleijnen, 1999). DoE is a common technique to structure the data so that

meaningful results can be obtained through an optimum number of experiments. It also serves the purpose of providing support to the structural approach of sensitivity analysis (Noordegraaf, Nielen and Kleijnen, 2003). The simulation that was programmed could be run infinitely, but unless there is a formalized way to look at the runs and collect the data, the outputs obtained will be useless.

An "experiment" within modeling and simulation is defined as executing the simulation model (Law and Kelton, 2000). Following Law and Kelton's definitions, the input parameters and the structural assumptions within the simulation model are called "factors," and the output measures are called "responses." Similarly, Kleijnen (1999) uses the term "factor" to indicate an input variable, a parameter or a module of a simulation model. According to Law and Kelton (2000), in simulation, an experiment is designed with the purpose of deciding which configurations are significant for the simulation set up before conducting too many runs which may eventually be unnecessary.

According to Rekab and Shaikh (2005), when the relationship between the response and the factors is not linear, a 2^k factorial design is not feasible. Since the factors in this experiment are the three philosophical dimensions, and the output responses are the problem complexity and the profile capability, it is fitting that a 3^k factorial design is used. The 3^k *factorial design* dictates that three levels are chosen for each input factor, and the simulation is run at each of the 3^k factor-level combinations. It is a general rule that a plus sign and a minus sign are used to determine the different levels. Law and Kelton (2000) state that there are no general techniques to select and specify the corresponding levels. Since there is no formal solution to this, they state that the way selection is made will depend on the intuitive feel of the modeler. However, they do present some rules of thumb for the choice, as such (Law and Kelton, 2000, p. 626):

- levels should be in some sense opposite of each other
- however, not so extreme as to become unrealistic
- levels should not be very far apart from each other to avoid masking important aspects of the response

According to the PPI model presented in previous sections, the philosophical dimensions will be considered as *factors* that will determine the output. The output will be twofold. The aggregate capability of the dimensions chosen (the capability gained or

lost by the profile), and the time, which will determine how long it took each profile to solve the complex problem. The levels for the factors are setup as follows:

- Factor A: Epistemological Scale
  - (-1) level: Empiricist predisposition
  - (0) level: Either Empiricist or Rationalist (no choice)
  - (+1) level: Rationalist predisposition
- Factor B: Ontological Scale
  - (-1) level: Substantive predisposition
  - (0) level: Either Substantive or Process (no choice)
  - (+1) level: Process predisposition
- Factor C: Teleological Scale
  - (-1) level: Goal predisposition
  - (0) level: Either Goal or NoGoal-oriented (no choice)
  - (+1) level: No-Goal predisposition

The layout for the factorial design is shown in Table 15 below:

Table 15. Layout for the 3^k Factorial Design

Factors (Dimensions)	Possible Level	Response 1 (Capability of Profile)	Response 2 (time)
Epistemology	(+), (0) or (-)	R_{11}	R_{21}
Ontology	(+), (0) or (-)	R_{12}	R_{22}
Teleology	(+), (0) or (-)	R_{13}	R_{23}

Therefore, for the six factors, the 3^k factorial design will result in 27 simulation runs. The entire design needs to be replicated as well for the following reasons:

- average value of the responses

- variability
- consistency

It is suggested by Law and Kelton (2000) that the whole design should be replicated *n* times, which would result in *n* independent values for each effect. Following this, these results could be used for an approximate 100 (1 – α) percent confidence interval using the t distribution with n – 1 degrees of freedom. The choice of the number of replications of the whole design *n* is, again, up to the researcher, and is a trade-off like many other choices. The higher the number of replications, the easier it becomes to understand whether an effect is real. However, the large number of n would mean more replications, which would correspond to more time. In this research, 10 replications are used for each simulation run, which is consistent with Flache and Hegselmann (2001) and Dal Forno and Merlone (2004). Table 16 below summarizes the discussion presented above.

Table 16. Summary of Experimental Setup

# of factors	3
# of responses	2
# of experiments	27
# of replications	10
Total # of experiments	270
Further statistical variables to be used	Sample mean of responses
	Estimate of variance
	% Confidence Interval

A three-level full factorial design matrix is shown below in Table 17. Each run was conducted according to this design.

Table 17. Full Factorial for Three Factors, Each at Three Levels

(From Rekab and Shaikh, 2005, p. 173)

	Factors				Factors				Factors		
Run	A	B	C	Run	A	B	C	Run	A	B	C
1	+	+	+	10	+	+	0	19	+	+	-
2	0	+	+	11	0	+	0	20	0	+	-
3	-	+	+	12	-	+	0	21	-	+	-
4	+	0	+	13	+	0	0	22	+	0	-
5	0	0	+	14	0	0	0	23	0	0	-
6	-	0	+	15	-	0	0	24	-	0	-
7	+	-	+	16	+	-	0	25	+	-	-
8	0	-	+	17	0	-	0	26	0	-	-
9	-	-	+	18	-	-	0	27	-	-	-

5.10 Summary of Research Method

This section is the continuation of Section Four, where the detailed research methodology that is followed in this study is discussed. Following the research methodology, the last level of the research hierarchy are the research method and steps, which are the central points of this section. The premises, rules and assumptions are made explicit, setting the grounds for the first step of Model Construction, which is described as the Concept phase. The model that is being referred to in this section is the agent-based model. The concept phase re-stated the verbal (or the conceptual) theory (or the combination of theories) that is put together by the premises.

Following this conceptual phase, the Concept to Computer (C2C) phase is addressed. The C2C process could be described as a pseudo code; in that, it is a combination of steps that should be followed which translate the verbal theory and the premises into a format such that they can be used as input data for a computer software program. The last phase that is described is the Computer phase. This includes the user-

model interaction, as well as the detailed explanation of how the agent-based model for this research is set up. These details included the type of agents, their behaviors, and their interactions. In order to initially determine the results of the computer simulation, two criteria are set. One is for how efficiently the individual profiles are, and the other on how much the initial problem is solved by those individuals with specific profiles. The last part of this section describes the different types of outputs and outcomes that are elaborated and analyzed in the following Results section.

6 DATA ANALYSIS AND RESULTS

Following the development of the simulation model, this section provides details on the types of analyses that are done, and the results that are obtained from these analyses. The section is divided into two main parts. The first part is an elaboration on the data analysis methods, and how they were applied and used for the purposes of this research, as well as a presentation of the results obtained from the analyses conducted. The second part discusses the sensitivity analysis and the validation of the agent-based model.

6.1 Results

After setting up the simulation according to the experimental runs, the following steps were conducted:

1. Run simulation with repetition
2. Export results in Excel & SPSS
3. Conduct graphical analysis
4. Conduct appropriate statistical analysis

The results of the simulation runs are presented and analyzed according to the specific profiles that were developed in the previous sections.

6.1.1 Initial Condition Setup

Before conducting the actual experiments to analyze how certain profiles dealt with complex and simple problems, certain variables, initial conditions and their effects had to be determined and adjusted. These variables were *number of agents, duration of run* and *predisposition scales*.

As described in the Agent-Based Model Construction section, two separate sliders controlled the number of agents used. One slider was set up to determine the number of agents representing the individual (meaning the different philosophical predispositions), and one slider was set up to determine the number of agents representing the problem (meaning the different characteristics of a complex problem). Before collecting the data to be analyzed to obtain the results of this research, different conditions were analyzed through these two sliders in a trial-and-error format. The simulation could have a high

number of individual agents, but a very low number of problem variables, and vice versa. With a higher number of agents representing the individual and not enough problem variables, it was determined that this setup did not provide an adequate representation of the complex problem. In other words, the capability of the profile would always be so much more than the complexity of the problem. This resulted in the simulation stopping after a very short amount of time, which was not sufficient to observe certain patterns emerging.

Similar reasoning was provided as to why the opposite setup was not found to be appropriate as well. When the number of agents representing individual and problem variables were kept equal, in other words, both sliders would show the same number, the results obtained were found to be inconsistent. The reason for this is the uneven nature of the individual and problem variables. The individual was represented through three variables, whereas the problem is represented by five different variables. This created the unevenness between the individual profile capabilities and problem complexities. Trying to adjust for this, it was determined that a slightly higher number on the slider determining the number of individuals, combined with a medium number of agents representing the problem would be the ideal combination, which meant that the profile would have enough capability to deal with the complexity of a problem. This is also in alignment with the premise that an individual would have appropriate capabilities to solve the complex problem; therefore the "capability" of the profile should be approximately equal to the "difficulty" of the problem, which is why the sliders were introduced. As seen in Figure 24, this also created much more consistent and therefore reliable results. However, it was also seen from tests conducted that even though this combination presented a more consistent pattern, the outcome (i.e. the percentages of problem solved and capability gained) were the same even when the number of agents were not matched to each other.

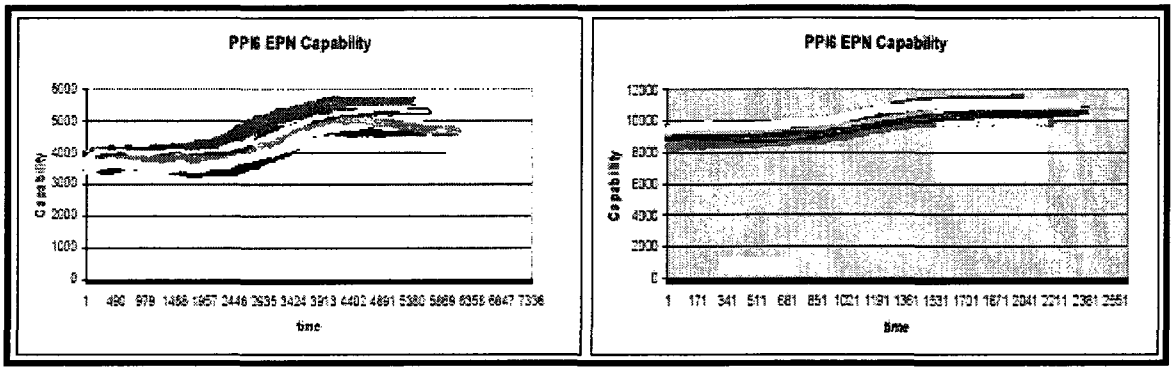

Figure 24. Effect of number of agents

The way the model was set up in NetLogo enables the user to determine whether the simulation will run until it is stopped by certain rules within the programming, or the user will be able to limit the duration to a certain time. For the simulation to keep on running, the program required that there should always be an agent representing an individual, as well as an agent representing a problem. If one of these agents is not present, i.e. the problem has been solved completely, or the capability of the individual has been used completely, the simulation stops and asks the user to initiate setup conditions and start again. The simulation could be stopped at a given time, before the need for this rule set to be implemented. All of the runs were stopped by the program when the problem was completely solved (whether simple or complex), or when one or more of the predispositions' capability reached zero.

Following Law and Kelton (2000), the extreme conditions for variables in the model are not used to conduct the actual analysis. For the purposes of this research, this meant that for each profile, each philosophical predisposition was represented through the *majority* of the agents. For instance, when looking at how PPI1 (ESG) dealt with complex problems, the epistemological dimension was represented 90% by Empiricist agents, and 10% by Rationalist agents. This ensured that the Empiricist variable was represented as the main predisposition, but not so much as an extreme case that it would seem illogical in the real world. The same logic was implemented for the Ontological and the Teleological scales.

6.1.2 Results for Each Profile

For the statistical analyses conducted, SPSS Statistics 17.0 was used. For the results of each of the profiles, the descriptive statistics were obtained, which describe the mean, standard deviation, the range and the variance of the results. The range and the variance were used as indicators for the consistency of the profiles. The mean and the standard deviation present the overall success rate of the profiles. All of these values provide a baseline to compare the profiles and draw conclusions on how each profile did individually, as well as how they compared to each other.

Aside from the descriptive statistics, the overall patterns of the capability of each profile is also shown and interpreted. For the graphs presented in the following section, there are three curves. The upper and the lower curves represent the upper and lower boundaries for the capability pattern of each profile. The middle curve represents the average value for the 10 replicate runs. The interpretations of the pattern, i.e. how the profile behaves through time, are made by observing the behavior of the average values of these 10 replications.

6.1.2.1 PPI 1: E-S-G

The first profile, PPI1 (ESG), showed a range of 22.22, and a variance of 51.88 throughout the 10 replication runs (Table 18). As seen from Figure 25, the capability of the profile initially decreases steeply, and then comes to a near steady state and decreases again slightly towards the end of the run, which is when the complex problem is solved completely.

The initial decrease indicates the lack of capability of the predispositions to deal with a highly complex problem. When starting to initially deal with a complex problem, the empiricist predisposition would indicate that the individual would want to look for available information, and the substantive predisposition would indicate that the individual would try to get a grasp of individual entities comprising the problem. However, due to the complexities, these predispositions could not be successful, which is where the sharp decrease happens. As the profile starts solving the problem, the problem becomes simpler. Even though this is the case, the predispositions may not always be

capable, which is why during the latter phases of the problem, the profile has not gained much capability.

The final capability loss of PPI1 was -32.7% and it took this profile a time of 6200 ticks in average to completely solve the complex problem. The high capability loss and the length of time indicate that this profile was not a good match to solve a complex problem. The high variance also indicates that this profile was not very robust in terms of solving the problem. This could indicate that every time an individual with a profile of PPI1 (ESG) attempts to solve a complex problem, there would be a different approach to a problem. However, this variety does not indicate any improvement on the solution. The profile still loses capability, and takes a long time to solve a complex problem.

Table 18. PPI1 Descriptive Statistics

Descriptive Statistics					
	N	**Range**	**Mean**	**Std. Deviation**	**Variance**
PPI1_ESG	10	26.33	-34.1452	8.14705	66.374

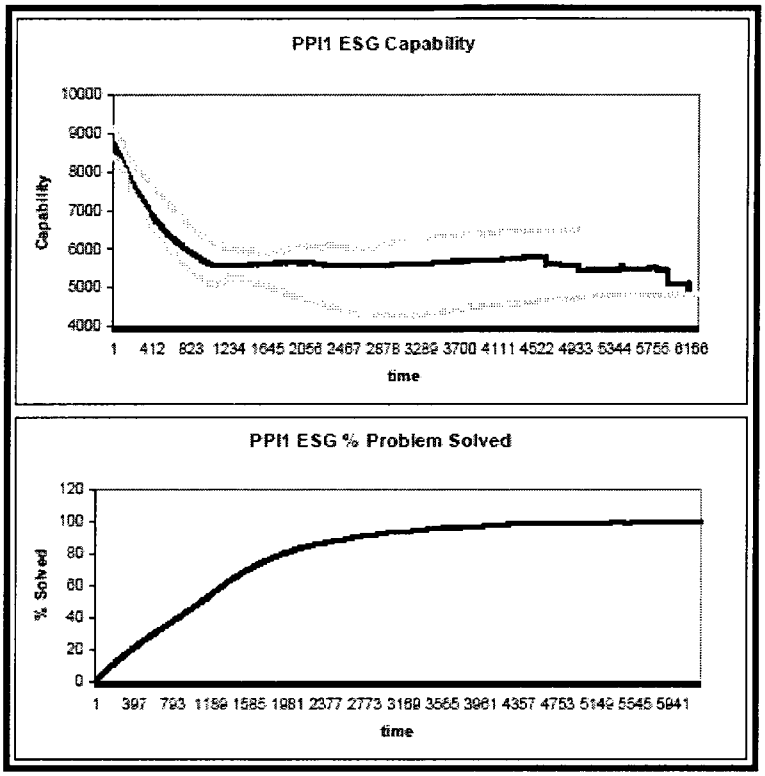

Figure 25. PPI1 patterns

6.1.2.2 PPI 2: E-P-G

The second profile, PPI2 (EPG), had a range of 34.72 and a variance of 108.21 during the multiple runs (Table 19), which is the highest within all profiles. This indicates that the performance of this profile is the least consistent. As seen from Figure 26, this profile dipped into a sharp decrease much quicker than the first profile, and following this decrease, instead of at a steady state. The capability started to increase slightly, which means that this profile did not lose as much capability during the initial phases of the problem-solving, when compared to PP1. The increase in the capability after the initial decrease shows that this profile is more capable of dealing with simple problems than the first profile.

The final capability loss of PPI2 was -6.15%, which shows an improvement over the first profile, PPI1, and this profile completely solved the complex problem in an average of 5300 ticks, which is quicker than the first profile. The change in the

ontological predisposition from substantive philosophy to process philosophy might have caused this improvement. It could be argued, however, that a process orientation would provide more capability to the individual during the solution of complex problems.

Table 19. PPI2 Descriptive Statistics

Descriptive Statistics					
	N	**Range**	**Mean**	**Std. Deviation**	**Variance**
PPI2_EPG	10	28.34	-9.8869	9.31218	86.717

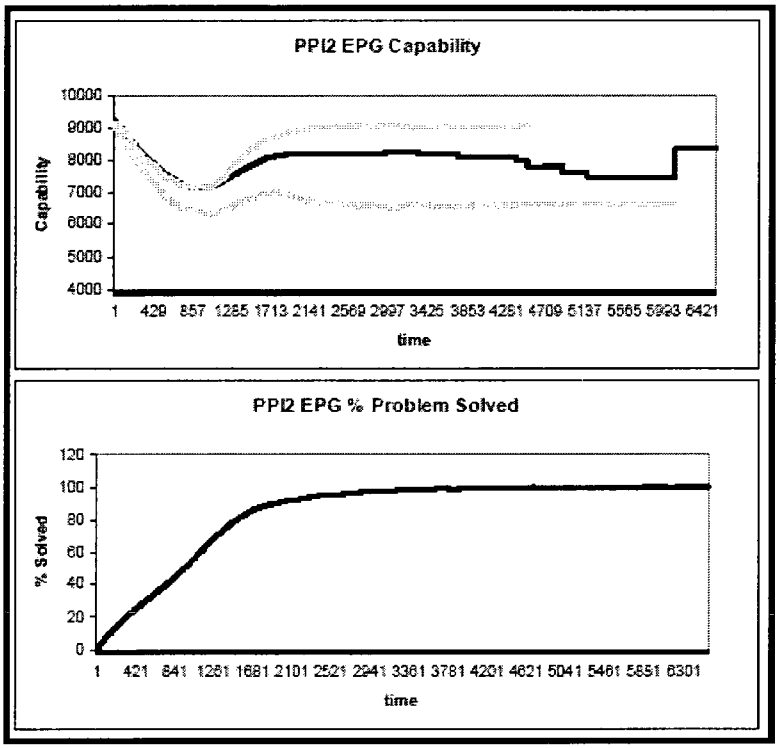

Figure 26. PPI2 patterns

6.1.2.3 PPI 3: R-S-G

The third profile, PPI3 (RSG) has the lowest statistics in terms of its range and variance (9.67 and 9.20, respectively) so far, which would indicate that it is the most consistent of the first three profiles in terms of multiple runs (Table 20). As for profile capability, PPI3 solved the complex problem completely within an average of 2900 ticks, and the profile gained around 15% capability. These improvements suggest better capabilities when approaching complex problems (Figure 27).

Different from the first two profiles, the epistemological predisposition of PPI3 is rationalist, which would provide an advantage when facing a complex problem. This is also reflected in the pattern obtained for the capabilities. During the initial stages of dealing with a complex problem, this profile did not lose much capability (unlike the first two profiles); and, for the rest of the simulation, as the complexity of the problem started decreasing, this profile showed better capabilities as well, which is shown by the increase in the curve. This indicates that this profile is also more capable dealing with simple problems, in addition to complex problems.

Table 20. PPI3 Descriptive Statistics

Descriptive Statistics					
	N	**Range**	**Mean**	**Std. Deviation**	**Variance**
PPI3_RSG	10	9.67	14.8588	3.03277	9.198

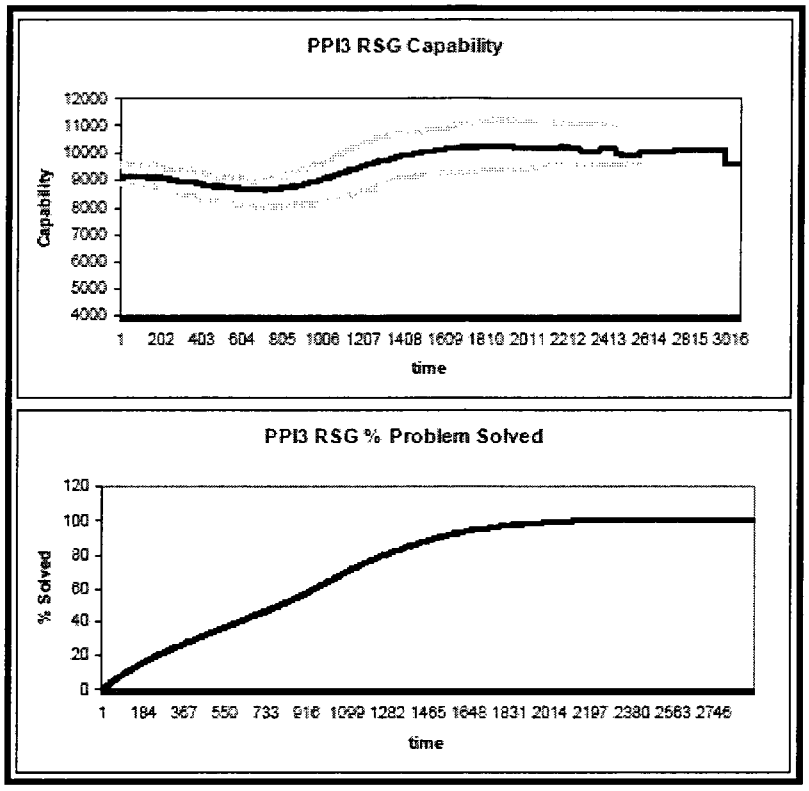

Figure 27. PPI3 patterns

6.1.2.4 PPI 4: R-P-G

The fourth profile, PPI4 (RPG) has a relatively high range and variance (20.63, 40.39) compared to PPI3 (Table 21). In terms of time for solving a complex problem, it would rank right after PPI1. The capability lost is lower than PPI1 and PPI2 (-2.5%), however, as seen from below figure, the capability of the profile decreases sharply after it increases, and the time for solving the complex problem is higher, with 5700 ticks in average (Figure 28).

The pattern obtained below is again unique for this profile. It can be seen that the profile initially gains some capability while first attempting to solve a complex problem. However, right after this increase in capability, as the problem complexity starts decreasing and shifting to a medium level, the profile loses some of its capabilities, but gains them back for a short amount of time. This is an interesting pattern. Unlike the first three profiles, the initial gain of capability indicates that PPI4 was most successful when

solving a highly complex problem. These results are interesting, since a rationalist predisposition increased the capability of PPI3, and a process orientation increased the capability of PPI2; however, when the two predispositions are present within one profile, they seem to work in an undesirable way. This may be an implication of the *emergence* that is a result of Agent-Based Modeling. This type of emerging behavior was one of the reasons why philosophical dimensions were represented as different agents in the model. This way, interesting results such as these can be obtained and conclusions can be drawn.

Table 21. PPI4 Descriptive Statistics

Descriptive Statistics					
	N	**Range**	**Mean**	**Std. Deviation**	**Variance**
PPI4_RPG	10	20.63	-2.5001	6.35522	40.389

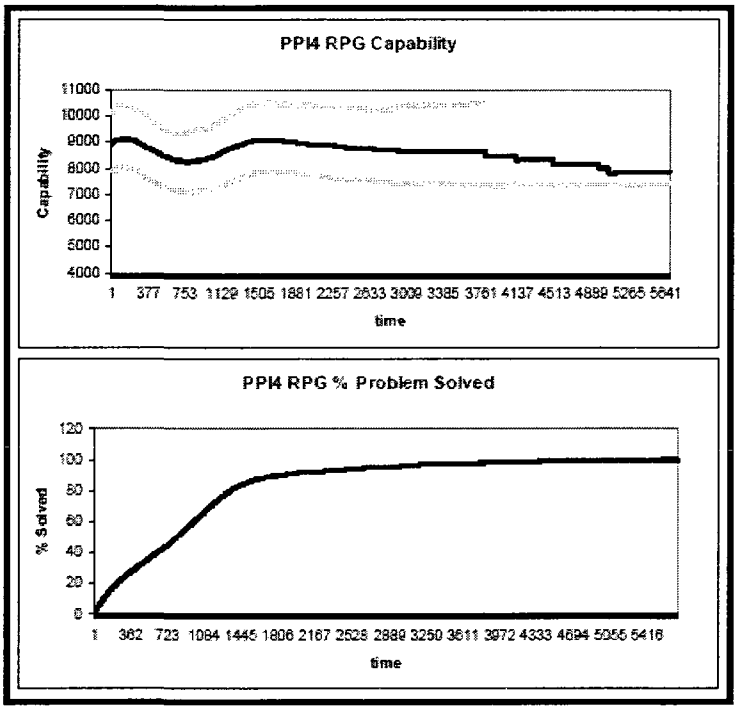

Figure 28. PPI4 patterns

6.1.2.5 PPI 5: E-S-N

The fifth profile, PPI5 (ESN) (Figure 29) is the first profile that has the teleological predisposition of not being goal-oriented. In terms of consistency and robustness, this profile is so far the most improved after PPI3, with a range of 17.58 and a variance of 28.27 (Table 22). The final capability lost by the profile is -12.3%, and the time it took this profile to solve the complex problem is an average of 5600 ticks (Figure 29).

The pattern obtained below is unique for PPI5. Similar to PPI2, there is an initial loss of capability, which indicates that this profile was not initially successful when attempting to solve a complex problem. This initial similarity for both profiles may be due to the fact that they share the same epistemological predisposition (empiricism). However, the decrease in PPI5 is not as sharp as PPI2. This may be an indication that this profile is the first profile so far to have a no-goal teleological predisposition. The increase after the profile starts solving the problem indicates that PPI5 is more capable of dealing with medium and simple problems than complex problems. The teleological predisposition may have provided better capabilities to the profile in terms of robustness and stability; however, the profile did not have any goal-orientation, but the complex problem had temporal constraints. This may be the reason why it took the profile a long time to solve the complex problem. One of the premises discussed previously was that when there are time limitations or deadlines attached to a problem, an individual with no goal orientation may not be a good fit for this situation. Not acknowledging these deadlines may cause a delay in the solution of the complex problem.

Table 22. PPI5 Descriptive Statistics

Descriptive Statistics					
	N	**Range**	**Mean**	**Std. Deviation**	**Variance**
PPI5_ESN	10	17.58	-12.3121	5.31652	28.265

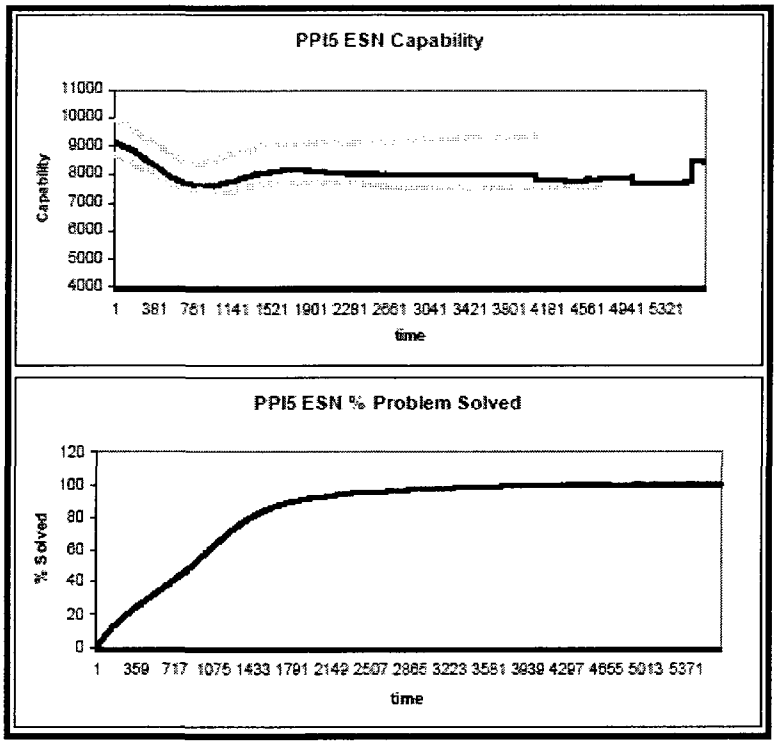

Figure 29. PPI5 patterns

6.1.2.6 PPI 6: E-P-N

The sixth profile, PPI6 (EPN) has the highest profile capability gained within the profiles analyzed so far (18%), as well as the lowest range and variance (4.09, 1.67) as seen in Table 23. These low values are also reflected in Figure 30. The average curve is very close to the maximum and minimum curves. This means that this profile is the most consistent and stable in terms of its capability and timing of solving complex problems. The time of reaching complete solution of the complex problem is also the lowest, with 2500 ticks of average per 10 runs.

From the pattern below, it can be observed that during the initial phases of the problem solution, the profile does not particularly lose or gain any capability, the line is fairly stable. However, over time, there is an increase in the capability. This can be attributed to the fact that initially the profile may be going through the available information, however low it may be, about the problem, which may take some time in the beginning. However, once that is done, the final solution of the problem follows fairly

quickly. The combination of the ontological predisposition being process-oriented and the teleological predisposition not being goal-oriented may have created better capabilities when dealing with complex problems. Another interesting point to note is that unlike the other four profiles, the capability of this profile did not decrease towards the end of the problem solution.

Table 23. PPI6 Descriptive Statistics

Descriptive Statistics					
	N	**Range**	**Mean**	**Std. Deviation**	**Variance**
PPI6_EPN	10	4.09	18.3876	1.29117	1.667

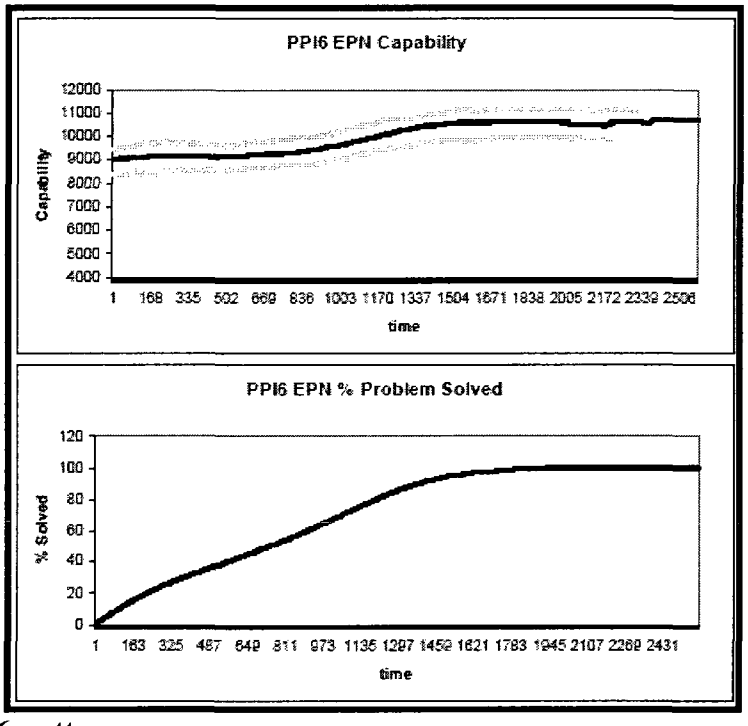

Figure 30. PPI6 patterns

6.1.2.7 PPI 7: R-S-N

The seventh profile, PPI7 (RSN) has a range of 10.14 and a variance of 11.79 (Table 24). The final capability gained is higher than the previous profiles (26.1%), and the time is also shorter (Figure 31). As seen from the figure, when starting to solve a complex problem, this profile does not lose much capability, similar to PPI6.

The improvement compared to PPI6 may be attributed to the fact that the epistemological predisposition of PPI7 is rationalist, and the ontological predisposition is substantive. The pattern obtained below is similar to PPI6; however, it can be seen that instead of a steady start, PPI7 initially has an increased capability, then a stable period, then another increase. Previously, it was observed that a process-orientation, compared to a substantive orientation, provided better capabilities to a profile. However, in the case of PPI7, when combined with a rationalist predisposition, the substantive orientation seems to work better when dealing with complex problems.

Table 24. PPI7 Descriptive Statistics

Descriptive Statistics					
	N	**Range**	**Mean**	**Std. Deviation**	**Variance**
PPI7_RSN	10	10.14	26.0805	3.43388	11.792

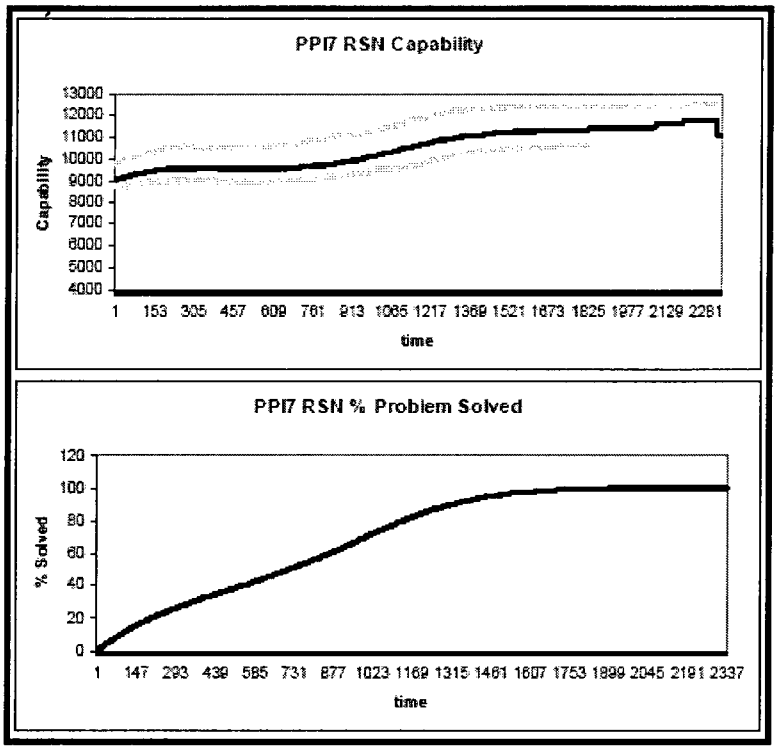

Figure 31. PPI7 patterns

6.1.2.8 PPI 8: R-P-N

The eighth and last profile, PPI8 (RPN) has solved the complex problem completely in the least amount of time (2200 ticks) when compared to all the other profiles. The capability gained (22.6%) is also high, similar to PPI7. However, the difference in time suggests that PPI8 reaches this point quicker than PPI7 (Figure 32).

The pattern for PPI8 is also similar to the pattern obtained for PPI7. However, the initial increase in capability for PPI8 is much more apparent. It could be argued that the change in the ontological predisposition (process, as opposed to substantive) proved to be advantageous when facing complex problems with time constraints. In terms of range and variance, PPI8 is also consistent and robust (10.59 and 8.76, respectively, Table 25).

Table 25. PPI8 Descriptive Statistics

Descriptive Statistics					
	N	**Range**	**Mean**	**Std. Deviation**	**Variance**
PPI8_RPN	10	10.59	22.5618	2.95908	8.756

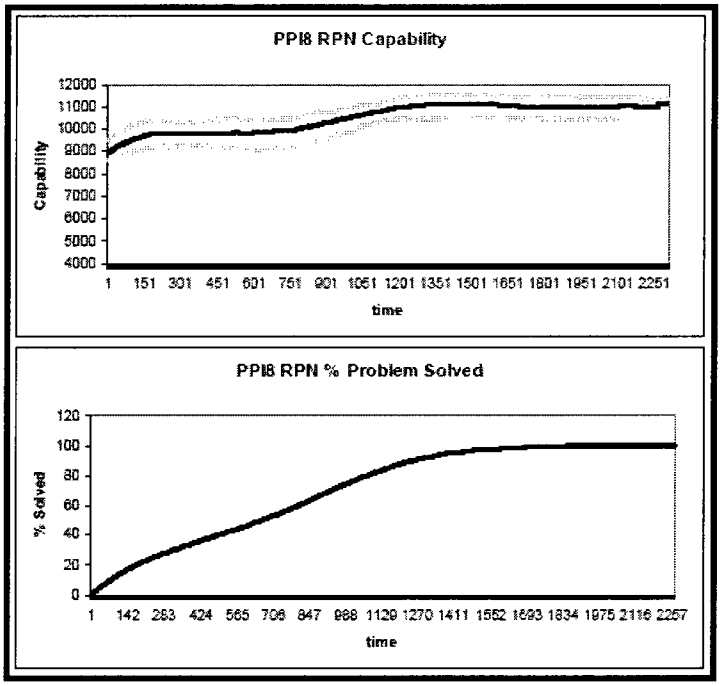

Figure 32. PPI8 patterns

6.1.3 Results for Overall Comparison

Having conducted the individual analyses and discussed possible interpretations, the focus now shifts to analyzing how the profiles did with respect to each other. In order to compare all eight profiles with each other, two batches of analyses were conducted. The first analysis was conducted on the problem solved, and the time it took the profiles to solve the complex problem. The second analysis was on the capabilities of the profiles. The way the results are organized is as follows. First, visual representations of the results are presented in terms of bar charts, which gives an initial idea on how each of the profiles did when compared to each other. Following this, ANOVA tables were obtained

for all of the profiles together. However, in order to further establish how different each profile is from each other, post hoc analyses were conducted, which provided the opportunity to obtain more detailed results. The first sub-section is related to the problem solved, and the second sub-section is related to the capability gained.

6.1.3.1 Results for Problem Solved

The bar chart below was obtained from the individual results of the simulation runs. Figure 33 is a representation of the time it took for each profile to reach 80%, 90% and 100 % solution for the complex problem. Within the model, the complex problem is solved completely by each of the profiles. However, the time it takes for the profiles to do this is different, depending on the profiles' predispositions.

According to results shown below, PPI8 (RPN) solved a complex problem completely in the least amount of time. This is followed by PPI7 (RSN). In both these cases, the ontological predisposition was Rationalist, and the Teleological predisposition was NoGoal orientation. When dealing with a complex problem, the results show that these particular predispositions provide useful capabilities to the individual. On the other hand, the profiles that needed the longest time were PPI1 (ESG) and PPI4 (RPG). The goal-orientation of the profile works as a disadvantage in the case of these two profiles.

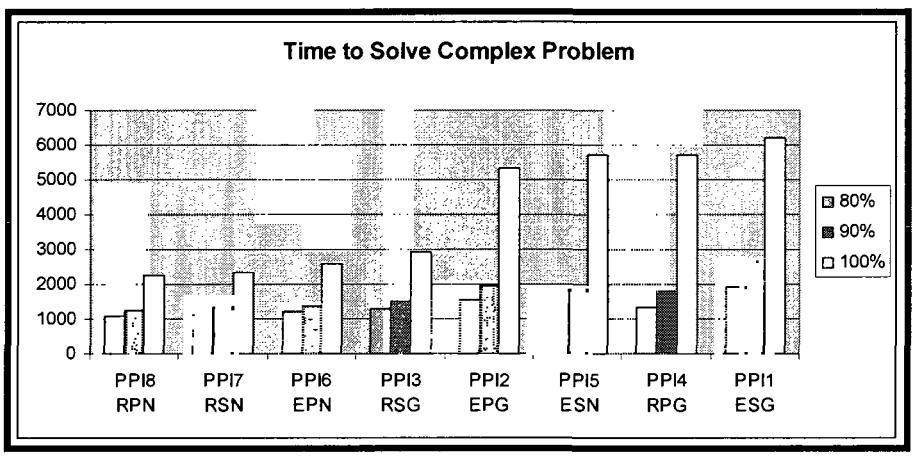

Figure 33. Comparison of profiles for complex problem solution

Some interesting conclusions can be drawn from this figure:

- It could be observed that the profiles were clustered into 2 groups; the first group consisting of PPI8, PPI7, PPI6 and PPI3; and the second group being PPI2, PPI5, PPI4 and PPI1.
- With the exception of PPI3 and PPI5, the two groups are divided according to their teleological dimension, with the profiles having no goal orientation on the left hand side, indicating quicker problem solution, and the goal oriented profiles taking a longer time to solve a problem.
- Even though PPI5 (ESN) shares the same ontological and teleological predispositions with profile PPI7 (RSN), the epistemological predisposition is the dominant one in this case.

In order to conduct a deeper analysis of this, the following ANOVA table has been obtained for the eight profiles (Table 26).

Table 26. ANOVA for All Profiles Solving Problems

ANOVA					
ProblemSolved					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	965335.396	7	137905.057	180.157	.000
Within Groups	2.636E7	34440	765.473		
Total	2.733E7	34447			

As seen from above table, the eight groups are different from each other ($p < 0.05$). However, in order to address the differences between the profiles more accurately in terms of *time*, further analysis have been conducted for the profiles considering the similarities according to the previous bar chart.

The traditional post hoc analysis methods such as Tukey's could not be used in this case, because the samples did not pass the homogeneity of variances test (Table 32, Appendix B). As a result of this, Games-Howell post hoc analysis was conducted. The

results obtained (Table 33. in Appendix B) showed that, similar to the bar chart above, PPI2, PPI4 and PPI5 were not significantly different from each other and therefore formed one cluster. The same results were seen for PPI6, PPI7 and PPI8, which were also not significantly different from each other. However, PPI1 and PPI3 were significantly different from all of the other profiles, and from each other. These results represent the similarities and differences between the eight profiles in terms of the time it took them to solve the complex problem. The following conclusions can be drawn from these results:

- When the epistemological predisposition is rationalist, and there is no goal orientation, then the ontological predisposition does not have a significant effect on the overall behavior of the profile, hence the lack of difference between PPI7 and PPI8. This may be due to the fact that since the rationalist predisposition will use skills such as reasoning, deduction and logic to gain information and acquire knowledge about a complex problem, how that problem is defined (whether as individual entities, or as a sequence) does not become relevant. If the epistemological predisposition was empiricist, this would have been different, as in the case of PPI5 (ESN) and PPI6 (EPN). These two profiles are different from each other, meaning that the ontological predisposition in this case has a significant effect, since the empiricist individual will need to collect hard data and facts to understand a problem. The definition of that problem becomes relevant in this type of situation.
- It can be seen that PPI3 and PPI2 are significantly different from each other as well. Even though they are different in terms of both their epistemological and ontological predispositions, one of the main premises was that the empiricist predisposition was shown to have much less capability when dealing with complex problems, hence the big increase in time.

6.1.3.2 Results for Profile Capability

This section presents the results obtained for the capabilities of each profile. As seen from Figure 34, some profiles gained capability, and some profiles lost capability. This is aligned with the proposition that certain predispositions would provide better capabilities to the individual than another.

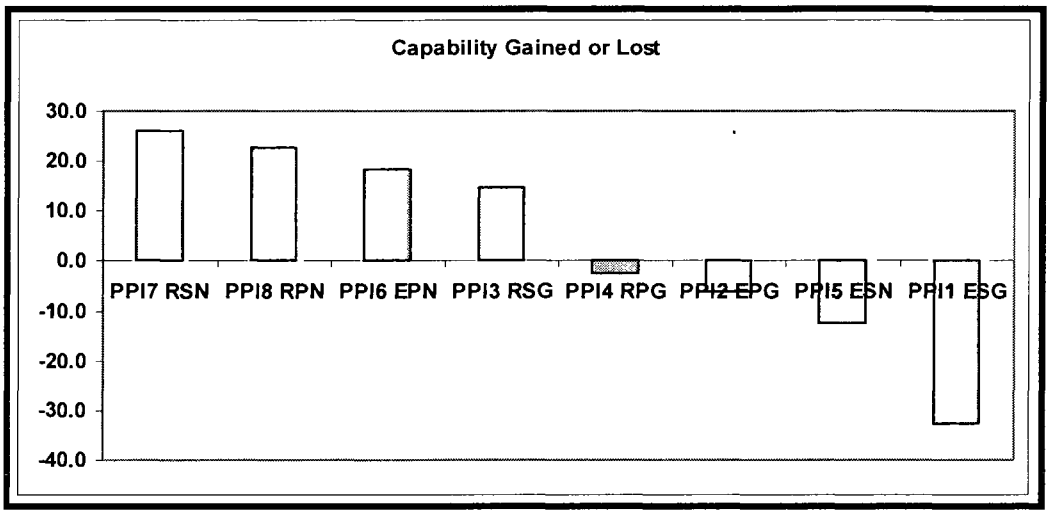

Figure 34. Comparison of profiles for capability gained/lost

Here are some initial conclusions that can be drawn from the above figure:

- Similar to previous results, PPI7 was the most successful in terms of gaining capabilities, followed by PPI8.
- PPI1 and PPI5, on the other hand, were the least successful of the eight profiles. These two profiles on the lower end of the graph contain the same epistemological and ontological predisposition, namely Empiricism and Substantive-orientation. Therefore, despite the change in the teleological predisposition, the epistemological and ontological predispositions were too dominant in terms of their disadvantages.
- Even though PPI7, which gained most capability, also has a substance-oriented ontological predisposition, the combination of the Rationalist and NoGoal orientations seem to provide better capabilities to the profile, as opposed to PPI5, which shares the same ontological and teleological predisposition.

Similar to the results for problems solved, an ANOVA was conducted to look at all of the eight profiles in terms of their capabilities. The following table is obtained (Table 27). The results show that all profiles are significantly different from each other.

Table 27. ANOVA for All Profile Capabilities

ANOVA					
Capability					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	7.709E10	7	1.101E10	41028.58	.000
Within Groups	9.256E9	34487	268403.859		
Total	8.634E10	34494			

However, in order to look at further detailed interpretations, a post hoc analysis was also conducted. The capability variables also did not pass the *homogeneity of variance* test (Table 34., Appendix B), therefore similar to the previous section, Games-Howell post hoc analysis was conducted (Table 35., Appendix B). The results show that only PPI7 and PPI8 are not significantly different from each other. The following conclusions can be drawn from this:

- Similar to the problem solved, the ontological dimension did not have any effect on the capability gained by the profiles PPI7 and PPI8.
- In terms of capabilities gained or lost, unlike the problem solved, the profiles behaved differently from each other (with the exception of PPI7 and PPI8). This means that all three philosophical dimensions had something different to contribute to the behavior of the overall profile.

6.1.3.3 Other Results

Further results were obtained by analyzing the multiple runs conducted for each profile. Some profiles proved to be much more consistent than others within the 10 replicate runs, as discussed previously for each profile. Table 28 is constructed to present an overall look on the consistency of the profiles.

For example, PPI6 had a variance of 1.7 and a range of 4.1 for capability gained, but PPI2 had a variance of 108.2 and a range of 37.7, which indicated that the results obtained during the 10 runs for PPI6 were much more similar to each other than the results obtained for PPI2. The stability and consistency of the profiles are important

elements as well, in addition to the percent capability gained and the time it takes each profile to solve a complex problem. Even though PPI6 is third among the profiles in terms of capability gained, the results from Table 28 show that this profile was the most consistent within the replication runs.

Table 28. Overall Statistics for Eight Profiles

	N	Range	Std. Deviation	Variance
PPI1_ESG	10	26.33	8.14705	66.374
PPI2_EPG	10	28.34	9.31218	86.717
PPI3_RSG	10	9.67	3.03277	9.198
PPI4_RPG	10	20.63	6.35522	40.389
PPI5_ESN	10	17.58	5.31652	28.265
PPI6_EPN	10	4.09	1.29117	1.667
PPI7_RSN	10	10.14	3.43388	11.792
PPI8_RPN	10	10.59	2.95908	8.756
Valid N (listwise)	10			

Another interesting aspect of the simulation was to see how the profiles did when dealing with simple problems. When dealing with complex and simple problems, the capability gained by the profiles presented different patterns according to the different levels of complexities of the problem. The capability pattern obtained by the eight profiles when dealing with simple problems is seen in Figure 35. When dealing with such problems, the capability of the profile increases in the beginning, but then starts to become steadier. It could be argued that initially, when faced with a complex problem, the profile (any of the profiles) would start trying to identify what the problem is, and try to find different ways to solve the problem, once it was more familiar with the problem. However, when dealing with simpler problems, the individual would already be more comfortable with the problem, and since there are no time constraints in a simple problem, would start going through the problem in a less rigorous manner.

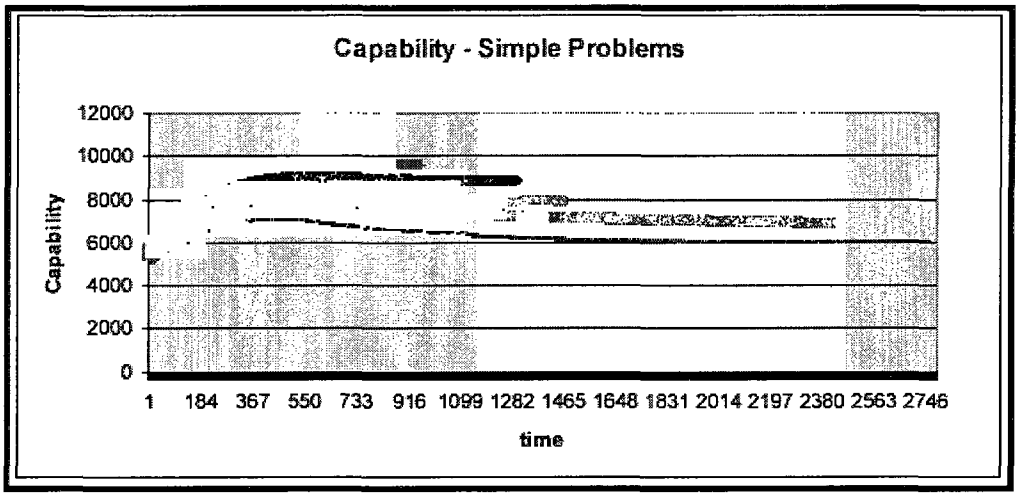

Figure 35. Profile capability for simple problems

Figure 36 shows the capabilities gained by each profile, as well as the time it takes each of the profiles to solve a simple problem. PPI8 gained the least amount of capability (19.6%), and it took this profile the longest to solve a simple problem (t = 2743). On the other hand, PPI2 was the most successful of all the profiles, with a capability gain of 75.8%, and a time of 777 ticks, which is the shortest. The characteristics of a simple problem were a good match to the capabilities of this profile.

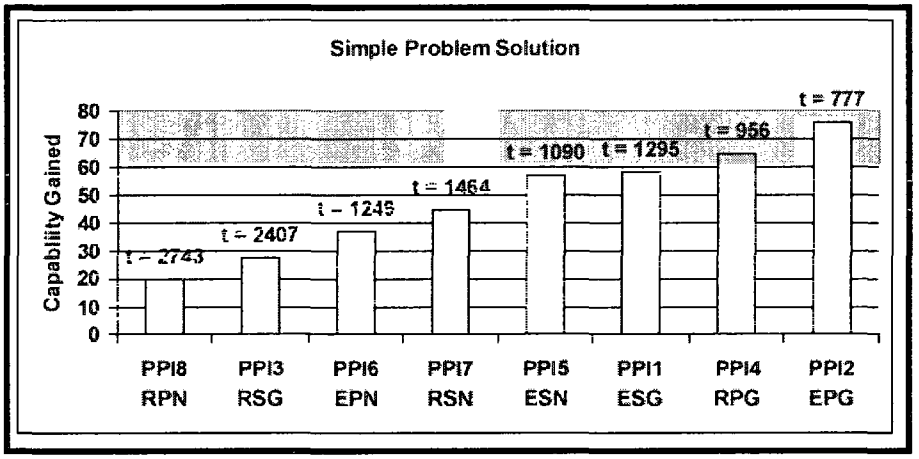

Figure 36. Simple problem and time

6.2 Sensitivity Analysis

Even though sensitivity analysis is part of the canons of research section, it is included here as well, since various analyses had to be conducted to ensure sensitivity, and it was appropriate that they are reported together with other results. Sensitivity analysis is an important step within the verification paradigm of modeling and simulation, and is conducted in order to see how sensitive the model is to changes in parameters and initial conditions, i.e. how the change in the input parameters affect the output measures (Law and Kelton, 2000). Marino, Hogue, Ray and Kirschner (2008) define sensitivity analysis as a method that can be used to quantify uncertainty in a complex model, regardless of the type. According to Kleijnen (1999), changing one factor at a time and analyzing the differences in the output measures is not sufficient, since it does not take into consideration the interaction between variables, i.e. what would happen if two or more factors were to change simultaneously. As a solution to this problem, he suggests that the sensitivity analysis be guided by DoE, which was discussed previously. Kleijnen also suggests the use of sensitivity analysis as support for validation if there is lack of data on the real system.

Marino et al. (2008) have noted that stochastic Agent-Based Models, in which decision-making rules are based on random chance, create challenges to most sensitivity analysis techniques, which are designed for deterministic models. They differentiate between *epistemic uncertainty* and *aleatoric uncertainty* during the modeling and simulation phase, where epistemic uncertainty denotes the fact that variability in a model outcome is due to experimentally introduced variation in input parameter, and aleatoric uncertainty occurs due to the "inherent stochastic components of the model" (p. 191). The main focus of sensitivity analysis is to gain insight on both of these types of uncertainties.

As discussed previously, extreme conditions were avoided when conducting the actual simulation, since the intention was to accurately model an individual, and how he/she deals with complex and simple problems. Kleijnen (1999, p. 648) defines sensitivity analysis as "the systematic investigation of the reaction of the simulation responses to *extreme* values of the model's input or to *drastic* changes in the model's structure" (italics original). Sensitivity analysis was considered to be a part of the

"parameter sweeping" validation technique by Macal and North (2007). Therefore, as suggested by Kleijnen (1999), extreme cases are now analyzed to understand the sensitivity conditions of the simulation model.

The extreme case initial conditions and input and output values were setup and analyzed only for the eight profiles. For the Epistemological, Ontological and Teleological scales of predispositions, the initial conditions were set to cover only the profile's specific predisposition. This means that when the simulation for PPI1 was conducted, 100% of the Epistemological agents were Empiricist, as opposed to 90%, as previously analyzed. Similar conditions were setup for the other dimensions as well. Figure 37 below presents the results for the hypothetical extreme cases. Three of the profiles (PPI2, PPI4 and PPI5) could only solve 80% of the problem and lost capability, and PPI1 could only solve about 50% of the complex problem (this was not shown in the figure since it was the only profile to solve only half of the problem). The remaining profiles (PPI3, PPI6, PPI7 and PPI8) solved 100% of the complex problem, and apart from PPI3, they all gained capability.

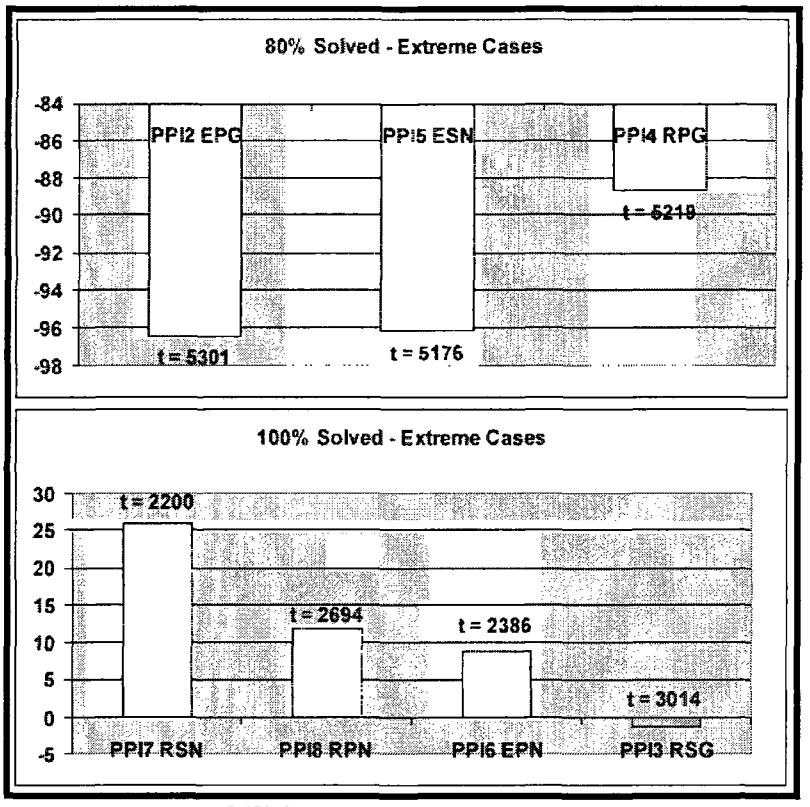

Figure 37. Extreme case capabilities

The majority of the results for the extreme case scenarios were found to be more consistent than the original runs, only PPI3 and PPI8 were found to be less consistent in a hypothetical scenario (Table 29).

Table 29. Extreme Case Profiles

	N	Range	Std. Deviation	Variance
PPI1_ESG	10	4.20	1.54058	2.373
PPI2_EPG	10	17.01	5.14208	26.441
PPI3_RSG	10	13.87	3.81558	14.559
PPI4_RPG	10	8.89	2.59304	6.724
PPI5_ESN	10	9.05	3.07421	9.451
PPI6_EPN	10	8.74	2.65134	7.030
PPI7_RSN	10	6.97	2.53751	6.439
PPI8_RPN	10	13.98	4.81452	23.180

In order to provide further support to the verification process through sensitivity, some of the premises were isolated and used as baselines to verify the model, as well as to provide evidence for the model's external validity. One of the extreme cases that could be readily observed was how an Empiricist and a Rationalist individual would perform with low or high available information. Therefore, the "Epistemology" dimension and the "available information" attribute of the problem were taken as samples, and the behaviors of both the Empiricist and the Rationalist predispositions were explored within high and low levels of information available (Figure 38 below).

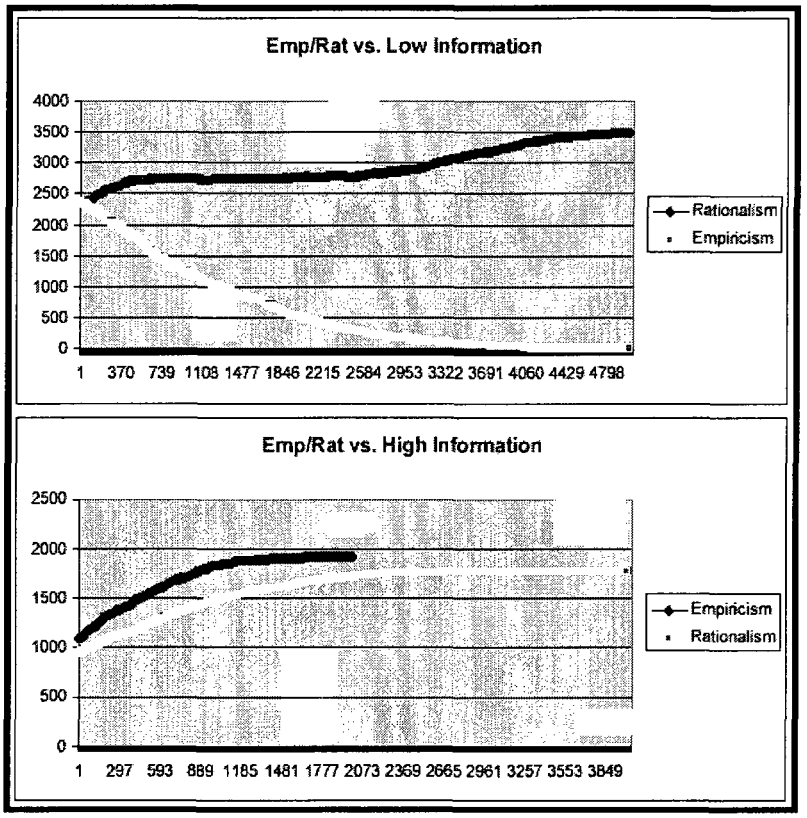

Figure 38. Emp/Rat vs. Low/High Information

The first graph above represents the behavior of the Epistemology dimension when the amount of available information is very low. The light colored curve, Empiricism, loses capability until it reaches zero, and the complexity of the problem remains at an unchanged zero (not shown in graph). However, the Rationalist predisposition has increased capability (about 45%) and can solve the complex problem. When there is much available information, the Empiricist predisposition solves the problem fully in about 2000 ticks, with a capability gain around 77%. The Rationalist predisposition solves the problem as well, however as seen from the above figure, it takes more time, and the capability gain is not as steep. Even though there may be hard data and facts available about the problem, a rationalist individual will tend to use reason and logic to deduce conclusions about the problem. There have been various studies (e.g. Kahneman and Frederick, 2002; Kahneman, 2003; Stanovich and West, 2002) which show that even though certain information about a problem or a situation is available, certain individuals will tend to ignore it, and come to a decision through intuition and

reasoning. Campbell (1968) argued that selecting the data relevant to the problem, among many other amounts and types of information that is not required is an issue when dealing with problems.

Similar analysis was done using the Teleological dimension and the Temporal Constraint variable of the complex problem and the curves listed below were obtained (Figure 39).

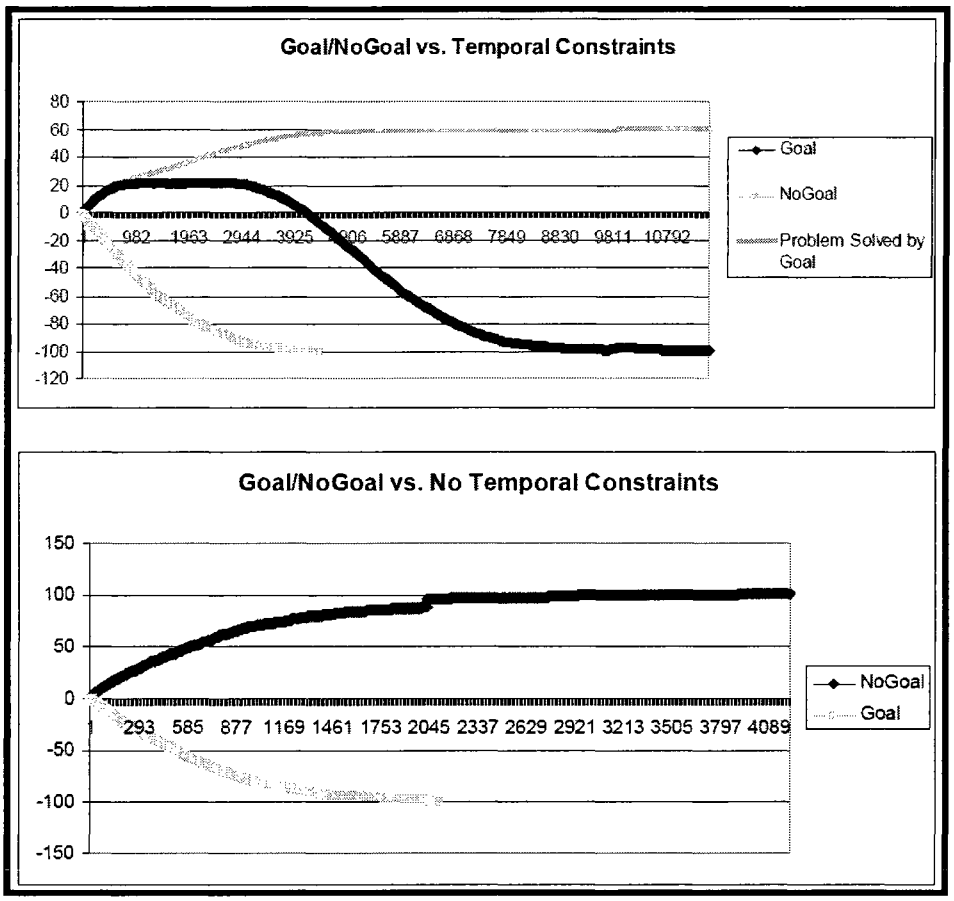

Figure 39. Goal/NoGoal vs. Temporal Variables

From the first graph, it can be seen that a goal-oriented individual has better capabilities when solving a problem that has temporal constraints. However, in time, when the problem gets simpler, this individual loses capabilities. As previously discussed within the premises, it has been shown that when an individual has control over the time

spent on a task (i.e. purposeful action), but there are no temporal constraints from the task itself, having hard goals delay the effort of solving that task (La Porte and Nath, 1976). This is represented by the sharp decrease in capability of the Goal curve in the first graph. The thin line that reaches a steady state at 60% represents the amount of problems solved by the individual who has a goal orientation. On the other hand, the individual without a goal orientation could not solve any of the problems, therefore, the percent of problem solved was 0% (not shown in graph).

The second graph represents the teleological predispositions with a problem that does not have any temporal constraints, meaning that the solution of the problem is not attached to a deadline. As seen from the two curves, the individual without a goal orientation was more successful when solving this type of problem. The problem was solved 100%, while the goal oriented individual was not capable of solving the problem. This is again in line with the discussion above, when an individual sets hard goals for himself/herself, this may work as a disadvantage when the problem or the task at hand does not have any time constraints.

The experimental setup described previously, and the results of extreme values for initial conditions, as well as other variables such as the duration of a single simulation run and the number of agents used, have been explained. Since empirically driven data was not available, certain values (such as complexity and capability) assigned to agents were chosen arbitrarily, albeit with strong justification, as described in Section 5, during the Agent-Based Model Construction phase. These values were scaled to one another in a purposeful manner.

The replications are also validated through a sample run of 20 replications on PPI8 (this was chosen because it was the most successful profile). The resulting pattern for 20 replications is similar to the one with 10 replications, as seen below in Figure 40. Had this pattern been different, or the results inconsistent, as part of the verification (or internal validity) process, some steps had to be traced back, and more experiments had to be conducted with more replications. Since this is not the case, 10 replications are proved to be appropriate for this research, which was the argument presented in the Experimental Setup section.

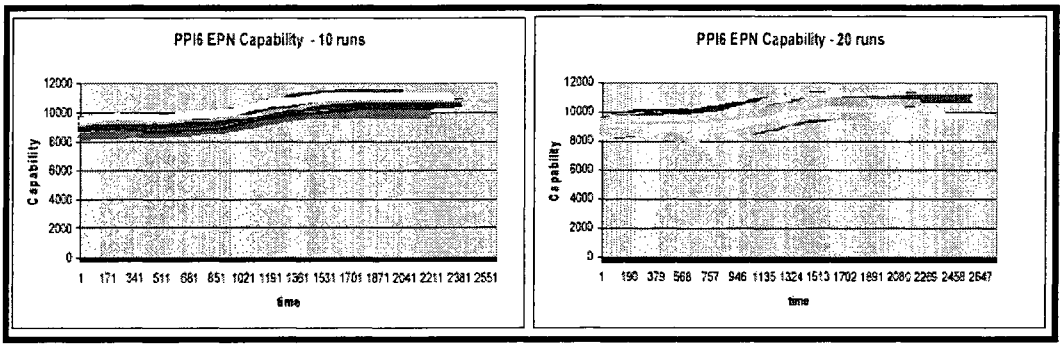

Figure 40. Comparison between 10 and 20 replications

One of the main purposes of conducting a Design of Experiments was that it provided support for the sensitivity analysis, as well as the validation of the simulation model when no real data existed. SPSS was used to analyze the data obtained through the runs conducted. The ANOVA tables with a 95% confidence interval for both of the outputs (profile capability and time gained) are shown in Appendix B (Table 30 and Table 31). Metamodels for both outputs are formulated using the regression model tables (Table 36 and Table 37, Appendix B), and the predicted results are cross-validated with the simulated results, similar to Noordegraaf, Nielen and Kleijnen (2003). The metamodels for *capability* had a higher adjusted R^2 (0.877, $p < 0.05$) than the one for *time* (0.756, $p < 0.05$). Both cases show that the regression model obtained is significant for both time and capability outputs.

One interesting result to note is that within the results obtained for the *time* variable, it can be seen from the regression table in Appendix B that the Ontology factor does not show to be significant. The results obtained for *capability*, however, show that all three dimensions are significant to the outcome, which the capability gained by the profile. This means that a change in the Ontological predisposition, i.e. a Substantive or Process orientation does not affect the time it takes an individual to solve a complex problem; though it does have an effect on the overall final capability of that individual.

The scatter plots were obtained for predicted vs. simulated results (Figure 41), by using ten different values for each of the dimensions. Following this, the correlation coefficient between the two results was calculated in order to see how close the two results were to each other. The coefficient was 0.957 ($p < 0.01$) for the *capability* results,

and was 0.923 ($p < 0.01$) for the *time* results (Table 38 and Table 39, respectively, Appendix B). Both of these results indicate that the metamodel prediction was sufficiently accurate, indicating that the model is valid for the purposes of this research.

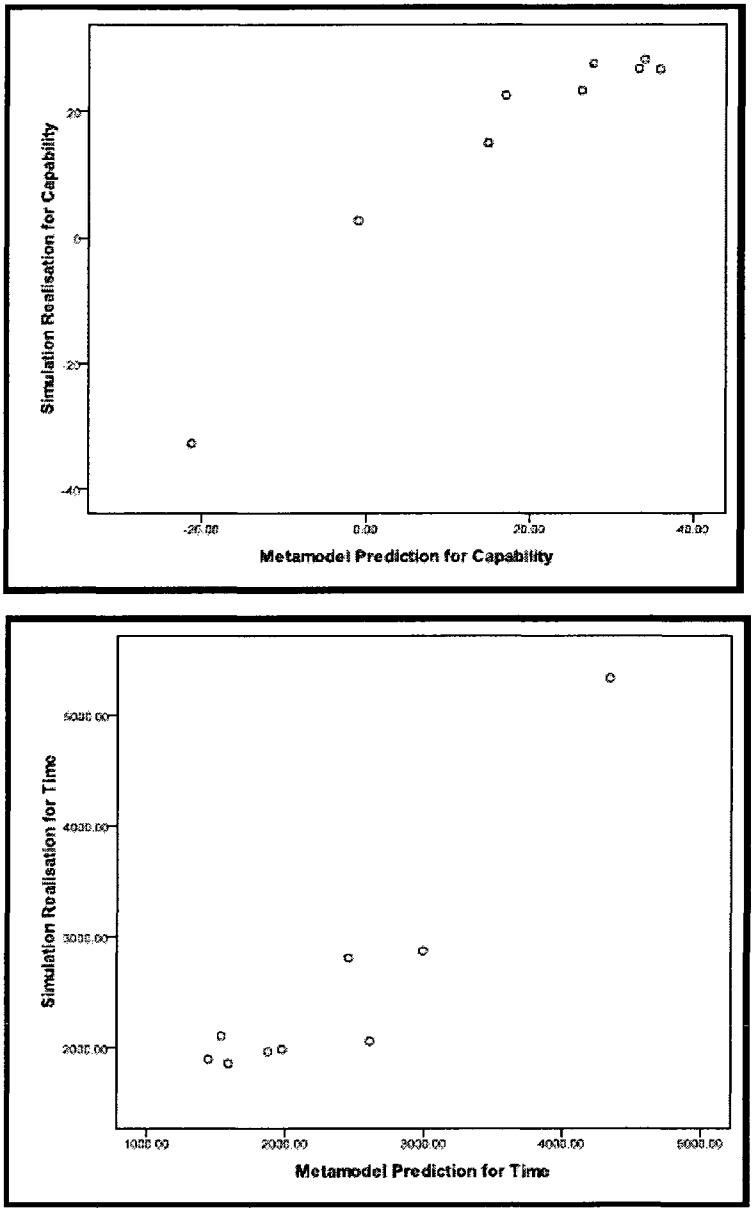

Figure 41. Simulated vs. predicted outputs

6.3 Summary of Analysis and Results

Following the Research Method, Section 6 is divided into two main parts. The first part discusses the results for each profile, in addition to presenting the results for overall comparison purposes, and the second part discusses on the sensitivity analysis conducted in this research.

In the end of the previous section, how the simulation was run, i.e. the experimental setup is discussed. Then, the necessary simulation experiments were run, and data was collected. The results were presented starting with the initial condition setup, which described the overall initial conditions in which all of the runs were conducted. The results for each profile were presented, and implications were discussed. Having gone through all of the eight profiles, the simulation runs, where no specific predisposition was identified, were discussed. This was followed by the overall comparison of profiles, in terms of their capabilities, as well as how they dealt with complex and simple problems.

The second part of this section presents an overview on the sensitivity analysis that was conducted. This was established through the use of extreme conditions during the initial setup. Since the overall results were not run using these conditions, the sensitivity analysis provided an opportunity for the author to gain some insight on how the profiles would present themselves within these extreme conditions.

7 DISCUSSION

7.1 Research Implications

Regardless of an individual's profession, whether an engineer, a manager or an artist, the philosophical tendencies of the individual carry much weight on how reality is perceived and knowledge is sought. Profiling an individual becomes crucial in the sense that it provides a deeper understanding of the alignment between the individual and the environment, as well as the individual and the situation. If one is aware of his/her predispositions and worldviews, this would lead to more successful engineers, more successful managers and leaders. The skill set that belongs to any profession depends on various factors related to the individual, such as where and how the individual was educated, the experience level of the individual, the environment in which the individual operates, the people with who the individual works and the individual's internal characteristics. The philosophical dimensions describe these internal and inherent characteristics.

The differences within, as well as between, individuals become more apparent when two individuals with different perceptions of the same problem need to work together to solve that problem. One individual tends to "dig right in" and tries to come up with solutions; while the other individual approaches the problem more slowly, and analyzes different components of the problem. The more complex the situation becomes, the bigger the gap between the two predispositions are. In these cases, the level of uncertainty may be high, as well as the irreducibility of the situation. When faced with such problems, a substantive approach posseses certain weaknesses compared to the process approach. This is exactly why being aware of one's profile becomes important. Even though an individual may be predisposed to use a certain approach, being aware that different approaches may exist proves to be one of the objectives of developing explicit philosophical worldviews.

One of the interesting results obtained was that moderate profiles could solve the entire complex problem; whereas profiles within extreme conditions could not. The expected outcome would actually be the opposite. This indicates that having a strong

predisposition is not the ideal way when approaching complex problems, and there should always be a component from the other perspective. The probability that an individual may use the capabilities provided by the opposite predisposition proves to be a useful option.

The PPI may be used as a way of determining which individual may be more capable of addressing a particular problem domain. If a problem domain requires a high level of holistic abstraction, why put an individual that requires a high level of analysis to perform this task? Or if an individual is empiric by nature, why task him/her with a problem that may not have measurable or even observable constructs? This is just on the epistemological side. When we talk about the teleological side, we have insights into how an individual addresses uncertainty, which may be consistent with the individual's risk-taking profile. When the individual's predisposition is towards perceiving the future as being predictable, certain risks may be associated with this predisposition under high levels of complexity, given that the state of the future may change. This may sound trivial, but if we look at disciplines such as project management and systems engineering, among others, the assumption is that processes are perfectly ergodic and final states perfectly known. Finally, on the ontological side, we are going to have different ways of seeing reality and this will establish the value perceived in efforts such as modeling and simulation vs. statistical rigor in facts and observed data.

When we talk about engineering management, bridging the gap between the technical, engineering side and the social, management side is always a discussion topic. Both engineers and managers will have different worldviews and predispositions due to their background, education and experiences. The profiles described by the PPI certainly reflect that. However, the PPI can also be considered as a binding agent. Whether engineers or managers, if an individual is aware of his/her profile, he/she can switch hats and choose to act in a different way to provide better solutions to complex problems. This flexibility is precisely what is expected from engineering managers, and also managing engineers.

This is highly pervasive with Socio-Technical Systems. It may be hypothesized that certain types of individuals will deal better with complex problems or complex situations, such as those presented in Socio-Technical Systems (STS) or System of

Systems (SoS). The main problem arising when dealing with STS/SoS is the "social" or the "human" element. Therefore, using the PPI to better align the fit between the individual and the system or to purposely match individuals towards a particular goal proves to be an important application of the PPI.

It is also interesting to note that the proposed profiles capture the different hierarchical levels within organizations. The profiles with Rational and Unpredictable components reflect the higher, upper levels of an organization. Leaders, for instance, need to have a certain vision in order to be successful, and part of this success comes from working well in uncertain situations. Whereas when we look at the lower levels of an organization, an employee does not need to know the big picture. The only goal is to complete a given task within certain deadlines, therefore Empirical and Predictable components reflect the lower levels of the hierarchy.

7.2 Future Research

The conceptual, methodological and practical implications of the research provide various opportunities for future research topics. One such future research area is transferring the research to an empiricist paradigm and empirically analyzing the profiles that have been developed, proposed and explored. The profiles here presented are done so in a rationalist manner, and an assessment on how to empirically test the PPI is part of a work in progress. The initial step taken for this is the operationalization of the profiles. This is done by developing a questionnaire (PPI-Q) in order to test and validate the dimensions, as well as the profiles themselves. Statements such as "In order to accept something to be true, I would need to have actual proof" and "I like to be organized and plan ahead" are used to determine the individual's predispositions and relevant profiles. Through appropriate demographic studies, profiles of different groups such as academics vs. practitioners can be determined. Furthermore, profiles of individuals who are in different professions (such as engineers, managers, leaders, scientists, etc.) can be explored. For instance, the PPI could be applied to leaders and different leadership styles. This future research may focus on capturing the underlying philosophical assumptions of leaders and leadership. Since leadership is a topic that has been researched *ad nauseam* with no common agreement within leadership scholars on what leadership theories are

significant, and which ones present a holistic picture, using the philosophical dimensions of the PPI would fill a significant gap in the body of knowledge, as well as solidifying the applicability of the developed profiles. It is hoped that the PPI-Q could be used in different contexts. Having a tested and reliable tool to asses the philosophical profile of an individual certainly would have a significant impact on many overlapping bodies of knowledge.

As discussed in the Results section, some of the profiles were very different from each other, and some of them were not. For instance, when the ontological and teleological dimensions are kept constant, it can be seen that profiles with the Empiricist predisposition (**E**SG, **E**PG, **E**SN, **E**PN) are all significantly different from profiles with the Rationalist predisposition (**R**SG, **R**PG, **R**SN, **R**PN). This is also true for the teleological predisposition. However, this is not valid for the ontological profile, e.g. R**P**N and R**S**N seem to be very similar to each other. One of the conclusions that can be drawn from this is that there may be certain priorities involved within the three dimensions itself. For instance, the epistemological dimension may be the primary dimension, i.e. the dominant predisposition, and the teleological dimension could have a secondary effect, and the ontological dimension could be described as the tertiary dimension. This could provide a good starting point for future research.

One of the assumptions within this research when developing profiles was that the individual's predisposition did not change throughout the complex problem's solution. The profile of an individual was kept constant since the research focused on *what* the *initial* behavior of the individual was, rather than on *how* that behavior changed (or whether or not it did) during the course of the problem solution. How much of individuals' worldviews and predispositions can change is open to debate. However, the mere realization that there are other ways to seek knowledge and to define and approach a problem will be an improvement on one's perspective. How solving a complex problem would affect the underlying philosophies and the profile of an individual is another research area that may branch out from this research.

8 CONCLUSION

The final section of this dissertation presents the discussion on crucial aspects of the research. In the beginning of the research, it has been proposed that individuals posses certain philosophical predispositions towards the way they see reality, the way they seek knowledge, and the way they perceive the future. When an attempt to define, analyze and solve complex problems has been made, additional insight on the way an individual acts was needed. The behavioral foundations of existing personality theories provide insight on different traits an individual may possess, and this may reflect on different aspects of an individual's life. However, this is not sufficient to provide the necessary means to analyze how the individual deals with complex problems which surround him or her. This is where the philosophical constructs were introduced. The underlying philosophical dimensions were argued to be Ontological, Epistemological and Teleological. Using these arguments, major premises were established, and in turn these premises were used to develop the PPI, which was presented as a general statement and related propositions. The initial premises were then used as guidelines for the rules that shaped the Agent-based model that was constructed. Through the modeling and simulation, the general theory and propositions were analyzed, and specific results were reached. The discussion section consists of four parts.

The first part of this section presents a discussion on the limitations of this research from various aspects. These limitations need to be addressed in order to show that the research is open to future research areas and further development. The choices, assumptions and decisions made in this study are substantiated throughout the document; also, research limitations are a part of the research process.

The second part of this section is a presentation and discussion of the significant and original contributions of this research to different bodies of knowledge. The contributions are *conceptual, methodological and practical.*

The last part discusses future research opportunities that may follow this study. As stated previously, within the body of the document, certain assumptions, choices and pre-suppositions have been made. In future research, both the conceptual and

methodological implications can be followed and certain limitations of the research can be addressed.

8.1 Research Limitations

- **Conceptual Limitations**

From a conceptual perspective, the choices, assumptions and pre-suppositions made by the author were explicitly stated. This ensures traceability and repeatability of the methodology, at the least; however, as in any research, there are interpretative elements that may include certain biases on the author's part.

One of the limitations can be considered as the choice of philosophical paradigms. Other paradigms which have not been considered for certain reasons may have been included in the profile, the effects tested, and, if necessary, eliminated. Through the rationalist perspective, these steps were done *a priori* theory development in this research.

Another limitation may be the bounding and the scope of this research. As discussed in previous sections, the uses of philosophical paradigms as personality dimensions have been the initiation point of this study. If this had been an inductive study, more possibilities could have been explored.

Similar to any research that deals with personality variables, this research was considered within a certain context, which was *complex problems* in this case. This could have been extended, or even eliminated, and the personality profiles developed would have been studied in a vacuum medium.

- **Methodological Limitations**

As with any case, the deductive approach has its limitations. Gorski (2004) addresses the methodological issues of Deductivism, in which he states that the methodology for deductivists is normative, where explanations are prescribed. In this case, methodology is prior to method. On the other side of the spectrum, however, methodology for realists is descriptive, and methodology is anterior to method. From a sociology perspective, he states that the reason why the hypothetico-deductive method is not appropriate is because the social-scientific explanations within sociology do not contain universal or statistical laws that could form the premise of a deductive argument.

Arthur (1994) argues that there are two reasons why deductive rationality does not work in complex and complicated situations: The first reason is that when a certain level of complexity is exceeded, the logical capacity of humans is limited, which is the idea of bounded rationality. Bounded rationality, originated by Herbert Simon, states that "the choices people make are determined not only by some consistent overall goal and the properties of the external world, but also the by the knowledge that decision makers do and do not have of the world" (Simon, 2000, p. 25). The rationality is bounded because the abilities an individual possesses are limited. The other reason for failure is triggered by the interactive situations of dynamic and complex environments. When individuals cannot rely upon each other like they do when dealing with perfect rationality, they are forced to guess their behavior, which lands them in a world of subjective beliefs. As a result, objective, well-defined, shared assumptions cease to apply, which brings an end to deductive reasoning. According to Goldstone (2004), it is true that the reason why inductive-empirical methods are working, and are being used, is because there are certain regularities in nature that may emerge through repetition, observation and experiment. However, he goes on to state, "the fact that people are unique and think for themselves is *not* a bar to deductions about people or their organizations" (Goldstone, 2004, p. 40). He argues that the only important consideration here is to treat these properties of individuals and organizations accordingly. Gorski also notes that the social scientists use the hypothetico-deductive method because it "provides a simple, unambiguous procedure for evaluating theories" (Gorski, 2004, p. 2).

8.2 Research Contributions

According to Eysenck (1987), there are five criteria that determine whether a theory is "good" or not:

1. Predictive Power
2. Ability to explain previous anomalies
3. Act as criterion between different interpretations
4. Ability to unify separate disciplines
5. Practical application of the theory

The contributions of this research are threefold, and they will be discussed with taking into consideration Eysenck's criteria.

The *first* contribution to the body of knowledge is *conceptual*. This research combined different philosophical constructs in order to provide the foundation for the individual's philosophical profile. As presented in the earlier sections, philosophy and psychology were not separated from each other in the past. It was argued in this research that re-introducing philosophy as predispositions and worldviews contributes to the personality and psychology body of knowledge, as well as the philosophical body of knowledge. Studies were presented that connected worldviews to personality, as well as epistemologies and teleologies to personality. Bringing all these different themes into one topic is one of the main contributions of this research. This is in line with unifying separate disciplines as Eysenck states. It is hoped that this can present new opportunities in personality research in such a way that underlying personal philosophies are accepted as crucial components of personality.

The *second* contribution, which is closely related with the conceptual part, involves the *methodology*. Rationalist Deductive Methodology, though being used in many fields, does not appear as a fully formalized research method. By presenting the robust guidelines and addressing the specific canons of this method, it was proved that the Rationalist Deductive approach provides much needed rigor and structure to a study such as this dissertation. Both the rationalist and the deductive components of the methodology and the detailed method contribute in different ways to the study.

The *third* contribution of this research is to *practice*. It has been established by many different studies (both academy and industry-oriented) that the application of personality profiles increase the productivity of the firm, as well as the productivity and satisfaction of the individual. Self-awareness is an extremely useful and necessary concept to have within an individual's life. If we are aware of our predispositions, our worldviews, our inner world, we will function better in the outer world. Establishing individual's philosophical profiles will also prove to be useful when it comes to interaction with other people, building teams etc. It is clear that individuals with certain predispositions will work better with individuals who posses the same worldviews. However, it is also important to be aware that there are other lenses one can use, other

than our own. This is one of the reasons the PPI will be important when applied to an organizational setting. An individual may be an empiricist, but if he/she is aware of other epistemological paradigms, for instance rationalist, he/she can choose to take over that particular worldview for a specific problem.

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APPENDICES

A. INTERACTION RULES FOR ALL AGENTS

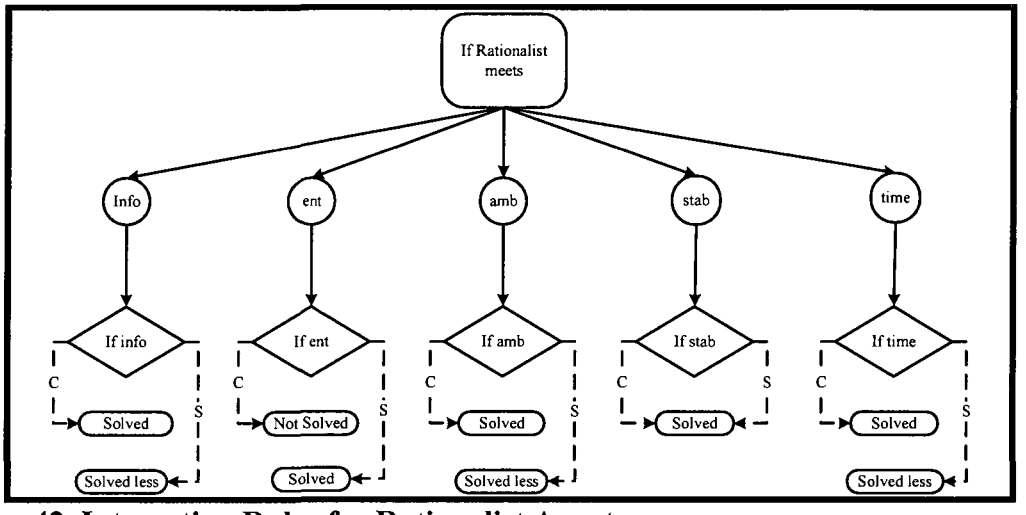

Figure 42. Interaction Rules for Rationalist Agent

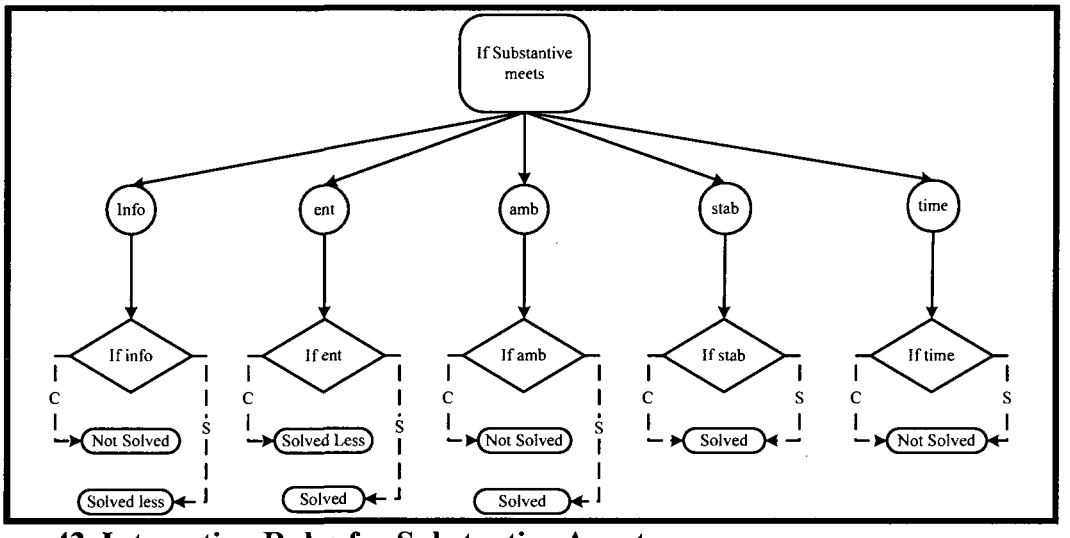

Figure 43. Interaction Rules for Substantive Agent

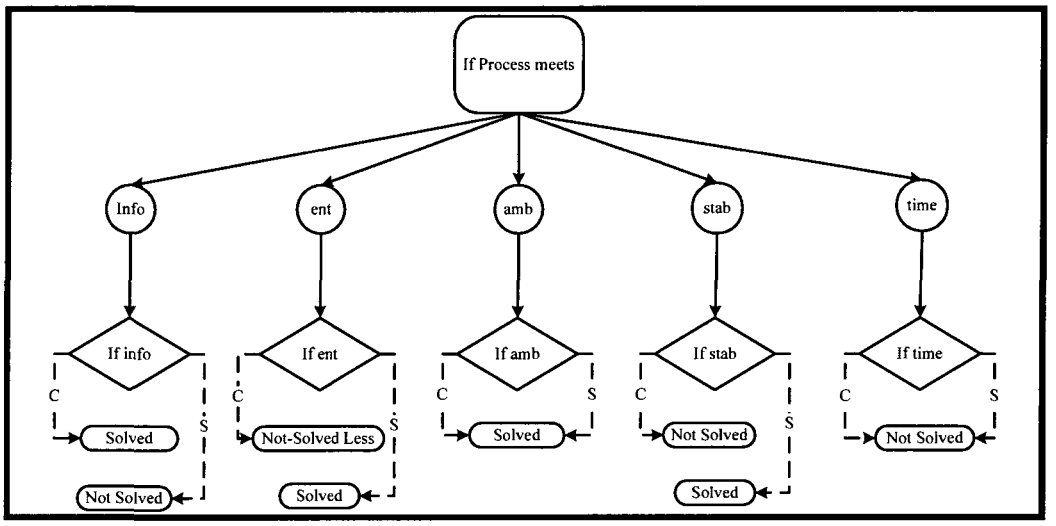

Figure 44. Interaction Rules for Process Agent

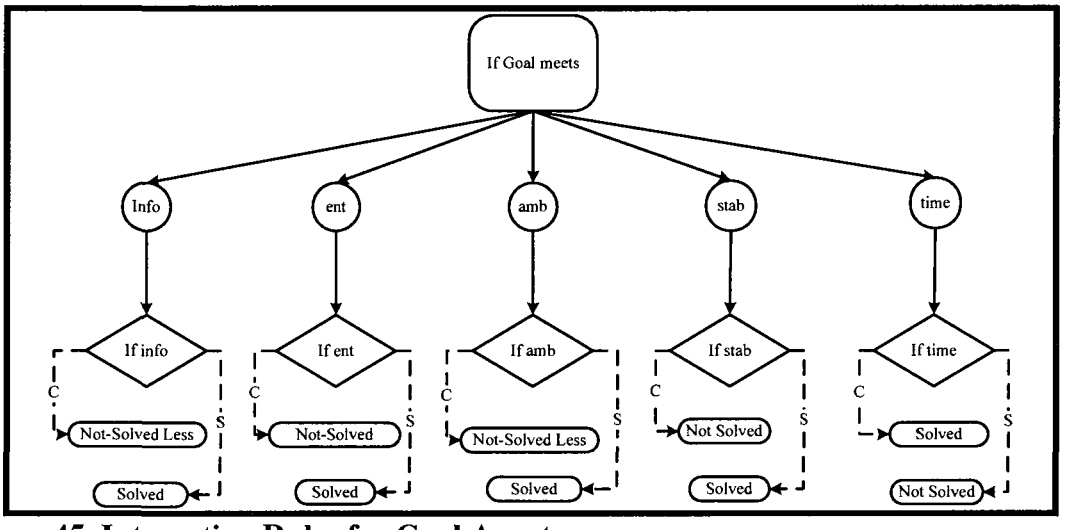

Figure 45. Interaction Rules for Goal Agent

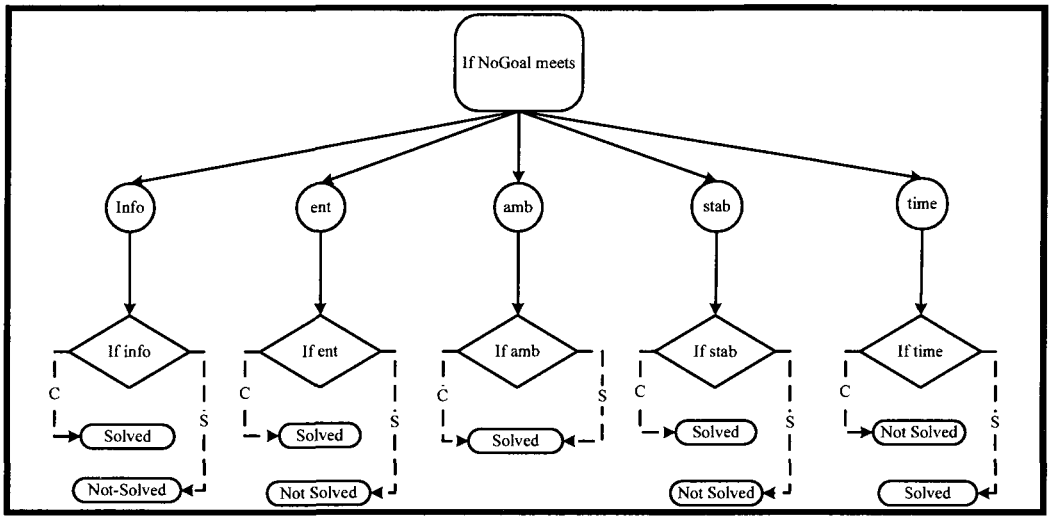

Figure 46. Interaction Rules for NoGoal Agent

B. ADDITIONAL STATISTICAL ANALYSES

Table 30. Profile Capability Metamodel

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.936[a]	.877	.799	6.45351

a. Predictors: (Constant), Ont_Tel, Epist_Tel, Epist_Ont, Epist_Ont_Tel, Tel_2, Ont_2, Epist_2, Tel, Ont, Epist

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4733.270	10	473.327	11.365	.000[a]
	Residual	666.364	16	41.648		
	Total	5399.634	26			

a. Predictors: (Constant), Ont_Tel, Epist_Tel, Epist_Ont, Epist_Ont_Tel, Tel_2, Ont_2, Epist_2, Tel, Ont, Epist

b. Dependent Variable: Capability

Table 31. Time Metamodel

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.869[a]	.756	.603	609.78593

a. Predictors: (Constant), Ont_Tel, Epist_Tel, Epist_Ont, Epist_Ont_Tel, Tel_2, Ont_2, Epist_2, Tel, Ont, Epist

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.841E7	10	1841351.007	4.952	.002[a]
	Residual	5949422.140	16	371838.884		
	Total	2.436E7	26			

a. Predictors: (Constant), Ont_Tel, Epist_Tel, Epist_Ont, Epist_Ont_Tel, Tel_2, Ont_2, Epist_2, Tel, Ont, Epist

b. Dependent Variable: Time

Table 32. Test of Homogeneity for Problem Solved

Test of Homogeneity of Variances			
ProblemSolved			
Levene Statistic	df1	df2	Sig.
213.129	7	34440	.000

Table 33. Post Hoc for Problem Solved

Multiple Comparisons						
ProblemSolved Games-Howell						
(I) Profile	(J) Profile	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-4.717237*	.471856	.000	-6.14761	-3.28686
	3.00	5.609158*	.653986	.000	3.62624	7.59208
	4.00	-3.933821*	.478593	.000	-5.38464	-2.48301
	5.00	-3.473692*	.490782	.000	-4.96146	-1.98593
	6.00	8.311300*	.702495	.000	6.18107	10.44153
	7.00	9.655137*	.729727	.000	7.44217	11.86810
	8.00	8.692570*	.728388	.000	6.48363	10.90151
2.00	1.00	4.717237*	.471856	.000	3.28686	6.14761
	3.00	10.326394*	.641845	.000	8.38024	12.27255
	4.00	.783416	.461865	.690	-.61669	2.18352
	5.00	1.243544	.474484	.148	-.19482	2.68190
	6.00	13.028537*	.691208	.000	10.93248	15.12460
	7.00	14.372374*	.718867	.000	12.19228	16.55247
	8.00	13.409806*	.717508	.000	11.23379	15.58582
3.00	1.00	-5.609158*	.653986	.000	-7.59208	-3.62624
	2.00	-10.326394*	.641845	.000	-12.27255	-8.38024
	4.00	-9.542979*	.646814	.000	-11.50419	-7.58177
	5.00	-9.082850*	.655885	.000	-11.07153	-7.09417
	6.00	2.702142*	.826328	.024	.19667	5.20762

	7.00	4.045980*	.849600	.000	1.46985	6.62211
	8.00	3.083412*	.848450	.007	.51074	5.65608
4.00	1.00	3.933821*	.478593	.000	2.48301	5.38464
	2.00	-.783416	.461865	.690	-2.18352	.61669
	3.00	9.542979*	.646814	.000	7.58177	11.50419
	5.00	.460129	.481184	.980	-.99856	1.91881
	6.00	12.245121*	.695824	.000	10.13508	14.35516
	7.00	13.588958*	.723307	.000	11.39542	15.78250
	8.00	12.626391*	.721957	.000	10.43691	14.81587
5.00	1.00	3.473692*	.490782	.000	1.98593	4.96146
	2.00	-1.243544	.474484	.148	-2.68190	.19482
	3.00	9.082850*	.655885	.000	7.09417	11.07153
	4.00	-.460129	.481184	.980	-1.91881	.99856
	6.00	11.784992*	.704263	.000	9.64940	13.92058
	7.00	13.128829*	.731430	.000	10.91071	15.34695
	8.00	12.166262*	.730094	.000	9.95215	14.38037
6.00	1.00	-8.311300*	.702495	.000	-10.44153	-6.18107
	2.00	-13.028537*	.691208	.000	-15.12460	-10.93248
	3.00	-2.702142*	.626328	.024	-5.20762	-.19667
	4.00	-12.245121*	.695824	.000	-14.35516	-10.13508
	5.00	-11.784992*	.704263	.000	-13.92058	-9.64940
	7.00	1.343837	.887481	.800	-1.34718	4.03486
	8.00	.381270	.886380	1.000	-2.30644	3.06898
7.00	1.00	-9.655137*	.729727	.000	-11.86810	-7.44217
	2.00	-14.372374*	.718867	.000	-16.55247	-12.19228
	3.00	-4.045980*	.849600	.000	-6.62211	-1.46985
	4.00	-13.588958*	.723307	.000	-15.78250	-11.39542
	5.00	-13.128829*	.731430	.000	-15.34695	-10.91071
	6.00	-1.343837	.887481	.800	-4.03486	1.34718
	8.00	-.962567	.908115	.965	-3.71623	1.79109

8.00	1.00	-8.692570*	.728388	.000	-10.90151	-6.48363
	2.00	-13.409906*	.717508	.000	-15.58582	-11.23379
	3.00	-3.063412*	.848450	.007	-5.65608	-.51074
	4.00	-12.626391*	.721957	.000	-14.81587	-10.43691
	5.00	-12.166262*	.730094	.000	-14.38037	-9.95215
	6.00	-.381270	.886380	1.000	-3.06898	2.30644
	7.00	.982567	.908115	.965	-1.79109	3.71623

*. The mean difference is significant at the 0.05 level.

Table 34. Test of Homogeneity for Capability

Test of Homogeneity of Variances			
Capability			
Levene Statistic	df1	df2	Sig.
1734.309	7	34487	.000

Table 35. Post Hoc for Capability

Multiple Comparisons						
Capability Games-Howell						
(I) Profiles	(J) Profiles	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-2145.28424*	9.01265	.000	-2172.6059	-2117.9626
	3.00	-3848.54115*	12.98004	.000	-3887.8956	-3809.1867
	4.00	-2766.85562*	9.00560	.000	-2794.1560	-2739.5552
	5.00	-2205.29102*	8.41108	.000	-2230.7900	-2179.7920
	6.00	-4225.57198*	14.91770	.000	-4270.8073	-4180.3366
	7.00	-4740.44948*	19.58366	.000	-4799.8448	-4681.0542
	8.00	-4729.36768*	14.66257	.000	-4773.8313	-4684.9040
2.00	1.00	2145.28424*	9.01265	.000	2117.9626	2172.6059
	3.00	-1703.25692*	11.64463	.000	-1738.5673	-1667.9465
	4.00	-621.57139*	6.94382	.000	-642.6209	-600.5218
	5.00	-60.00679*	6.15323	.000	-78.6599	-41.3537
	6.00	-2080.28775*	13.77148	.000	-2122.0539	-2038.5216
	7.00	-2595.16525*	18.72526	.000	-2651.9642	-2538.3663
	8.00	-2584.08345*	13.49470	.000	-2625.0128	-2543.1541
3.00	1.00	3848.54115*	12.98004	.000	3809.1867	3887.8956
	2.00	1703.25692*	11.64463	.000	1667.9465	1738.5673
	4.00	1081.68553*	11.63917	.000	1046.3916	1116.9795
	5.00	1643.25013*	11.18552	.000	1609.3293	1677.1709
	6.00	-377.03083*	16.64053	.000	-427.4868	-326.5749

	7.00	-891.90833*	20.92580	.000	-955.3669	-828.4498
	8.00	-880.82653*	16.41221	.000	-930.5916	-831.0614
4.00	1.00	2766.85562*	9.00560	.000	2739.5552	2794.1560
	2.00	621.57139*	6.94382	.000	600.5218	642.6209
	3.00	-1081.68553*	11.63917	.000	-1116.9795	-1046.3916
	5.00	561.56460*	6.14289	.000	542.9425	580.1867
	6.00	-1458.71636*	13.76686	.000	-1500.4685	-1416.9642
	7.00	-1973.59386*	18.72187	.000	-2030.3825	-1916.8052
	8.00	-1962.51206*	13.48999	.000	-2003.4272	-1921.5969
5.00	1.00	2205.29102*	8.41108	.000	2179.7920	2230.7900
	2.00	60.00879*	6.15323	.000	41.3537	78.6599
	3.00	-1643.25013*	11.18552	.000	-1677.1709	-1609.3293
	4.00	-561.56460*	6.14289	.000	-580.1867	-542.9425
	6.00	-2020.28096*	13.38551	.000	-2060.8795	-1979.6824
	7.00	-2535.15846*	18.44326	.000	-2591.1047	-2479.2122
	8.00	-2524.07666*	13.10059	.000	-2563.8140	-2484.3393
6.00	1.00	4225.57198*	14.91770	.000	4180.3366	4270.8073
	2.00	2080.28775*	13.77148	.000	2038.5216	2122.0539
	3.00	377.03083*	16.64053	.000	326.5749	427.4868
	4.00	1458.71636*	13.76686	.000	1416.9642	1500.4685
	5.00	2020.28096*	13.38551	.000	1979.6824	2060.8795
	7.00	-514.87750*	22.17984	.000	-582.1351	-447.6199
	8.00	-503.79570*	17.98379	.000	-558.3261	-449.2653
7.00	1.00	4740.44948*	19.58366	.000	4681.0542	4799.8448
	2.00	2595.16525*	18.72526	.000	2538.3663	2651.9642
	3.00	891.90833*	20.92580	.000	828.4498	955.3669
	4.00	1973.59386*	18.72187	.000	1916.8052	2030.3825
	5.00	2535.15846*	18.44326	.000	2479.2122	2591.1047
	6.00	514.87750*	22.17984	.000	447.6199	582.1351
	8.00	11.08180	22.00906	1.000	-55.6591	77.8227

8.00	1.00	4729.36768*	14.66257	.000	4684.9040	4773.8313
	2.00	2584.08345*	13.49470	.000	2543.1541	2625.0128
	3.00	880.82653*	16.41221	.000	831.0614	930.5916
	4.00	1962.51206*	13.48999	.000	1921.5969	2003.4272
	5.00	2524.07666*	13.10059	.000	2484.3393	2563.8140
	6.00	503.79570*	17.98379	.000	449.2653	558.3261
	7.00	-11.06180	22.00906	1.000	-77.8227	55.6591

*. The mean difference is significant at the 0.05 level.

Table 36. Regression Model Coefficients for Capability Gained

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	33.323	3.286		10.141	.000
	Epist	8.495	1.521	.490	5.585	.000
	Ont	3.308	1.521	.191	2.175	.045
	Tel	7.299	1.521	.421	4.799	.000
	Epist_2	-8.332	2.635	-.278	-3.162	.006
	Ont_2	-8.986	2.635	-.300	-3.411	.004
	Tel_2	-10.859	2.635	-.362	-4.122	.001
	Epist_Ont_Tel	.558	2.282	.021	.245	.810
	Epist_Ont	-7.214	1.863	-.340	-3.872	.001
	Epist_Tel	-.952	1.863	-.045	-.511	.616
	Ont_Tel	1.628	1.863	.077	.874	.395

a. Dependent Variable: Capability

Table 37. Regression Model Coefficients for Time

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1542.474	310.488		4.968	.000
	Epist	-358.514	143.728	-.308	-2.494	.024
	Ont	-36.603	143.728	-.031	-.255	.802
	Tel	-507.314	143.728	-.436	-3.530	.003
	Epist_2	580.970	248.944	.288	2.334	.033
	Ont_2	600.703	248.944	.298	2.413	.028
	Tel_2	626.236	248.944	.311	2.516	.023
	Epist_Ont_Tel	-82.545	215.592	-.047	-.383	.707
	Epist_Ont	507.138	176.030	.356	2.881	.011
	Epist_Tel	-35.962	176.030	-.025	-.204	.841
	Ont_Tel	-381.187	176.030	-.268	-2.165	.046
a. Dependent Variable: Time						

Table 38. Correlation Coefficient for Capability Gained

Correlations			
		Predicted	Simulated
Predicted	Pearson Correlation	1	.957**
	Sig. (2-tailed)		.000
	N	9	9
Simulated	Pearson Correlation	.957**	1
	Sig. (2-tailed)	.000	
	N	9	9
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 39. Correlation Coefficient for Time

Correlations			
		Pred_Time	Simul_Time
Pred_Time	Pearson Correlation	1	.923**
	Sig. (2-tailed)		.000
	N	9	9
Simul_Time	Pearson Correlation	.923**	1
	Sig. (2-tailed)	.000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

VITA

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Dr. Bozkurt received her Master of Engineering Management degree from Old Dominion University's Engineering Management and Systems Engineering Department in 2003, and her Bachelor's degree from Hacettepe University's Chemical Engineering Department in Ankara, Turkey. She was a full-time instructor for the Statistical Concepts in Engineering course in both live and televised mediums, as well as an asynchronous Introduction to Engineering Management course for two years. She was also a Graduate Teaching Assistant for both Graduate and Undergraduate-level classes such as Systems Engineering Management, Project Management and Logistics and Supply Chain Management. She has collaborated with several faculty members on a variety of activities, which include leading several groups developing grant proposals for NSF and other institutions on areas such as Critical Infrastructures, Transportation Systems, Emergency Management and Risk and Vulnerability Analysis, some of which have been accepted and funded. She has also assisted the Assistant Dean of College of Engineering and Technology in the initial development and writing of the proposal for a Doctor of Engineering (D.Eng.) program, which is a unique practitioner oriented degree that was recently approved and added to the programs offered in department of EMSE in ODU. She has one accepted journal paper, and nine published conference papers.