The Systems Thinking Paradigm and Higher-Order Cognitive Processes

by

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Abstract

The present study examined a new psychological construct we have coined “The Systems Thinking Paradigm.” The systems thinking paradigm describes a cognitive style with which one is more likely to understand that complex phenomena in the world are comprised of multiple interconnected components and that change in any of these components can elicit often-unpredictable variation in other parts of the system. We investigated systems thinking and its relationship to older psychological mechanisms in order to refine the systems thinking paradigm and explore its relationship intelligence, personality, and cognitive complexity. Results suggested that systems thinking, while related to verbal intelligence, openness to experience, and attributional complexity, makes unique contributions to creativity and to some extent to how people construe complex social problems. This study also found preliminary evidence for the notion that systems thinking, while related to other psychological processes, is likely to be a distinct construct.

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The Systems Thinking Paradigm and Higher-Order Cognitive Processes

The world is constantly changing and evolving; (Nguyen, Graham, Ross, Maani, & Bosch, 2012; Walker & Salt, 2006), and as a result policy-makers are faced with situations of increasing complexity. In an ever-expanding population, we face many complex concerns of increasing scale; how do we ensure that the natural resources of Earth will continue to support human life? How do we avoid a repeat of the financial meltdown of 2008? How do we address complex issues like climate change and widespread poverty? These questions address some of the most important social issues facing society today and, while the answers to each are likely to be complex, we still attempt to understand and answer these questions in the context of a reductionist approach. We continue to break down complex issues into individual parts and analyze each part in isolation from one another. This method of understanding is deeply rooted in the empirical approach first conceived during the Enlightenment era (Wulun, 2007). In the empirical method, individuals attempt to understand various natural and unnatural phenomena by deconstructing it into component parts that are more easily subjected to scientific scrutiny; this method thus represents a natural world that is static, linear, and mechanistic in nature. While this traditional approach has served us well in the past, it is becoming increasingly evident that a linear approach is limited (e.g., Walker & Salt, 2006; Zolli & Healy, 2012), such that we can no longer afford to address complex issues as before, the strictly linear approach has become insufficient. What then, can replace the traditional empirical approach grounded in a linear and mechanistic worldview? For many researchers, (e.g., Ben-Zvi-Assaraf & Orion, 2010; Cabrera, Colosi, & Lobdell, 2008; Porter & Cordoba, 2007; Sweeney & Sterman, 2007) the answer is systems thinking.

The Theoretical Basis of Systems Thinking.

Complex adaptive systems theory was developed in order to help understand and address the complexity inherent in complex adaptive systems (CAS) such as economies and eco-systems (Gunderson & Holling, 2002). Complex adaptive systems theory calls for the understanding that observable phenomena are complex systems comprised of multiple components, and that these components are highly interconnected. Thus, in order to understand the behaviour of any CAS, we must first understand that system behaviour emerges from the interconnected nature of system components. That is, a complex system is defined by a large number of components and each component affects, and is affected by, every other component within the boundaries of the system, such that one cannot appreciate the system's whole by simply examining its parts (Meadows, 2008; Walker & Salt, 2006; Westley, Zimmerman, & Patton, 2007). This is the crux of complex adaptive systems theory. Problems of poverty, economic turmoil, and climate change emerge from interactions involving far too many components to be satisfactorily understood by the analysis of singular components such as unemployment rates, mortgage policies, and methane emissions. These components are simply one part of the system, and cannot fully explain its behaviour.

At its core, systems thinking is essentially a cognitive paradigm or manner of thinking that is consistent with the tenets of complex adaptive systems theory. Specifically, systems thinking embraces the notion that complex phenomena in the world are comprised of multiple interconnected components, and that change in any one or more components can elicit often-unpredictable change in other parts of the system (e.g., Randle, 2012; Stroink & Randle, 2013). The systems thinking paradigm eschews the idea that understanding a complex system is achieved when every individual component has been identified and it's individual function(s) mapped. Instead, systems thinking indicates that "the whole is greater than the sum of its parts" and that this whole constitutes a dynamic system. In order to properly understand complex phenomena, we must first recognize that such phenomena can be understood as a system, and that these systems are made up of many interconnected components, each contributing to the emergent behaviour of the system as a whole. For example, one could not hope to understand how a car operates without first understanding the influence of the vehicle's fuel system, its drivetrain, and its operator; removal of one or all of these components results in a shift of the system into a new regime (Walker & Salt, 2006); the car malfunctions. This example illustrates the essence of systems thinking; we cannot fully understand the whole without considering all components and their interconnected nature.

The Roots of Systems Thinking and the World of Business

Researchers in business and specifically in organizational management have taken considerable interest in systems thinking (e.g., Cao, 2007; Kogetsidis, 2011; Mehrjerdi, 2011). However, despite interest in systems thinking, the exact meaning of the term is still a matter of some debate. Systems thinking is based on complex adaptive systems theory and is concerned with an individual's tendency to understand that much of the world cannot be understood through reductionism, and instead entails a broader perspective to fully appreciate the immense and intricate complexity of our world. However, in organizational management research, systems thinking is mainly conceptualized as a superior problem-solving framework (Mehrjerdi, 2011) for the handling of complex management problems such as employee dissatisfaction and decreased product demand. This notion is fairly well established in the Organizational Management literature (e.g., Cao, 2007; Kogetsidis, 2011).

However, much of this research theorizes systems thinking as a skill-based problem-solving framework (Cao, 2007; Mehrjerdi, 2011) but it is our contention that systems thinking may also exist as an individual cognitive difference that does not necessarily require a formal training process to develop. Instead it may subsist as an individual difference dimension as the tendency to perceive and understand relevant phenomena as a complex adaptive system (even if such terminology is never used) and that these phenomena are comprised of multiple interacting components that are likely to change over time (they are dynamic). Some preliminary research has hinted at this postulation. Randle and Stroink examined this tendency in a sample of undergraduate students using a specially designed, psychometrically tested, scale (Randle & Stroink, 2012). Results showed definite individual differences in mean systems thinking scores, with some individuals scoring quite high on the measure, thus prompting the need for the proposed research.

As mentioned earlier, systems thinking has gained a large amount of research attention in the organizational management literature. Mehrjerdi (p. 910) wrote that "systems thinking is a conceptual framework for problem-solving that considers problems in their entirety" suggesting that systems thinking is invaluable for complex problem resolution because it does not attempt to rectify the situation by altering only one or two components of a pathological system (e.g., increasing wages, making management staff more accessible). While such short-term solutions may alleviate the problem for a time, they fail to address the root cause(s) of a complex problem (e.g., why and at what scale are increased wages necessary?; why do employees wish for more visible management staff) and so the problem persists. In the field of organizational management, systems thinking has largely been defined as a problem-solving framework that attempts to correct some situation by considering every feature of the issue when developing and implementing a solution (Kogetsidis, 2011; Mehrjerdi, 2011).

Mehrjerdi (2011) further suggests that one means of evaluating implemented organizational strategies is by applying a systems thinking framework. In this framework, systems thinking is used to evaluate some organizational aspect by searching for outcome patterns that may not be visible by the inspection of immediate results. Mehrjerdi writes that systems thinking is an effective evaluation tool because it involves thinking about outcomes in terms of feedback loops rather than the linear approach traditionally used in program evaluation (e.g., Program A is directly responsible for Outcome B) (Mehrjerdi, 2011). Systems thinking can be used to generate a powerful model in which to explore outcomes and to better understand the factors responsible for these outcomes. It seems likely that if managers want to see long-term solutions, larger issues must be addressed through more than the exorcising of one or two, often the most visible, symptom(s) of the problem and systems thinking can help provide an improved framework for evaluation that may be one pathway to improved organizational management.

Systems thinking has also been suggested to be beneficial in dealing with the everyday complexity of problems in large organizations. Kogetsidis suggests that systems thinking is appropriate when traditional optimization tactics (with origins in empiricism) become irrelevant and inappropriate (Kogetsidis, 2011). These situations tend to arise when many or some individuals (stakeholders) hold differing views on problems that are ill defined, such as appropriate parental leave arrangements. These problems can cost organizations in terms of lost work hours and low employee motivation, and can also be similarly damaging to an employee seeking sufficient parental leave. Ergo the problem is not well defined, it affects many different stakeholders at many different organizational levels (from management to factory floor workers), and lacks structure. The problem is complex. In these problem situations, it is suggested that systems thinking is instrumental for problem resolution because system thinking enables problem solvers to develop a more holistic, and clearer, picture of the problem at hand (Dominici & Levanti, 2011).

Systems thinking and complex decisions within an organization. The notion that systems thinking can help inform decision-makers has also been extended to the context of large-scale organizations. Mason (2005) suggests that "organizations are multifarious and can rarely be understood in terms of single properties" (p. 77) highlighting the importance of applying a systems thinking framework when planning organizations and making organization-wide decisions. Thus it is likely poor practice to analyze organizations using a reductionist paradigm, as research suggests that focusing managerial attention to an isolated part(s) of an organization can lead to disaster in the long run (Mason, 2005). Mason goes on to suggest that when organizations have run into various problems, many of these problems could have been minimized or eliminated had management realized the interconnected relationship between various organizational entities and their properties. This concept is paralleled by a number of systems scientists, albeit under different labels. One such argument, drawing on resilience discussions, suggests that complex adaptive systems, such as an organization and the environment, are complex adaptive systems that are bound by "thresholds" and experience stable states (Walker & Salt, 2006). A stable state is a property of a complex system in which the behaviour of the system remains largely unchanged over a period of time. Change in certain components of the systems or their interactions can result in one of these conceptual thresholds being crossed. When this occurs, the system can be propelled into a new stable state. This new stable state can be undesirable. However, not every threshold, when crossed, will indefinitely result in a new stable state, and new stable states may in fact be highly beneficial and desirable to achieve; for example the return of a coral reef to areas where it was previously abundant would be an example of both a desirable and beneficial change.

The ability to foresee and navigate thresholds that define the balance between a systems' desirable steady state and an undesirable one should be facilitated by systems thinking. If an individual tends towards systems thinking, either with training and awareness or not, they should show a preference for decisions that are made based on more complex evidence such as the consideration of a higher number of components. That is, a systems thinker may be motivated to make decisions based on the consideration of more causal relationships between a higher number of decision components than the individual who prefers or ascribes to a linear style of thinking.

Systems thinking and the perception of complex organizational problems. However, it is not simply the motivation to consider more causal relationships that defines the systems thinker. Individuals who engage in systems thinking may also differ in how they perceive and define complex problems. One of the most beneficial aspects of systems thinking may be the ability to recognize the limits of a linear understanding of causality (e.g., A causes B; Wulun, 2007), particularly in relation to complex situations. In these situations, the immediate cause of a given outcome may not be readily apparent, it may not be co-located with the outcome. Previous research has found that individuals higher in systems thinking demonstrate an improved understanding of the underlying structure of a complex problem, and are more likely to develop and implement problem solving strategies based on this (often) richer understanding (Manni & Maharaj, 2004). Accordingly, it appears that individuals who are high in systems thinking perceive complex problems differently and so are able to develop a more complete picture of a complex problem and its components. Additionally, not only are systems thinkers better able to understand a problem's structure; they are also able to develop and implement more complex solutions to the problem (Manni & Maharaj, 2004).

While systems thinking has received widespread attention in organizational management literature as an organizational framework, there is also a fair amount of research that places emphasis on increasing systems thinking ability in potential managers and MBA graduates (e.g., Zulauf, 2007). For example, Kunc (2012) describes one means of increasing systems thinking ability amongst a group of graduate students (Kunc, 2012). In this example, students were enrolled in a strategic development processes course, which embedded systems thinking principles into its curriculum. This course made use of a five-stage modeling process originally designed by Sterman (2000), which places emphasis on the importance of causal relationships between the system whole and its components, the understanding of behaviour change over time using graphing mechanisms, and the understanding of feedbacks loops in the development of theories of performance of a large firm (Kunc, 2012; Sterman, 2000). Once students had completed this course, their theories of the firm's performance were then compared to expertly derived theories of the same firms' performance. However, results from this study showed only marginal improvement in systems thinking ability.

Further, a systems thinker understands that organizational decisions are affected by more than just the immediate organization's boundary and hence may be more likely to make decisions by also considering the influence of other complex systems that are outside the organization (e.g., the state of the economy and market demand) itself. Such consideration should lead to the generation of better long-term organizational decisions and this ability may reveal itself as an implicit preference for more complex decisions, even if complex systems terminology (e.g., *stable states, thresholds*) is never used. Thus, individuals who engage in systems thinking may perceive complex problems differently from non-systems thinking individuals. However, much of this research is speculative in nature and so represents an important gap in the literature.

Consequently, while other research has shown that systems thinking can aide in organizational management (e.g., Cao, 2007; Kogetsidis, 2011) it is our opinion that systems thinking may be deeper than a skill to be taught or a tool to be used. In previous research, systems thinking has largely been conceptualized as a skill that must be learned and hence requires a targeted intervention designed to increase awareness of system theory principles (e.g., Ben-Zvi Assaraf & Orion, 2010; Booth-Sweeney & Sterman, 2007; Plate, 2010). We, however, suggest that systems thinking may be an individual cognitive difference that can exist to varying degrees in the general population, and that individuals who are higher in systems thinking will be more likely to make decisions based on the following strategies or abilities:

1. Systems thinking individuals consider a higher number of system components when faced with a decision.
2. They consider a deeper level of interaction amongst all system components, and appreciate that each component affects and is affected by every other component in the system.
3. They consider these interactions by also considering their interaction with other separate, but nested systems.
4. They have a tendency to consider that the cause(s) of the problem may not be co-located with the problem itself, and that the cause(s) may be seemingly distal to the problematic outcome or even across different domains (e.g., causes of addiction residing in homelessness, poverty, and discrimination).

The Psychological Construct of Systems Thinking.

While researchers have been discussing systems thinking for some time, the exact definition of the concept has been the matter of some debate. In previous work, we have dealt with these differing definitions and have synthesized them into a new definition of systems thinking. We defined systems thinking as the tendency to perceive and understand relevant phenomena as complex adaptive systems that are comprised of multiple, interacting components and the ability to work with the interconnected, dynamic, and emergent nature of complex systems (Stroink & Randle, 2013). This definition attempts to amalgamate similar aspects of various systems thinking definitions in an effort to facilitate closer agreement amongst researchers and disseminators alike. In sum, systems thinking is a cognitive paradigm in which an individual is more likely to recognize that different entities in nature as well as in human enterprise, involve a number of multiple interrelated components, and that change, however slight, to any one or more of these components can radically alter how the system will behave and adapt.

Importantly, however, in our definition of systems thinking an individual may or may not be aware that they are considering an event or entity through a systems thinking lens; it is possible that systems thinking may be used without explicit awareness. This conceptualization of systems thinking as a way of thinking that one may use without conscious knowledge of it is a relatively novel one, as systems thinking tends to be discussed in the literature as a skill requiring formal instruction (e.g., Ben-Zvi-Assaraf & Orion, 2010; Espejo, 1994; Richmond, 1993). A previous study conducted by the authors revealed individual differences in scores on a scale designed to assess systems thinking (Randle, 2012). Analysis of these data revealed variations in systems thinking in a survey study that did not include any formal instruction of systems thinking. Further, systems thinking scores were also significantly associated with scores on a creativity measure, while cognitive complexity, also assessed in this study, was not significantly associated with these same creativity scores. This finding suggests that systems thinking may rely on a similar cognitive process as creative thinking, and this relationship may provide a clue into the underlying cognitive mechanism(s) involved in systems thinking. This is a worthwhile endeavor, as prior research has consistently shown that human beings tend to be rather poor systems thinkers (e.g., Booth-Sweeney & Sterman, 2007; Plate, 2010; Sterman, 1989)

Why is Systems Thinking Uncommon? The failure of individuals in implementing a systems thinking approach is not fully understood, however the fact that human beings tend not to ascribe to a systems thinking paradigm could be due in part to the epistemological model maintained by the West in the current educational system. The Western educational system is structured around a mechanistic paradigm that is linear in scope and understands the world as a machine (LeFay, 2006; Wulun, 2007). In such a mechanistic worldview, if a problem is too difficult to address as a whole, then we can simply break down the problem into smaller, more manageable parts and analyze each in isolation from one another (Wulun, 2007). This empirical notion forms the basis of the current educational system in which subjects are taught to students in a piecemeal fashion, with little emphasis placed on how subject matter may relate to one another (e.g., History and Geography) or what the real-world applicability may be. It is possible that systems thinking is simply being "taught out" of today's students (Hung, 2008). Unfortunately, when we employ this reductionist approach, much of our understanding of the system's behaviour is lost or distorted. In other words, when we are attempting to appreciate problems that are complex, the reductionist approach may be inappropriate, and often the consequences of a particular decision are not fully felt/understood for some time (e.g., Zolli &

Healy, 2012). If systems thinking can increase the likelihood of generating better solutions to today's complex problems, then we must facilitate its application, and to do so we must garner a better understanding of what systems thinking is and what it is not.

Measuring Systems Thinking. While systems thinking is thought to be helpful in managing complexity, the development of an appropriate measurement inventory was required. Systems thinking needed an established scale and so we developed one through numerous empirical investigations. Prior to the development of this scale, most of the existing assessment instruments have been created only with groups of people possessing certain characteristics such as specialized knowledge of a water shed (Ben-Zvi-Assaraf & Orion, 2010), knowledge of stock and flow concepts (Booth - Sweeney & Sterman, 2000) or an ability to micro-manage simulated city scapes (Manni & Maharaj, 2004). Thus, an inventory designed to measure a "general" systems thinking tendency has been absent. Furthermore, most of the available measures have been produced to assess specific systems thinking skills in order to test the effectiveness of a systems thinking intervention. For example, the "The Cognitive Mapping Assessment Task" has been developed in order to measure an individual's application of systems thinking to a complex understanding of a fishery management controversy (Plate, 2010) following a targeted systems thinking intervention. This is a scenario-based task in which participants are asked to consider the underlying causal framework of fishery management, and then to generate a causal map that explains the fictitious controversy. Causal maps generated by participants are then compared to maps generated by experts for branching patterns and number of components identified (Plate, 2010).

The Cognitive Mapping Assessment task, and others like it, was developed for the assessment of systems thinking in a sample population who have at least some rudimentary knowledge of a specific area, such as business management or geography (Ben-Zvi Assaraf & Orion, 2010; Sterman, 1989). While such measures are undoubtedly useful for measuring systems thinking in a business management or an environmental context, it reveals little about a "generalized" systems thinking tendency, in which systems thinking is applied in numerous and varying contexts. In light of these limitations, we have defined systems thinking as a cognitive tendency to recognize observable phenomena as complex systems, one that is independent of specialized knowledge or ability (e.g., of a water-shed or business terminology). The need for a general systems thinking scale currently exists and as a result we developed a self-report survey measure of systems thinking.

This measure is a standard Likert-type scale that has been designed to assess systems thinking as a distinct cognitive paradigm and not just a set of specific skills, as is usually done in systems thinking research. In order to develop this scale, we have thus far conducted 5 separate empirical studies. In one of these earlier studies, the original 40-item systems thinking scale demonstrated a fairly high internal reliability estimate of .90 (Cronbach's α; Davis, 2013). We began with this initial pool of 40 items, and through psychometric procedures such as factor analysis and internal reliability estimates, we reduced the systems thinking scale to 15-items. Reanalyzing this data set indicated that the shortened version of the system thinking scale shows comparable internal consistency estimates with Cronbach's α exceeding .85. Thus, another aim of the proposed research was to further evaluate the psychometric properties of our systems thinking measure. More information about this scale, including sample items and internal consistency estimates, can be found in the methods section of this paper.

Systems Thinking and Complex Decision-Making

Another area of systems thinking research that has received increasing attention has been the application of systems thinking to complex decision-making processes and policy planning outside the sphere of organizational management (e.g., Livingood et al., 2011, Manni & Maharj, 2004; Parent, Roy, & St-Jacques, 2007). The realization that the dominant paradigm, which is linear and mechanistic in nature (LeFay, 2010; Wulun, 2007), may be inadequate to address the complex social issues of today has resulted in a call for an alternative framework, one that is better equipped to work with complexity. In this vein, an increasing amount of decision-making literature has championed the benefits of systems thinking as the foundation for this new framework.

Systems thinking is seen as advantageous to the decision-making process because it involves the consideration of multiple facets of a particular problem or phenomenon, and how these facets interact with one another over time and across varying scales (e.g., individuals, communities, and governments). The notion that a system consists of multiple components that interact, change over time (are dynamic) and are not static is a central tenet of systems thinking (Walker & Salt, 2006; Westley et al., 2006; Zolli & Healy, 2012). It is also one of the main tenets thought to be beneficial to complex decision-making processes (Booth - Sweeney & Sterman, 2000; Hamdani, Jetha, & Norman, 2011). This is reasonable, as the understanding that system components are dynamic should facilitate the implementation of policies and procedures that are better prepared for the inevitable “shock(s)” that naturally occur in any complex system. Some of these “shocks” could include the emergence of a new product that is in direct competition with an existing product as in marketing, or a shock could also result from a drought or high precipitation levels in a socio-ecological system (e.g., Walker & Salt, 2006). Because the use of systems thinking enables one to appreciate the emergent behaviour of a system over time, it is possible that systems thinking can help policy-makers better prepare for these shocks, thereby increasing the overall resilience of a complex system (Walker & Salt, 2006).

Systems Thinking, Psychometric Intelligence, and Personality

A glimpse of the systems thinking literature suggests that systems thinking is a higher-order cognitive process. Thus, it may imply that individuals who engage in system thinking are also those who enjoy high intelligence. However, no one has yet investigated the potential relationship between systems thinking and human intelligence. This seems like an oversight as research has shown that individuals tend to be poor systems thinkers (e.g., Booth-Sweeney & Sterman, 2007; Plate, 2010; Sterman, 1989) yet the reason(s) as to why this may be have not been fully understood. Again such an oversight represents a clear gap in the existing literature and so we attempted to differentiate the systems thinking construct from intelligence in order to generate further research interest.

It has generally been accepted that intelligence consists of two separate, but related, types: crystallized intelligence and fluid intelligence (Nesbitt et al., 2012; Redick et al., 2013). Therefore it is possible that systems thinking may be related to one type of intelligence and not the other. Prior research has suggested that crystallized intelligence is comprised of ingrained abilities such as vocabulary knowledge (Nesbitt et al., 2012). Thus, when an individual is attempting to learn scholarly facts, such as the name of the 21st President of the United States, it is crystallized intelligence functioning that is most important for performance.

Fluid intelligence functioning, on the other hand, has been defined as the deliberate use of coordinated mental processes in order to solve problems that cannot be adequately addressed using quicker, automatic processes, such as the retrieval of a fact ingrained in crystallized intelligence. However, these processes are not mutually exclusive. Crystallized intelligence is amassed by employing one's fluid intelligence ability (Nesbitt et al., 2012). Thus, one's crystallized intelligence is linked to fluid intelligence, but nevertheless are separate constructs. This supposition has found validation in other research as well. For example, it was found that participants who possessed average crystallized intelligence functioning could still demonstrate impaired fluid intelligence functioning, in some cases as low as 2 *SD* below average (Blair, 2006). This suggests that independent cognitive processes control both crystallized and fluid intelligence functions.

However, we note that intelligence scores yielded from traditional psychometric instruments may not be valid in differing cultures (Sternberg, 2004). Sternberg (2004) argues that intelligence means different things to different cultures and therefore intelligence may not be meaningfully understood outside of its cultural context (Sternberg, 2004). However, while the "types" and "items" of intelligence vary across cultures, components of intelligence and the corresponding mental representations are universal across cultures. That is, any act of problem solving that requires intelligence follows the same formula in any culture. Namely, (1) individuals need to recognize that a problem exists, (2) they need to define what the problem is, (3) they need mentally represent the problem, (4) use resources to solve the problem, (5) monitor implemented solutions, and finally, (6) evaluate success (Sternberg, 2004). Thus, it is likely that brain structures used in problem solving are constant across cultures, but what constitutes an intelligent person will vary. For example, some researchers have studied intelligence outside of the West and have suggested that individuals in different cultures construe concepts quite differently, and so concept-formation as a product of intelligence may not be as valid in one culture as it is in another (Sternberg, 2004). Thus, different cultures may think about the same phenomenon differently, and so observed differences in intelligence may actually reflect differences in cultural properties and perceptions (Helms-Lorenz, Van de Vijver, & Poortinga, 2003). Nonetheless, for the purposes of this study, we assumed that participants have been largely educated in our Western system, and so traditional psychometric intelligence is unlikely to reflect cultural differences alone.

Systems Thinking, Fluid Intelligence, and Personality. The notion that systems thinking may be more strongly associated with one intelligence type than the other is an attractive one, since it may shed light on how systems thinking is cultivated and may provide an insight into how we can increase systems thinking tendencies. If systems thinking is indeed as useful for approaching complex problems as has been claimed (e.g., Manni & Maharaj, 2004), then the present research may help us to understand how this tendency may be nurtured in individuals who are already systems thinkers or imparted into those individuals who are not.

Towards this aim, one area of enquiry lies in establishing the association between systems thinking and fluid intelligence. It is generally agreed that fluid intelligence functioning plays a role in the accumulation of crystallized intelligence (Nesbitt, 2012), and so fluid intelligence may be more relevant to systems thinking than crystallized intelligence alone. Fluid intelligence has been defined as one’s ability to solve novel problems requiring little stored knowledge as well as the ability to learn (Nesbitt, 2012). It is a more controlled, deliberate process. It may be that systems thinking is an extension of fluid intelligence functioning, since more time spent considering a problem should lead to the acknowledgment of more problem components or aspects. However, research has shown that most individuals are poor systems thinkers and the association between fluid intelligence and systems thinking, if found, should prove telling.

Intelligence has also been investigated in personality research. Specifically, fluid intelligence has been found to be positively associated with the Big 5 trait of Openness to Experience (see Ziegler, Danay, Heene, Asendorpf, & Buhner, 2012). The relationship between openness and fluid intelligence functioning is a provocative one. Randle and Stroink conducted a pilot study in 2013 that investigated the relationship between systems thinking and a variety of personality traits including the Big 5 (Conscientiousness, Agreeableness, Neuroticism, Openness to Experience, and Extraversion) and Machiavellism, using psychometrically valid instruments (the NEO-FFI and the Mach IV). Statistical analysis revealed that systems thinking was only significantly associated with Agreeableness ($r = .18$, $p = .05$) and Openness to Experience ($r = .43$, $p = .01$). This finding suggests that systems thinking, if indeed an underlying cognitive construct, may be controlled by similar processing mechanisms as fluid intelligence functioning or possibly systems thinking itself may be one of these processes. If this postulation is correct, it may be feasible to improve systems thinking by employing means similar to those useful for increasing fluid intelligence functioning. Other research also hints at this possibility. For example, Soubelet and Salthouse have investigated the relationship between Big 5 personality traits and various cognitive functions (Soubelet & Salthouse, 2011). Findings from their study revealed that Openness to Experience had the strongest relationship with four cognitive abilities; crystallized intelligence, fluid intelligence, memory (verbal and episodic), and processing speed (Soubelet & Salthouse, 2011). Thus, another ambition of the proposed research is to further examine the role of personality in the development of systems thinking.

In addition to the potential role played by personality in predicting systems thinking, previous research involving twin studies, found that the relationship between intelligence and openness to experience seems to result from shared genetic factors (Bartels et al., 2012). This finding is particularly intriguing because in the pilot study mentioned above systems thinking was found to be positively associated with openness to experience. Thus, it is feasible that the link between systems thinking and openness to experience may also partly rely on shared genetic factors, like the relationship between intelligence and openness to experience. If this hypothesis is true, then systems thinking might also involve an inherited genetic component, thereby providing support for the notion that systems thinking may be more than a set of teachable skills and in fact may be a psychological trait. Furthermore, the relationship between openness to experience and fluid intelligence has been found in sample populations of children as young as seven years old (Lonnqvist, Vainikainen, & Verkasalo, 2012) to elderly adults aged 74-90 (Gregory, Nettelbeck, & Wilson, 2010), suggesting that this relationship is universal and as such, merits further investigation.

Systems Thinking, Intelligence, and Creativity

In an honour's thesis study conducted in 2012, Randle and Stroink investigated the relationship between systems thinking, creativity, and cognitive complexity (Randle & Stroink, 2012). Findings from this study indicated a positive 3-way association between systems thinking, cognitive complexity, and creativity. However, regression analysis revealed that only an individual's systems thinking score explained a unique amount of variance in creativity scores. This finding suggests that, while all three constructs were significantly associated with one another, systems thinking is more strongly related to creativity and hence, may operate through similar cognitive processes. This postulation is intriguing given other research that is concerned with the association between intelligence and creativity (e.g., Beaty & Silvia, 2012; Benedek, Konen, & Neubauer, 2012). Specifically, researchers have become interested in the relationship between intelligence type (fluid intelligence and crystallized intelligence) and creative ability (see Benedek et al., 2012). Arising from this line of work, Benedek and colleagues suggest that having a high crystallized intelligence factor may be essential for the effortless and flexible *retrieval of ideas* from long-term memory, while the creation of new and original ideas, which is also a feature of creativity, may be facilitated through executive functioning processes and hence may be related to fluid intelligence (Benedek et al., 2012). Given the potential link between systems thinking and creativity, it may be that systems thinking is a higher order process that may be related to both fluid intelligence and executive functioning.

Indeed, a growing body of research has begun to re-conceptualize the relationship between creative ability and intelligence (Beaty & Silvia, 2012; Nusbaum & Silvia, 2011; Silvia & Beaty, 2012). Historically, creative ability was thought to be the result of increased connections among different, “spaced-out” concepts in semantic memory, and that creative ideas arise as a result of the activation of these newly connected concepts (Mednick, 1962). Recent research has revisited this notion and has begun to question this conceptualization of creative behaviour. Specifically, some researchers have put forth the idea that executive functioning is more important to creative thought than previously suggested (e.g., Beaty & Silvia, 2012).

The Serial Order Effect in Creative Responding. Researchers have postulated that the well-known serial order effect may be taken as evidence that creativity and divergent thinking arise through the influence of executive processes (Nusbaum & Silvia, 2011). Essentially, the serial order effect describes how later ideas tend to be “better” than earlier ones and some researchers suggest that this indicates a greater role for executive functioning in creativity. Beaty and Silvia (2012) suggest that there are three executive processes that change in accordance with increased creativity. First, individuals tend to find, use and then abandon various cognitive strategies while completing a divergent thinking task and this same strategy is also seen in creative ability (Beaty & Silvia, 2012; Gilhooly, Fioratou, Anthony, & Wynn, 2007). Second, executive switching, which happens when individuals stop producing ideas from one abstract category and switch to another, occurs over time and thus may also play a role in the serial-order effect (Beaty & Silvia, 2012). Third, Beaty and Silvia (2012) suggest that "creating good responses involves managing interference from obvious uses, previously generated responses, and responses closely connected to the object's salient features" (p. 311) indicating that creative individuals are able to generate better ideas later as a result of being able to ignore cognitive interference produced by previous ideas and uses. Since interference management is a central executive process (Unsworth, 2010), that also has a temporal property, it may indicate a link between creativity and central executive control.

The potential relationship between fluid intelligence and creativity is an interesting one as it could have profound implications for the understanding of systems thinking. If creativity is more closely related to fluid intelligence than previously thought, then the relationship between systems thinking and creativity would suggest that systems thinking is at least partially controlled by executive functioning processes. Moreover, it is entirely possible that creativity itself emerges from both executive functioning (Beaty & Silvia, 2012) as well as the ability to see and form new connections between related concepts (Benedek et al., 2012). By conceptualizing creativity in this way, we should be able to investigate the relationship between creativity and systems thinking using regression analysis. In previous work, we administered an earlier version of our systems thinking measure and asked participants to draw a diagram which maps the causal reasons for a friends break-up. In this study, systems thinking predicted a higher number of connections drawn in the diagram (Randle, 2012). Thus, since creativity may be partly driven by an improved ability to see connections, then systems thinking may predict creativity because of its associated tendency to process the world in terms of connections. Additionally, creativity may be facilitated by a combination of systems thinking and fluid intelligence, which would point to the role of executive processes in systems thinking ability.

Systems Thinking, Creativity and Cognitive Complexity. In prior research, cognitive complexity has been defined as a stable, individual difference in the quantity of thought that individuals *choose* to expend (Reid & Foels, 2010). It is simply the enjoyment of deliberate thinking in general, or “thinking for the fun of it”. Further, individual cognitive complexity also involves the nature of thoughts regularly experienced by the actor in comparison to the general population (Reid & Foels, 2010). Those individuals who are more cognitively complex may think differently than individuals who are less cognitively complex (Reid & Foels, 2010). Consequently, cognitive complexity has been conceptualized as consisting of two dimensions, (1) how much individuals enjoy thinking and (2) how their thoughts differ from others. One theoretical aspect of cognition that has been used to explore cognitive complexity is individual differences in attributional complexity (less complex vs. more complex) as well as an individuals’ Need for Cognition (Reid & Foels, 2010). Using this definition of cognitive complexity, we have previously examined the relationships between systems thinking, the need for cognition and attributional complexity, and we found that all three constructs were significantly positively correlated (Randle, 2012) with each other and with creativity. However, when these variables were entered into a regression model, we found that only systems thinking scores accounted for a significant amount (approximately 10.5 %) of variance (B = 1.54, t (64) = 3.24, p = .002). This finding suggests that systems thinking, while related to cognitive complexity, remains a distinct construct.

Present Study

Building on suggestions from prior psychological research (Cabrera, Colosi, & Lobdell, 2008; Dyehouse, Bennett, Harbor, Childress, & Dark, 2009; Pala & Vennix, 2005; Porter & Cordoba, 2009), we proposed that systems thinking is more than an ability requiring instruction and is likely an underlying psychological construct that exists as an individual difference dimension that can also be increased with appropriate training and experience. Thus, the overarching goal of the present study was to further clarify the psychological concept of systems thinking by examining it in the context of intelligence, personality, and cognitive complexity in outcome measures such as creativity and social problem construal.

Previous research has suggested that systems thinking and creativity may operate through similar cognitive processes such as fluid intelligence (Beaty & Silvia, 2012; Benedek, Konen, & Neubauer, 2012). Thus, through the first hypothesis of this study we investigated the possibility that systems thinking, given its relationship to creativity (see Randle & Stroink, 2012) and its emphasis on a deeper level of controlled processing, is more strongly related to fluid intelligence (e.g. abstract reasoning; controlled processing) than crystallized intelligence (e.g. verbal intelligence; factual knowledge).

Hypothesis 2 was also concerned with establishing systems thinking as a distinct cognitive construct. In a pilot study conducted by the authors, it was found that systems thinking was significantly related to both the Big 5 personality traits of openness to experience and agreeableness. In this pilot study, openness to experience was particularly strongly associated with systems thinking ($r = .43$, $p = .01$), and so we expect to replicate previous results by finding a similarly high association between systems thinking and openness to experience as well as systems thinking and agreeableness in the present sample. We were also interested in understanding these associations better and so we examined systems thinking and openness to experience in the context of relevant outcome variables. We hypothesize that systems thinking, would strongly associated with openness to experience, and only moderately associated with agreeableness.

Hypothesis 3 addressed the associations between systems thinking, and cognitive complexity. Specifically, we postulated that systems thinking would be related to at least one aspect of cognitive complexity. Given previous research (Reid & Foels, 2010), we utilized two measures of cognitive complexity, the need for cognition and attributional complexity. In a previous study using a smaller sample, cognitive complexity was significantly correlated with systems thinking. Thus, in order to differentiate systems thinking from cognitive complexity, we investigated the possibility that systems thinking would be associated with cognitive complexity, but that this association would be accounted for by the relationship between systems thinking and intelligence and personality.

Hypothesis 4 attempted to further differentiate systems thinking by investigating the possibility that systems thinking is more strongly associated with creativity than intelligence, personality, and cognitive complexity. If systems thinking is more predictive of creativity, it would suggest that systems thinking, while related to other aspects of cognition, is nonetheless a distinct construct that contributes uniquely creativity. If such an effect is found, it would suggest that not only is systems thinking distinct, but that it may also be partly driven by executive function. In order to assess creativity, we included three separate self-report measures, the Creative Experiences Questionnaire (Merchelback et al., 2001), the short-form of the Creative Behaviours Inventory (Dollinger, 2011), and the Consequences task (Furnham et al., 2012). Unfortunately, the evidence for self-reported creativity assessment has not advanced as far as other areas in psychology (Silvia et al., 2012), and so creativity researchers recommend administering a variety of assessment measures in order to provide the most accurate picture of creative ability possible (Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012).

Through hypothesis 5, we expected that systems thinking would be more strongly predictive of an improved conceptualization of three complex social problems, homelessness, climate change and addiction, than cognitive complexity, intelligence or personality. In other words, we expected that systems thinking, independent of intelligence, personality, and cognitive complexity, would be significantly associated with performance on this open-ended problem construal task. If systems thinking predicts better performance on the problem construal task than intelligence, personality, or cognitive complexity, it would provide more evidence for the notion that systems thinking, while related to other psychological processes, is a unique cognitive construct.

Research Hypotheses

There were five main hypotheses for this research project:

1. We hypothesized that systems thinking would be more strongly associated with fluid intelligence than crystallized intelligence.
2. We hypothesized that systems thinking would be significantly associated with the Big 5 personality traits of openness to experience and agreeableness.
3. We hypothesized that systems thinking would be associated with one or both indicators of cognitive complexity (attributional complexity or need for cognition), but that cognitive complexity may not contribute uniquely to the prediction of systems thinking beyond its relationships with intelligence and personality.

4. In order to further differentiate systems thinking, we hypothesized that systems thinking would be more strongly predictive of three measures of creativity than intelligence, personality or cognitive complexity.
5. Finally, we hypothesized that systems thinking would be more strongly predictive of performance on three aspects of social problem construal than intelligence, personality or cognitive complexity.

Method

Participants

Introductory Psychology students were recruited from the Lakehead University student pool resulting in a final sample size of *N* = 154 (107 female). Participants' ranged from 18 - 59 years of age, with a mean age of 20.8 (*SD* = 6.38). Participants completed an average of 14.78 years of formal education. Aside from a minimum age of 18, no other exclusion criteria applied. Participants received one bonus mark in their psychology course as a result of participating in this study.

Measures

The Systems Thinking Scale – Revised. The systems thinking scale is a 15-item self report measure (Stroink & Randle, 2013). It is a survey measure designed to assess participants' proclivity for systems thinking. The first draft of this scale included 40 items assessing participants' agreement with statements reflecting beliefs that social, economic, health, and environmental systems were interconnected and dynamic, and that major outcomes can ultimately stem from seemingly small choices. Several items also assessed preferences for organizing information into a larger picture perspective and learning through the integration of subjects and the interconnection of ideas. Sample items include: "The Earth, including all its inhabitants, is a living system", "When I have to make a decision in my life I tend to see all kinds of possible consequences to each choice", and "Adding just one more small farm upstream from a lake can permanently alter that lake". In this study, the systems thinking-revised scale showed an acceptable internal reliability estimate (Cronbach's α) of .74 and is shown in Appendix A.

The Shipley Institute of Living Scale. The Shipley Institute of Living Scale (Shipley, 1967; Zachary, 2000) is a brief measure of general intellectual functioning that is divided into two subtests, a 40-item vocabulary test and a 20-item test of abstract thinking (Zachary, 2000). The Shipley provides age-normed scores on three subtests; a vocabulary subtest, an abstract subtest, and a full-scale estimated intelligence quotient based on the WAIS-R. The Shipley Vocabulary subtest utilized a multiple-choice format in which participants were asked to select one of four words that "means the same or nearly the same" as a specified target word. The Abstraction subtest also utilized a multiple-choice format, and participants were asked to complete a logical sequence of characters by choosing the letter or number that best completes the sequence. The Vocabulary subtest and the Abstraction subtest have been found to significantly correlate with established measures of crystallized and fluid intellectual functioning (see Matthews, Orzech, & Lassiter, 2011). Correct responses are then summed and yields six summary scores: (1) Vocabulary Score, (2) Abstraction score, (3) a Total Score, (4) a Conceptual quotient, (5) Abstraction quotient, and (6) an estimated full scale IQ score. A participants' full-scale IQ score is based on either the Wechsler Adult Intelligence Scale (WAIS) or the revised Wechsler Adult Intelligence Scale (WAIS-R) (Zachary, 2000). Prior research suggests that performance on the Shipley's Vocabulary subtest is a measure of crystallized intelligence functioning, which is thought to reflect learned verbal ability, while performance on the

Abstraction subtest is a measure of fluid intelligence functioning, which reflects problem-solving abilities that are more flowing in nature (Matthews, Orzech, & Lassiter, 2011).

The Creative Experiences Questionnaire. The Creative Experiences Questionnaire (CEQ) is a 25-item self-report measure of fantasy proneness (Merckelback, Horselenberg, & Muris, 2001) and creative experiences. It has been used in prior research as a measure of one aspect of creativity (see Fisher, Heller, & Miller, 2013; Perez-Fabello, & Campos, 2011). The CEQ used a yes/no forced choice response set; "yes" responses are summed to obtain a total score (0 – 25). A higher number of items endorsed as "yes," suggests higher levels of fantasy proneness (Merckelback, Horselenberg, & Muris, 2001). Sample items include "As a child, I thought that the dolls, teddy bears, and stuffed animals that I played with were living creatures" and "As a child, I devoted my time to playing a musical instrument, dancing, acting, and/or drawing." In this study, the CEQ showed an acceptable internal reliability estimate (Cronbach's α) of .78 and is shown in Appendix B.

The Creative Behaviour Inventory – Short Form (Dollinger, 2011). The Creative Behaviour Inventory-short form (CBI) is a 28-item measure of creativity. The short form of the CBI has been utilized in numerous studies and is a widely accepted self-report measure of creativity (Dollinger, 2003; Silvia et al., 2012). The CBI asks participants to indicate how often they have participated in various creative behaviours in their adolescent or adult lives, using a 4-point scale with scores ranging from "*0 = Never Did This*" to "*3 = Did This More Than 5 Times.*" Sample items include "Painted an original picture (excluding school or university course work)" and "Designed and made a piece of clothing (excluding school or university course work). In this study, the CBI had an excellent internal reliability estimate (Cronbach's α) of .87 and is shown in Appendix C.

Modified Version of the Consequences Test. Christensen, Merrifield and Guilford originally developed this test in 1953 (as cited in Furnham et al., 2011) and it has been utilized in recent studies (e.g., Furnham et al., 2011; Furnham & Nederstrom, 2010; Randle, 2012) as a brief measure of creativity. The consequences task involves presenting participants with three highly unlikely, hypothetical situations and participants were asked to list as many consequences of these situations as possible. These scenarios included: the onset of sudden deafness, the onset of sudden colourblindness, and suddenly not needing to eat. Participants were asked to list as many consequences as they could for each of these hypothetical situations. Responses were then summed to produce a Fluency score. A participant's fluency score is a measure of creative ability. In this study, the consequences task showed an acceptable internal reliability estimate (Cronbach's α) of .79 and is shown in Appendix D.

Cognitive Complexity. To assess the broader construct of cognitive complexity, we administered two scales, the Need for Cognition scale (Cacioppo & Petty, 1982) and the Attributional Complexity scale (Fletcher, Danilovics, Fernandez, Peterson, & Reeder, 1986). These scales have been used in prior research in order to assess cognitive complexity (e.g., Reid & Foels, 2010). The Need for Cognition scale is a 34-item self-report measure rated on a 7-point Likert scale. In an earlier study, the Need for Cognition scale demonstrated an internal reliability coefficient of .91 (Randle, 2012), which is consistent with previous studies (e.g., Woo, Harms, & Kuncel, 2007; Cronbach's α = .90). Sample items include: "More often than not, more thinking just leads to more errors" and "I enjoy thinking about an issue even when the results of my thought will have no effect on the outcome of the issue." In this study, the Need for Cognition scale showed an excellent internal reliability estimate (Cronbach's α) of .91 and is shown in Appendix E.

The Attributional Complexity scale (Fletcher et al., 1986) measures an individual's preference for complex, rather than simple, explanations for human behaviour and has been used in prior research as one aspect of cognitive complexity (e.g., Reid & Foels, 2010). This scale is a 28-item self-report measure that asks respondents to rate their agreement with a variety of statements using a 7-point Likert scale (1 = Strongly Disagree). Sample items include: "I think a lot about the influence that society has on my behavior and personality" and "When I try to explain other people's behavior I concentrate on the person and don't worry too much about all the existing external factors that might be affecting them." In this study, attributional complexity scale showed an excellent internal reliability estimate (Cronbach's α) of .91 and is shown in Appendix F.

The NEO-FFI-3 (Costa & McCrae, 2010). The NEO-FFI-3 is a shortened, 60-item self-report version of the NEO-PI and is designed to assess the Big 5 personality traits of conscientiousness, agreeableness, neuroticism, openness to experience, and extraversion. The NEO-FFI used a 5-point Likert-type scale (0 = Strongly Disagree and 4 = Strongly agree) and is amongst one of the most widely used measures of personality (Park et al., 2013). The NEO-FFI has been used in recent research (e.g., Beauchamp, Lecomte, Lecomte, Leclerc, & Corbriere, 2013; Spinhoven et al., 2012) as a brief, psychometrically valid measure of personality. Sample items include "I am not a worrier", "I am a very active person", and "I am a productive person who always gets the job done." In this study, the subscales on the NEO-FFI showed internal reliability estimates (Cronbach's α) ranging from .75 - .86 and is shown in Appendix G.

The Problem Construal Task. The problem construal task is a qualitative, open-ended measure designed to suit the purposes of the proposed research. It was devised in order to assess how participants tend to perceive and describe complex situations and problems. For the purposes of this research, we generated three complex social problems: homelessness, climate change, and addiction. Participants were asked to write 3 separate paragraphs describing what they believed to be the cause(s) of each of the three issues, and then to propose a solution to each. Responses were coded to generate a numerical score based on three aspects of systems thinking: (1) number of casual components used in describing the cause as well as the solution, (2) number of connections used to describe the cause and solution, and (3) the identification and consideration of other complex systems that influence the problem but may not be the direct cause of it. The complete open-ended task is shown in Appendix H.

The Marlowe-Crowne Social Desirability Scale. The Marlowe-Crowne social desirability scale is a 33-item true/false measure that assesses the tendency to respond in a favourable light (also known as Faking-Good). The true/false format was coded 0 = True and 1 = False, and a higher score indicates a more socially desirable response set. This scale demonstrates an internal consistency coefficient (using the Kuder-Richardson formula) of .88 (Crowne & Marlowe, 1960) and a test-retest reliability coefficient of .89 (Crowne & Marlowe, 1960). In this study, the Marlowe-Crowne SDS showed an acceptable internal reliability estimate (Cronbach's α) of .77 and is shown in Appendix I.

Demographics Questionnaire. This brief questionnaire collected background information around participants' age, gender, year of study, their major academic interest(s), ethnicity and the total number of years of formal education completed. This demographic information was kept confidential. The demographics questionnaire is shown in Appendix J.

Procedure

Participants were recruited from Introductory Psychology courses. Participants who elected to participate in this study completed an online survey package. An e-mail invitation was sent out to Introductory Psychology courses that briefly described the intent and procedure of this study and provided potential participants with a Survey Monkey link. Once participants followed this link, they were presented with an electronic version of the cover letter (Appendix H) outlining the details of the present study. The cover letter discussed the nature of the tasks involved in this study. It also discussed the voluntary nature of the study. Further, it informed participants that any information provided will be held in strict confidentiality, and it also discussed bonus point information. The cover letter also informed potential participants that there was no foreseeable risk for participating in this study. Participants were informed that there was no penalty for choosing not to participate in this research. Once participants read this cover letter, they then proceeded to the next screen containing an electronic version of the informed consent form (Appendix I). This form further discussed confidentiality and anonymity and informed participants that we anticipated no risk as a result of participating in this study. Participants indicated their consent by clicking the “accept” button located at the end of the consent form; if individuals did not want to participate they were instructed to exit their browser window. Following the consent form screen, participants were presented with a series of screens containing the survey package. Once the participant had progressed through all survey screens, they were presented with another link to follow in order to input bonus point information. We made use of this second survey in order to ensure that provided data could not be associated with participant identity.

Results

Initial Data Screening

Obtained data was checked for data entry errors. Descriptive statistics for all major scales can be seen in Table 1. Reliability analysis was performed using Cronbach's alpha for all scales. Scale Means were calculated and histograms were examined to check for normality.

Table 1

Descriptive Statistics of all Major Scales

Measure	*n*	*M*	*SD*	α
Systems Thinking	154	5.31	.63	.74
Vocabulary (Crystallized)*	142	57.59	6.90	--
Abstraction (Fluid)*	142	51.43	7.04	--
Total IQ*	142	53.99	6.43	--
Conscientiousness	154	3.39	.53	.81
Agreeableness	154	3.58	.53	.80
Neuroticism	154	3.11	.68	.86
Openness	154	3.44	.50	.75
Extraversion	154	3.55	.49	.78

Note: * Intelligence scores indicate Age-Normed T-Scores (Zachary, 2000)

Descriptive statistics were also calculated for all outcome measures and are shown in Table 2. Outcome measures were also checked for data entry errors as well as reliability analysis (Cronbach's α). As expected, of all scale means, only two were significantly non-normal using the z-distribution, the Creative Behaviour Inventory (CBI) and the Creative Experience Questionnaire (CEQ). To compensate for non-normality, mean CBI score was transformed by applying a common base 10 logarithmic transformation. This transformation method has been outlined in Tabachnick and Fiddell (2013), and all subsequent analysis involving the CBI variable was carried out on transformed values. Total CEQ scores were also transformed via a simple square root transformation (Tabachnick & Fiddell, 2013), and all subsequent analysis involving CEQ scores were carried out on transformed values.

Correlations between demographics and systems thinking, intelligence, personality traits, need for cognition, attributional complexity, creative behaviours, creative experiences, creativity as evidenced by performance on the consequences task, and problem construal were calculated. Analysis revealed no significant associations between age and scale means. Correlational analysis also revealed that years of formal education was only significantly associated with openness to experience, $r = .18$, $p = .05$, indicating that individuals who have completed more years of formal education scored higher in openness to experience.

Table 2

Descriptive Statistics for all Outcome Scales

Measure	*n*	*M*	*SD*	α
Need for Cognition	150	4.28	.62	.91
Attributional Complexity	147	4.68	.64	.91
Creative Behaviours (CBI)[a]	154	.24	.10	.87
Creative Experience (CEQ)[b]	154	2.99	.71	.78
Creativity (Consequences)	152	9.29	3.58	.79
Problem Construal (Causes) [c]	126	7.50	3.79	--
Problem Construal (Links) [c]	126	3.93	1.71	--
Problem Construal (Systems) [c]	126	3.97	1.66	--

Note: [a] Log10 Transformed
[b] Square Root Transformed
[c] Open-Ended Task

A one-way ANOVA revealed significant effects of gender on agreeableness, with females scoring higher than males, $F(1, 139) = 7.20$ $p = .01$. There was a significant effect of gender on neuroticism, with females scoring higher than males, $F(1, 139) = 6.31$ $p = .01$. There was also a highly significant effect of gender on need for cognition F (1, 138) = 13.50 p = .01, with females indicating a higher need for cognition than males, as well as a significant effect of gender on creative behaviours, F (1, 139) = 7.51 p = .01, indicating that female participants tended to engage in more of the measured behaviours than males, means and standard deviations for all significantly different variables are shown in Table 3. There were no significant effects of gender on any other scale variables.

Table 3

Means and Standard Deviations for Significant Effects of Gender

Measure	Male	Female
Agreeableness	3.37 (.54)	3.67 (.54)
Neuroticism	2.85 (.74)	3.17 (.63)
Need for Cognition	4.59 (.70)	4.18 (.53)
Creative Behaviours	.20 (.08)	.25 (.11)

Hypothesis 1: Systems Thinking and Psychometric Intelligence

We hypothesized that systems thinking would be more strongly associated with fluid intelligence than crystallized intelligence. In order to allow meaningful interpretation of obtained intelligence scores, raw scores were transformed into standardized t-scores (Zachary, 2000), and all subsequent analysis was carried out using these standardized scores. As an initial analysis, bivariate correlations revealed that systems thinking was significantly correlated with all three intelligence scores. Correlations are shown in Table 4. These findings indicate that increased systems thinking is associated with generally higher levels of intellectual functioning across all three subscales on the Shipley Institute of Living Scale.

Table 4

Correlations Between Systems Thinking and Intelligence Measures

Measure	*n*	*r*
Verbal Intelligence	142	.38**
Abstract Reasoning	142	.17*
Full-Scale IQ	142	.30**

Note: * Correlation is Significant at .05 level

** Correlation is Significant at .01 level

Given that all three intelligence scores were significantly associated with systems thinking, all four variables were entered into a stepwise regression model predicting systems thinking. Verbal intelligence was entered at the first step, and the overall ANOVA model was significant, F (1, 140) = 23.73, $p < .0001$. Abstract reasoning was entered into the model at the second step and was also significant, F (2, 139) = 12.26, p < .0001. Finally, overall intelligence was entered at the last step and again, the overall model was significant. F (3, 138) = 8.21, $p <$ .0001. Inspection of the co-efficients however, suggests that only verbal intelligence (a measure of crystallized intelligence; Matthews, Orzech, & Lassiter, 2011) accounted for a significant portion of variance in both model 1, $B = .38$, t (141) = 4.87, $p < .0001$ and in model 2, $B = .36$, t (141) = 4.42, $p < .0001$. Contrary to our first hypothesis then, these findings indicate that only verbal intelligence predicted a significant amount of variance in systems thinking, $R^2 = .15$, F (1, 140) = 23.73, $p < .0001$, while abstract reasoning (a measure of fluid intelligence; Matthews, Orzech, & Lassiter, 2011) and general intelligence did not account for significant variance in obtained systems thinking scores.

Hypothesis 2: Systems thinking and the Big 5 Model of Personality

Secondly, we hypothesized that systems thinking would be significantly associated with both openness to experience and agreeableness. Consistent with this hypothesis, bivariate correlations between systems thinking and personality traits revealed that systems thinking was significantly associated with both openness to experience and agreeableness. Correlations for all personality traits are shown in Table 5. This initial analysis indicates that systems thinking is related to two aspects of personality, increased agreeableness and increased openness to experience.

In order to further investigate the relationship between systems thinking and personality, openness to experience and agreeableness were entered into a multiple regression model with systems thinking as the criterion variable. The overall ANOVA model was highly significant, $R^2 = .31$, (2, 150) = 33.00, $p < .0001$. Inspection of the coefficients showed that nearly 48% of variance in systems thinking was explained by openness to experience alone, $B = .48$, t (150) = 6.26, $p < .0001$, while agreeableness explained 2%, $B = .19$, t (150) = 2.78, $p = .006$. These findings suggest that individuals, who are higher in openness to experience as well as agreeableness, may be more likely to engage in systems thinking.

Table 5

Correlations between Systems Thinking and Personality Traits

Measure	*n*	*r*
Conscientiousness	153	-.004
Agreeableness	153	.28**
Neuroticism	153	.09
Openness to Experience	153	.52**
Extraversion	153	.12

Note: * Correlation significant at the .05 level

** Correlation significant at the .01 level

Hypothesis 3: Systems Thinking and Cognitive Complexity

We hypothesized that systems thinking would be positively associated with two measures of cognitive complexity, the Need for Cognition and Attributional Complexity, but that the relationship between systems thinking and each measure of cognitive complexity would not uniquely contribute to systems thinking beyond personality and intelligence. To test this possibility, we calculated bivariate correlations between systems thinking and cognitive complexity. Bivariate correlational analysis revealed that systems thinking was significantly associated with both the need for cognition, $r = .18$, $p = .05$ and attributional complexity, $r = .48$, $p = .01$, thus providing support for the first part of this hypothesis. We then regressed systems thinking on the need for cognition as well as attributional complexity. Linear regression analysis revealed that the overall ANOVA model was highly significant, $R^2 =. 23$, $F (2, 144) = 22.02$, $p < .0001$, explaining approximately 23% of obtained variance in systems thinking scores. Inspection of the regression coefficients however, revealed that this effect was only accounted for by attributional complexity, $B = .49$, $t (144) = 6.11$, $p < .0001$, while the need for cognition was non-significant, $B = -.02$, $t (144) = -.23$, *n.s.*

The second part of this hypothesis was that attributional complexity would not uniquely explain systems thinking. In order to test this prediction, we conducted a final linear regression using intelligence, personality, and attributional complexity as predictor variables and systems

Table 6

Regression Coefficients between Systems Thinking and Psychological Variables

Measure	*B*	*SE B*	*p*
Attributional Complexity	.23	.08	.004
Openness to Experience	.31	.10	< .001
Agreeableness	.16	.08	.03
Verbal Intelligence	.16	.08	.04
Abstract Reasoning	.04	.01	*ns*

Note: *ns* = Not Significant

thinking as the criterion variable. Analysis revealed that the overall ANOVA model was highly significant *F* (5, 135) = 16.42, $p < .0001$, explaining approximately 38% of obtained variance in systems thinking scores. Regression coefficients revealed that all four variables, attributional complexity, openness to experience, agreeableness, and verbal intelligence retained significance in predicting systems thinking, and that openness to experience and attributional complexity are the two strongest predictors. Regression coefficients are shown in Table 6.

Hypothesis 4: Systems Thinking and Creativity

We hypothesized that systems thinking would be more strongly predictive of three measures of creativity than intelligence, personality or cognitive complexity.

To test this postulation, bivariate correlations were calculated between mean systems thinking scores and three measures of self-report creativity: the Creative Behaviour Inventory (Dollinger, 2011), the Creative Experience Questionnaire (Merckelback, Horselenberg, & Muris, 2001), and a modified version of the Consequences task. Correlations between all measures are shown in Table 7. Contrary to our hypothesis, systems thinking was only significantly associated with performance on the consequences task, while openness to experience was significantly associated with all three creativity tasks. Intelligence and agreeableness were only significantly associated with scores on the consequences task.

Given that systems thinking, verbal intelligence, abstract reasoning, personality and attributional complexity were all significantly associated with performance on the consequences task, we entered all variables into a linear regression model. Regression analysis indicated that, while the overall ANOVA model was significant, *F* (6, 133) = 4.54, $p < .0001$, an examination of the coefficients revealed that this effect was accounted for mainly by attributional complexity, *B* =. 19, *t* (133) = 2.03, *p* = .04, and abstract reasoning, *B* = .19, *t* (133) = 2.28, *p* = .02, while systems thinking approached significance, *B* = .18, *t* (133) = 1.83, *p* = .07, all other coefficients where non-significant. Due to the similarity in coefficients between systems thinking and attributional complexity, we ran another linear regression entering only systems thinking, attributional complexity, and abstract reasoning as predictors, excluding verbal intelligence and personality. Analysis showed that a regression model using only these three predictors was significant, $R^2 = .15$, $F(3, 136) = 8.34$, $p < .0001$. Regression coefficients revealed that systems thinking, *B* = .19, *t* (136) = 2.07, *p* = .04, abstract reasoning, *B* = .19, *t* (136) = 2.33, *p* = .02, and attributional complexity, *B* = .18, *t* (136) = 2.00, *p* = .05 each explained unique portions of variance in performance on the consequences task.

Table 7

Correlations between Systems Thinking, Intelligence, Personality and Creativity

Measure	CBI	CEQ	Conseq.
Systems Thinking	.05	.14	.31**
Verbal Intelligence	.03	-.06	.21*
Abstract Reasoning	.04	-.03	.25**
Openness to Experience	.31**	.41**	.17*
Agreeableness	.05	-.08	.17*
Attributional Complexity	.11	.21*	.30**
Need for Cognition	-.06	< -.00	-.01

Note: * Correlation Significant at .05 level

** Correlation Significant at .01 level

Hypothesis 5: Systems thinking and Social Problem Construal

Our final hypothesis was that systems thinking, while associated with intelligence, personality, and cognitive complexity, would make unique variance contributions to performance on the social problem construal task, coded for the number of causes, causal links, and reference to other external influences, independent of intelligence. Bivariate correlations are shown in

Table 8. Analysis revealed that systems thinking, attributional complexity, openness to experience, agreeableness, and verbal intelligence were all positively associated with the number of causes identified in the social problem construal task. Bivariate correlations also revealed that these same constructs were also positively associated with the number of links identified. A final set of bivariate correlations found that systems thinking, attributional complexity, agreeableness, and verbal intelligence were positively associated with the number of external systems identified, while openness to experience was not. Given the relatively strong relationships between systems thinking, verbal intelligence, personality and attributional complexity with each aspect of the consequences task, we entered these variables into separate hierarchical regression models.

Table 8

Correlations between Major Scales and Social Problem Construal

Measure	Causes	Links	External Systems
Systems Thinking	.37**	.31**	.26**
Attributional Complexity	.35**	.30**	.23**
Openness to Experience	.31**	.27**	.12
Agreeableness	.26**	.18*	.31**
Verbal Intelligence	.43**	.36**	.31**
Abstract Reasoning	.11	.12	.08

Note: * Correlation significant at the .05 level
** Correlation significant at the .01 level

In our first hierarchical regression, the number of causes identified was entered as the criterion variable and verbal intelligence, attributional complexity, openness to experience, and agreeableness were entered as predictors at the first step and systems thinking was entered as a predictor at the second step. This design allows us to examine the effect of systems thinking while controlling for all other predictors. Model 1 was significant, $R^2 = .26$, F (4, 120) = 10.31, $p < .0001$. However while Model 2 was significant, F (1, 119) = 8.59, $p < .0001$, adding systems thinking as predictor only resulted in an improved $R^2 = .27$ and did not result in a statistically significant change, F (1, 119) = 1.53, $p = .22$. Inspection of the regression coefficients revealed that only verbal intelligence, B =. 27, t (119) = 3.05, $p = .003$, remained as a significant predictor of performance.

In our second hierarchical regression, total number of links identified was entered as the criterion variable and verbal intelligence, attributional complexity, openness to experience, and agreeableness entered as predictors at the first step and systems thinking was entered as a predictor at the second step. Model 1 was significant, $R^2 = .17$, F (4, 120) = 6.13, $p < .0001$. However while Model 2 was also significant, F (5, 119) = 5.16, $p < .0001$, adding systems thinking as predictor only resulted in an improved $R^2 = .18$ and did not result in a statistically significant change, F (1, 119) = 1.24, $p = .27$. Inspection of the regression coefficients revealed that only verbal intelligence, B =. 23, t (119) = 2.45, $p = .02$, remained as a significant predictor of performance.

In our final hierarchical regression, the number of external systems identified was entered as the criterion variable, and verbal intelligence, attributional complexity, and personality were entered as predictors at the first step, and systems thinking entered at the second step. Model 1 was significant, $R^2 = .17$, F (3, 121) = 8.04, $p < .0001$. However while Model 2 was also significant, F (4, 120) = 6.14, $p < .0001$, adding systems thinking as predictor did not result in an improved $R^2 = .18$ and did not result in a statistically significant change, F (1, 120) = .52, p =

.47. Inspection of the regression coefficients revealed that only verbal intelligence, *B* =. 20, *t* (120) = 2.14, $p = .03$, and agreeableness, *B* =. 22, *t* (120) = 2.53, $p = .01$, remained as a significant predictors of performance.

Results from three separate hierarchical regressions found that systems thinking was not a significant predictor of performance in any aspect of the problem-construal task. However, due to the written nature of this task, it is possible that the effects of systems thinking, attributional complexity, and personality are masked by individual differences in writing ability, irrespective of systems thinking. In order to control for this possibility, we re-ran these hierarchical regression models but excluded verbal intelligence from each.

A hierarchical regression model with the total number of causes identified as the DV, showed that Model 1, was significant, $R^2 = .18$, F (3, 122) = 9.11, $p < .0001$. Model 2 was also significant, F (4, 121) = 7.93, $p < .0001$, and adding systems thinking as predictor showed an improved $R^2 = .21$ and resulted in a statistically significant change, F (1, 121) = 3.77, $p = .05$. Inspection of the regression coefficients revealed that attributional complexity, *B* =. 19, *t* (121) = 2.00, $p = .04$, and systems thinking, *B* =. 19, *t* (121) = 1.94, $p = .05$, remained significant predictors of performance.

A second hierarchical regression model with the total number of links identified as the DV, showed that Model 1 was significant, $R^2 = .12$, F (3, 122) = 5.39, $p = .002$. Model 2 was also significant, F (4, 121) = 4.79, $p = .001$, but adding systems thinking as predictor showed an only marginally improved $R^2 = .14$ and did not result in a statistically significant change, F (1, 121) = 2.75, $p = .10$. Inspection of the regression coefficients revealed no statistically significant predictors of performance on this aspect of the task.

A final hierarchical regression model with the total number of external systems identified as the DV, showed that Model 1 was significant, $R^2 = .12$, $F(3, 122) = 5.76$, $p = .001$. Model 2 was also significant, $F(4, 121) = 4.96$, $p = .001$, but adding systems thinking as predictor showed an only marginally improved $R^2 = .14$ and did not result in a statistically significant change, $F(1, 121) = 2.36$, $p = .13$. Inspection of the regression coefficients revealed that only agreeableness, $B = .25$, $t(121) = 2.80$, $p = .006$, was a statistically significant predictor of performance on this aspect of the task.

Discussion

This research was a preliminary investigation into the psychological construct of systems thinking. Specifically, we were interested in better understanding how systems thinking may relate to other well-known psychological constructs such as personality, creativity, and cognitive complexity. Towards this aim, we developed 5 separate hypotheses based on previous studies and our own read of the existing, but sparse, literature in the systems thinking area.

Summary of Main Findings

Hypothesis one was that systems thinking, given its relationship with creativity (Randle & Stroink, 2012), would be more strongly associated with fluid intelligence than crystallized intelligence. Bivariate correlations revealed that systems thinking was significantly associated with all three intelligence measures (verbal intelligence, abstract reasoning, and estimated full-scale IQ) and not just to fluid intelligence (abstract reasoning), as we had hypothesized. Somewhat surprisingly, regression analysis showed that only verbal intelligence (an indicator of crystallized intelligence) remained as a significant predictor of systems thinking, while abstract reasoning (an indicator of fluid intelligence) and estimated IQ were not. These results suggest that systems thinking is not redundant with one's ability to reason (fluid intelligence), and that systems thinking may be linked with an individual's level of verbal intelligence.

Our second hypothesis was aimed at better understanding the relationship between systems thinking and the Big 5 model of personality traits (Costa & McCrae, 2010). We postulated that systems thinking would only be significantly associated with agreeableness and openness to experience. Analysis revealed that hypothesis two was indeed supported, and only openness to experience and agreeableness were significantly associated with systems thinking in this sample, while conscientiousness, neuroticism, and extraversion were not. Regression analysis found that openness to experience was the strongest predictor of systems thinking in this sample accounting for approximately 48% of explained variance in systems thinking scores.

Our third hypothesis investigated the potential relationships between systems thinking and cognitive complexity. Specifically, we predicted that systems thinking would be positively associated with two measures of cognitive complexity, the need for cognition and attributional complexity (e.g. Reid & Foels, 2010), and that cognitive complexity would not *uniquely* explain systems thinking over and above intelligence or personality. Analysis revealed that only the first aspect of this hypothesis was supported. Systems thinking was significantly associated with attributional complexity as well as the need for cognition, though of these two only attributional complexity predicted systems thinking in a linear regression model. Contrary to the second part of this hypothesis, further regression analysis indicated that attributional complexity remained a strong and significant predictor of systems thinking, along with openness to experience, agreeableness, and verbal intelligence. Thus, this finding suggests that systems thinking is related to all three attributes, intelligence, personality, and attributional complexity as an indicator of cognitive complexity.

In our fourth hypothesis, we predicted that systems thinking would be more strongly predictive of three measures of creativity than intelligence, personality or cognitive complexity. Again, contrary to our expectations, bivariate correlations revealed that systems thinking, intelligence, personality, and cognitive complexity were only significantly associated with performance on one measure of creativity, the consequences task. Only openness to experience was significantly associated with a tendency to engage in creative behaviours or fantasy proneness. Given these relationships, we decided to regress performance on the consequences task with our major variables. In this initial regression model, we entered all variables that were statistically significant as predictors. In this model, only the coefficients for abstract reasoning and attributional complexity were statistically significant while systems thinking approached significance. However, it is possible that the effect of systems thinking in predicting performance on the consequences task may have been masked by the influence of verbal intelligence and personality, making a significant effect harder to detect. Thus, we created a second regression model using only systems thinking, attributional complexity and abstract reasoning as predictors. This model explained approximately 16% of the variance in consequences scores, with each variable contributing a statistically significant amount of unique variance in consequences scores. This finding suggests that systems thinking affects creativity differently than either abstract reasoning or attributional complexity, although all three are predictive of creativity. This finding provides further preliminary evidence that systems thinking is a unique psychological construct.

Our final hypothesis examined the relationships between systems thinking, intelligence, personality, attributional complexity and social problem construal in order to test whether systems thinking is independent of each construct when participants were considering complex social problems. Contrary to our postulation however, verbal intelligence, personality, and attributional complexity in addition to systems thinking were all significantly associated with performance on the social problem construal task. As a result, we entered verbal intelligence, personality, attributional complexity and systems thinking into a hierarchical regression model with performance on each aspect of the problem construal task as criterion variables. Results from these analyses suggested that only verbal intelligence predicted a significant amount of variance in the number of causes and links identified, while verbal intelligence and agreeableness predicted significant amounts of variance in the identification of external systems in the problem construal task. However, due to the verbal nature of this task, we decided to run a second set of hierarchical regressions that did not include verbal intelligence as a predictor. Results from these analyses showed that systems thinking remained a significant predictor of performance in identifying more causal components, while it was non-significant in predicting the number of links identified or the number of external systems. Because systems thinking was associated with performance on the task but was not predictive of performance, it seems that systems thinking may be indirectly involved in social problem construal, while increased verbal intelligence was necessary to perform well on the task.

Systems thinking and Other Psychological Constructs

As mentioned above, the overarching goal of this study was to examine the psychological construct of systems thinking in greater detail by examining systems thinking in relation to the cognitive processes of intelligence, personality, and cognitive complexity. As a result, this project was largely exploratory in nature, given the dearth of literature available on the psychological construct of systems thinking. Throughout this project, we proceeded through two levels of analysis: correlation, and multiple regressions. This two-step analysis allowed us to (1) establish statistically significant associations between systems thinking, intelligence, and personality, (2) establish the predictive characteristics of systems thinking beyond intelligence and personality, and (3) garner a deeper appreciation of the underlying psychological processes that may necessitate systems thinking. The results from this study suggest that systems thinking appears to be significantly related to three separate psychological constructs. As a result of both correlation and multiple regression analysis, it appears that the psychological construct of systems thinking is at least partly driven by verbal intelligence, openness to experience, and a preference for more complex explanations (attributional complexity) for social behaviour.

Systems thinking and Psychometric Intelligence. Across all analyses, verbal intelligence consistently emerged as a predictor of systems thinking. The relationship between systems thinking and verbal intelligence was especially prevalent in the open-ended, social problem construal task. Verbal intelligence scores as measured by the Shipley scale have been argued to be a valid measure of an individual's crystallized intelligence (Matthews, Orzech, & Lassiter, 2011). However, the result of this study suggests an alternative interpretation, and it's possible that the Shipley actually taps only one aspect of crystallized intelligence, namely verbal ability. Because the Shipley vocabulary subtest does not include items that assess fact-based knowledge stored in memory, it is essentially a word association task. That is, in order to perform well on this test, participants were required to connect the target word with other semantically similar words, while simultaneously excluding distraction words. Thus, performance on this test may reflect an improved ability to think in a more connected manner, which could facilitate performance on a written task such as our social problem construal task. Our regression results support this notion because verbal intelligence was consistently a strong predictor of improved performance on the problem-construal task, which could illustrate a greater tendency to think in terms of connection and so enable the identification of more causes, and the links between each.

Again, due to the verbal nature of the task, in a second set of hierarchical regression analyses, we removed the influence of verbal intelligence in predicting performance on the problem construal task. When we removed verbal intelligence from the model, only systems thinking and attributional complexity remained as significant predictors of increased performance in the number of causes identified. However, this effect was not found for the number of links identified or a higher number of external systems identified. Thus, systems thinking may uniquely contribute to the ability to identify more causes for complex social problems but was not uniquely involved in affecting the number of links or external systems articulated by participants.

In addition to having some unique role in affecting how complex social problems are described, systems thinking also plays a role in creativity. This study found that systems thinking was a unique predictor of creativity beyond abstract reasoning, once verbal intelligence and personality were removed from the regression model. Another possibility is that verbal intelligence is highly apposite to performance on open-ended written tasks. Again, by having participants sit down and write an essay, we may have been inadvertently tapping an increased writing ability, rather than the psychological construct of systems thinking. Such questions await further research.

Systems Thinking and Personality. As mentioned earlier, a multiple regression analysis found that nearly 48% of the variance in obtained systems thinking scores was accounted for by openness to experience, while adding agreeableness to the model increased explained variance by 2%. Systems thinking was not significantly associated with conscientiousness, neuroticism, or extraversion. Thus, it appears that individuals who are higher in openness to experience are also more likely to engage in systems thinking. These findings suggest that being higher in openness to experience may be a precursor to systems thinking tendency. The strong association between systems thinking and openness to experience found in this study may not be entirely surprising given the similarities between systems thinking and openness to experience (Costa & McCrae, 2010). It has been suggested that open individuals tend to entertain novel ideas more readily than less open individuals and are more likely to hold values less in line with social norms (Gregory, Nettelbeck, & Wilson, 2010) both of which are traits that would seem consistent with our definition of systems thinking. In contrast, more "closed" individuals tend to embrace the familiar and are less likely to try something new, which may be more indicative of a preference for a more familiar, predictable, and hence linear, cognitive tendencies.

Systems Thinking and Attributional Complexity. Attributional complexity may be involved in systems thinking because the operational definition of the construct involves several aspects thought to also be indicative of systems thinking. These aspects include the preference for complex explanations, an awareness of the extent other peoples' behaviours are a function of interactions with others, the tendency to think about the underlying processes involved in causal attributions, and a tendency to infer external causes operating from the past (a dynamic component) (Fletcher et al., 1986). These aspects of attributional complexity are also present in systems thinking, and so help explain the relatively strong relationship between systems thinking and attributional complexity. However, the definition and measure of attributional complexity involves a motivational component not seen in systems thinking. It is assumed that people scoring lower in attributional complexity are not motivated to do so, whereas systems thinking is considered more of a cognitive paradigm or way of thinking that people hold in varying degrees.

However it is likely that systems thinkers can also engage in more linear thinking should the situation warrant it, such that the awareness of other, less important components are "filtered out" of the problem space or are ignored. Such a supposition raises an intriguing question. That is, do individuals who are systems thinkers have no choice but to engage in systems thinking, or can it be "switched" on and off? Future research should attempt to investigate this possibility. Another important distinction between systems thinking and attributional complexity is the theoretical foundation underlying systems thinking. The systems thinking construct reflects people's capacity to think in a manner consistent with complex adaptive systems theory, regardless of any formal training or use of the terminology. Thus, the construct taps a cognitive paradigm with theoretical roots. Attributional complexity involves people's motivation to consider more complex explanations for people's behaviour, and as such is generally consistent with systems thinking, but does not have the same breadth.

Systems Thinking, Creativity, and Social Problem Construal

In addition to examining systems thinking and its relationship to intelligence, personality, and cognitive complexity, we were also interested in investigating systems thinking in the context of two other outcome variables, namely creativity and social problem construal. Previous research conducted by the authors found that systems thinking was significantly related to performance on a measure of creativity (Randle & Stroink, 2012), and so we attempted to replicate this finding using two other measures of creativity. We predicted that systems thinking would be related to creativity. However, our analysis showed that systems thinking was only related to the consequences task, which assesses one aspect of creativity, and it was not associated with an increased tendency to engage in creative behaviours or an increased tendency to engage in fantasy and daydreaming. Of the three measures of creativity, the consequences task is the one that best taps divergent thinking, so it is noteworthy that this capacity to generate a broad list of potential consequences to an unexpected event is associated with systems thinking. Indeed, systems thinking may be tapping a capacity to detect connections and to associate concepts widely.

While systems thinking was significantly associated with performance on the consequences task, it did not uniquely predict performance when entered into our initial regression model. However, our second analysis found that systems thinking, abstract reasoning, and attributional complexity were significant predictors of performance once the influence of verbal intelligence and personality were removed from the regression model. These findings suggest that systems thinking is not redundant with abstract reasoning or attributional complexity, but alongside these constructs, makes unique contributions to predicting creativity as assessed with the consequences task. Additionally, because systems thinking uniquely explained portions of variance in creativity scores as well as abstract reasoning (an indicator of fluid intelligence) and attributional complexity it suggests that systems thinking is not a product of either fluid intelligence or attributional complexity. It is possible that these unique processes may affect divergent thinking differently. Indeed, it may be that the tendency to think in terms of connections is a characteristic of divergent thinking, while forming these links into a cohesive solution may rely on an executive function that is being tapped with our measure of abstract reasoning (Nisbett et al., 2012). These findings suggest that systems thinking may be a separate, but related, psychological construct from both fluid intelligence and attributional complexity, since all three have unique relationships with creativity scores.

We were also interested in examining the effects of systems thinking in the context of complex problem construal. We hypothesized that individuals who engage in systems thinking would be more likely to conceptualize complex problems such as homelessness, climate change, and addiction by considering (1) a higher number of system components, (2) a higher number of links between influencing system components and (3) a greater number of causal factors that are seemingly external to the problem domain (e.g. not co-located with the issue). In order to test this possibility, we developed an open-ended written task designed to assess differences in problem-construal. Contrary to our hypothesis, systems thinking did not significantly predict performance on this task, while verbal intelligence consistently emerged as a significant predictor. However, once we removed verbal intelligence from the regression model, systems thinking did predict the number of causal factors identified, as did attributional complexity. This finding suggests that while related to attributional complexity, systems thinking maintains some unique role in predicting problem construal. Moreover, openness to experience and agreeableness did not predict performance on this aspect of the task, which suggests that systems thinking is indeed a separate construct from personality.

Limitations of the Study and Future Directions

This study, while providing some support for the notion that systems thinking is a separate construct from intelligence, personality, and cognitive complexity, it is not without its limitations. The first limitation of this study is the relatively restricted sample used for analysis. We utilized a convenience sample of introductory psychology students, from a relatively heterogeneous population, and thus the generalizability of these results could be called into question. Because this study made use of intelligence scores obtained from a relatively young university population, there is the possibility of inflated intelligence scores. It is quite possible that our sample is reflective of a population with a specific intellectual ability and so systems thinking may manifest differently in individuals who did not attend university. Additionally, it is possible that systems thinking follows a developmental course. If this is true, more developmentally mature individuals may demonstrate superior systems thinking qualities. This seems particularly likely given the relationship found between systems thinking and verbal intelligence, which can follow a developmental course (Nesbitt et al., 2012). Future studies should utilize a more general sample across a variety of individuals drawn from a larger, more general population. A second limitation of this study is it's cross-sectional design. While time constraints necessitated a cross-sectional study, a longitudinal study would be more informative and would facilitate the study of the emergence of systems thinking over critical developmental periods. Another limitation of this study is that performance on the social problem construal task is highly dependent on verbal intelligence, and so it is possible that the effects of systems thinking on social problem construal were masked by the verbal nature of the task. If this is true, it could account for why systems thinking did not predict social problem construal when verbal intelligence was also in the model. Future research could make use of a structured interview design, in which participants are asked to verbally explain these social problems. Such a design would allow the exploration of qualitative problem construal without having to rely on pre-existing writing ability, which is likely to be higher in a University samples like the one utilized here.

In this study, analysis suggests that verbal intelligence, openness to experience, and attributional complexity were strongly associated with systems thinking but it is possible that systems thinking is nonetheless a distinct cognitive process. Indeed, the findings presented here show that systems thinking, while related to all three of these constructs, does account for unique proportions of explained variance in one measure of creativity and one measures of social problem construal once the influence of verbal intelligence was removed. Thus in order to develop a parsimonious model of systems thinking, future research should attempt to replicate these findings using larger, more diverse samples. It will also be important that future research investigate systems thinking, intelligence, and personality in the context of different outcome variables. One interesting outcome would be field dependence/independence (FDI). Examining these variables in relation to systems thinking and intelligence will help to further delineate the influence of systems thinking in FDI. Since FDI has been implicated in improved academic achievement (Nicolau & Xistouri, 2011; Tinajero & Paramo, 1998), by examining the influence of systems thinking on FDI researchers may gain a clearer picture of the potentially beneficial effects of systems thinking on general academic achievement. Additionally, the study of systems thinking and intelligence on FDI would also provide a greater understanding of the role of intelligence in systems thinking proclivity. Future research should also investigate the role of systems thinking and intelligence in improved complex decision-making. Complex-decision making is one area where systems thinking is thought to be highly beneficial (Booth-Sweeney & Sterman, 2007; Dyehouse et al., 2009; Pala & Vennix, 2009), since systems thinking should facilitate improved recognition of influencing factors in a given complex decision, as well as improved appreciation of these effects over time. Examining the role of both systems thinking and intelligence in the context of complex-decision making provides yet another piece in the systems thinking mosaic. If complex decision making is improved amongst systems thinkers while holding intelligence constant, it will provide further evidence that systems thinking is both beneficial to the decision-making process and that it is a indeed separate cognitive construct.

Conclusions

The overarching goal of this study was to clarify the psychological concept of systems thinking by examining it in the context of intelligence, personality, and cognitive complexity in predicting creativity and social problem construal as outcome measures. This study attempted to distinguish systems thinking by investigating its relationships to other, previously established psychological concepts. Given the regression results obtained in this study, systems thinking may arise as a result of the interaction between openness to experience and verbal intelligence, possibly in a developmental process. It also appears to be strongly related to attributional complexity. However, systems thinking also predicted unique amounts of variance in creativity and one aspect of social problem construal beyond openness to experience, agreeableness, and attributional complexity, suggesting that systems thinking is unique from each. While systems thinking is likely separate from personality and attributional complexity, its relationship with verbal intelligence remains unclear. Elsewhere we have suggested that the strong relationship between verbal intelligence and systems thinking may actually reflect an increased tendency of participants higher in verbal intelligence and systems thinking to consider the world in terms of connections, rather than singular components. Since the verbal intelligence measure was essentially a word association task, we may have actually been tapping a tendency to think in connections rather than crystallized intelligence (see Matthews, Orzech, & Lassiter, 2011). Furthermore given the distribution of systems thinking scores obtained in this study, it appears that systems thinking may also exist as an individual difference dimension. Future research should continue to investigate individual differences in systems thinking, intelligence, and creativity if we wish to create a more parsimonious model of systems thinking and so arrive at new and innovative solutions to the increasingly complex problems of our modern world.

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Appendix A

The Systems Thinking Scale-Revised

Instructions: Please indicate your agreement with each of the following statements, using the scale provided. There are no right or wrong answers.

1	2	3	4	5	6	7
Strongly disagree	Moderately disagree	Slightly disagree	Neutral	Slightly agree	Moderately agree	Strongly agree

1. The Earth, including all its inhabitants, is a living system
2. All the Earth's systems, from the climate to the economy, are interconnected
3. Seemingly small choices we make today can ultimately have major consequences
4. Individual people are not as separate from one another as they seem
5. Environmental problems, social problems, and economic problems are all separate issues (R)
6. When I have to make a decision in my life I tend to see all kinds of possible consequences to each choice.
7. I learn best when I can see how the different pieces of a subject relate to one another.
8. I like to know how events or information fit into the big picture
9. Ultimately, we can break all problems down into what is simply right or wrong (R)
10. Rules and laws should not change a lot over time (R)
11. Everything is constantly changing
12. Only very large events can significantly change big systems like economies or ecosystems (R)
13. Adding just one more small farm upstream from a lake can permanently alter that lake

14. My health has nothing to do with what is happening in the world (R)
15. It is possible for a community to organize into a new form that was not planned or designed by an authority or government

Appendix B

The Creative Experiences Questionnaire

Instructions: Please indicate "yes" if the following statements apply to you, and "no" if these statements do not apply to you. There are no right or wrong answers.

1. As a child, I thought that the dolls, teddy bears, and stuffed animals that I played with were living creatures.
2. As a child, I strongly believed in the existence of dwarfs, elves, and other fairy tale figures.
3. As a child, I had my own make believe friend or animal.
4. As a child, I could very easily identify with the main character of a story and/or movie.
5. As a child, I sometimes had the feeling that I was someone else (e.g., a princess, an orphan, etc.).
6. As a child, I was encouraged by adults (parents, grandparents, brothers, sisters) to fully indulge myself in my fantasies and daydreams.
7. As a child, I often felt lonely.
8. As a child, I devoted my time to playing a musical instrument, dancing, acting, and/or drawing.
9. I spend more than half the day (daytime) fantasizing or daydreaming.
10. Many of my friends and/or relatives do not know that I have such detailed fantasies.
11. Many of my fantasies have a realistic intensity.
12. Many of my fantasies are often just as lively as a good movie.
13. I often confuse fantasies with real memories.

14. I am never bored because I start fantasizing when things get boring.
15. Sometimes I act as if I am somebody else and I completely identify myself with that role.
16. When I recall my childhood, I have very vivid and lively memories.
17. I can recall many occurrences before the age of three.
18. When I perceive violence on television, I get so into it that I get really upset.
19. When I think of something cold, I actually get cold.
20. When I imagine that I have eaten rotten food, I really get nauseous.
21. I often have the feeling that I can predict things that are bound to happen in the future.
22. I often have the experience of thinking of someone and soon afterwards that particular person calls or shows up.
23. I sometimes feel that I have had an outer body experience.
24. When I sing or write something, I sometimes have the feeling that someone or something outside myself directs me.
25. During my life, I have had intense religious experiences which influenced me in a very strong manner.

Appendix C

The Creative Behavior Inventory – Short Form

Instructions: This inventory is simply a list of activities and accomplishments that are commonly considered to be creative. For each item, indicate the answer that best describes the frequency of the behaviour in your adolescent and adult life. Be sure to answer every question. In some cases, you should count the activities that you have done as a school-related assignment. In other cases, you should not. To avoid confusion, the phrase "*excluding school or university course work*" makes it explicit when NOT to count such work. Please answer these questions using the scale below.

A = Never Did This B = Did this once or twice C = 3-5 times D = More than 5 times

1. Painted an original picture (excluding school or university course work)
2. Designed and made your own greeting cards
3. Made a craft out of metal (excluding school or university course work)
4. Put on a puppet show
5. Made your own holiday decorations
6. Built a hanging mobile (excluding school or university course work)
7. Made a sculpture (excluding school or university course work)
8. Had a piece of literature (e.g., poem, short stories, etc.) published in a school or university publication
9. Wrote poems (excluding school or university course work)
10. Wrote a play (excluding school or university course work)
11. Received an award for an artistic accomplishment
12. Received an award for making a craft
13. Made a craft out of plastic, Plexiglas, stained glass, or a similar material (excluding school or university course work)
14. Made cartoons
15. Made a leather craft (excluding school or university course work)
16. Made a ceramic craft (excluding school or university course work)

17. Designed and made a piece of clothing (excluding school or university course work)
18. Prepared an original floral arrangement
19. Drew a picture for aesthetic reasons (excluding school or university course work)
20. Wrote the lyrics to a song (excluding school or university course work)
21. Wrote a short story (excluding school or university course work)
22. Planned and presented an original speech (excluding school or university course work)
23. Made jewelry (excluding school or university course work)
24. Had art work or craft work publicly displayed
25. Assisted in the design of a set for a musical or dramatic production (excluding school or university course work)
26. Kept a sketch book (excluding school or university course work)
27. Designed and constructed a craft out of wood (excluding school or university course work)
28. Designed and made a costume

Appendix D

The Consequences Test

Instructions: Below you will find three unlikely events listed. Please list every consequence or outcome of each event that you can think of. In order to ensure that you do not exceed a reasonable amount of time, it is recommended that you complete each question in 3 minutes or less. There are no right or wrong responses. Please list your responses in the space provided.

1. Imagine that you find yourself suddenly unable to hear (sudden deafness). Please list every consequence you can think of as a result of being unable to hear. Please list your answers in the space provided below.

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2. Imagine that you suddenly find yourself unable to see colour (sudden colourblindness). Please list every consequence you can think of as a result of being unable to see colour. Please list your answers in the space provided below.

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3. Imagine that you suddenly find that human beings no longer need to eat. Please list every consequence you can think of as a result of human beings no longer needing to eat. Please list your answers in the space provided below.

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Appendix E

The Need for Cognition Scale

Instructions: Please indicate your agreement with each of the following statements, using the scale provided. There are no right or wrong answers.

1	2	3	4	5	6	7
Strongly disagree	Moderately disagree	Slightly disagree	Neutral	Slightly agree	Moderately agree	Strongly agree

1. I really enjoy a task that involves coming up with new solutions to problems.
2. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
3. I tend to set goals that can be accomplished only by expending considerable mental effort.
4. I am usually tempted to put more thought into a task than the job minimally requires.
5. Learning new ways to think doesn't excite me very much (R)
6. I am hesitant about making important decisions after thinking about them (R)
7. I usually end up deliberating about issues even when they do not affect me personally.
8. I prefer just to let things happen rather than try to understand why they turned out that way (R)
9. I have difficulty thinking in new and unfamiliar situations (R)
10. The idea of relying on thought to make my way to the top does not appeal to me (R)
11. The notion of thinking abstractly is not appealing to me (R)
12. I am an intellectual
13. I only think as hard as I have to (R)

14. I don’t reason well under pressure (R)
15. I like tasks that require little thought once I’ve learned them (R)
16. I prefer to think about small, daily projects to long-term ones (R)
17. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities (R)
18. I find little satisfaction in deliberating hard and for long hours (R)
19. I more often talk with other people about the reasons for and possible solutions to international problems than about gossip or tidbits of what famous people are doing
20. These days, I see little chance for performing well, even in “intellectual” jobs, unless one knows the right people (R)
21. More often than not, more thinking just leads to more errors (R)
22. I don’t like to have the responsibility of handling a situation that requires a lot of thinking (R)
23. I appreciate opportunities to discover the strengths and weaknesses of my own reasoning
24. I feel relief rather than satisfaction after completing a task that required a lot of mental effort (R)
25. Thinking is not my idea of fun (R)
26. I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something (R)
27. I prefer watching educational to entertainment programs
28. I think best when those around me are very intelligent
29. I prefer my life to be filled with puzzles that I must solve
30. I would prefer complex to simple problems

31. Simply knowing the answer rather than understanding the reasons for the answer to a problem is fine with me (R)
32. It's enough for me that something gets the job done; I don't care how or why it works (R)
33. Ignorance is bliss (R)
34. I enjoy thinking about an issue even when the results of my thought will have no effect on the outcome of the issue.

Appendix F

The Attributional Complexity Scale

Instructions: Please indicate your agreement with each of the following statements, using the scale provided. There are no right or wrong answers.

1	2	3	4	5	6	7
Strongly disagree	Moderately disagree	Slightly disagree	Neutral	Slightly agree	Moderately agree	Strongly agree

1. I don't usually bother to analyze and explain people's behavior. (AC-1)
2. Once I have figured out a single cause for a person's behavior I don't usually go any further (AC-2)
3. I believe it is important to analyze and understand our own thinking processes (AC-3)
4. I think a lot about the influence that I have on other people's behavior (AC-4)
5. I have found that the relationships between a person's attitudes, beliefs, and character traits are usually simple and straightforward (AC-5)
6. If I see people behaving in a really strange or unusual manner I usually put it down to the fact that they are strange or unusual people and don't bother to explain it any further (AC-6)
7. I have thought a lot about the family background and personal history of people who are close to me, in order to understand why they are the sort of people they are (AC-7)
8. I don't enjoy getting into discussions where the causes for people's behavior are being talked over (AC-1)
9. I have found that the causes for people's behavior are usually complex rather than simple (AC-2)

10. I am very interested in understanding how my own thinking works when I make judgments about people or attach causes to their behavior (AC-3)
11. I think very little about the different ways that people influence each other (AC-4)
12. To understand a person's personality/behavior I have found it is important to know how that person's attitudes, beliefs, and character traits fit together (AC-5)
13. When I try to explain other people's behavior I concentrate on the person and don't worry too much about all the existing external factors that might be affecting them (AC-6)
14. I have often found that the basic cause for a person's behavior is located far back in time (AC-7)
15. I really enjoy analyzing the reasons or causes for people's behavior (AC-1)
16. I usually find that complicated explanations for people's behavior are confusing rather than helpful (AC-2)
17. I give little thought to how my thinking works in the process of understanding or explaining people's behavior (AC-3)
18. I think very little about the influence that other people have on my behavior (AC-4)
19. I have thought a lot about the way that different parts of my personality influence other parts (e.g., beliefs affecting attitudes or attitudes affecting character traits) (AC-5)
20. I think a lot about the influence that society has on other people (AC-6)
21. When I analyze a person's behavior I often find the causes form a chain that goes back in time, sometimes for years (AC-7)
22. I am not really curious about human behavior (AC-1)
23. I prefer simple rather than complex explanations for people's behavior. (AC-2)

24. W hen the reasons I give for my own behavior are different from someone else's, this often makes me think about the thinking processes that lead to my explanations (AC-3)
25. I believe that to understand a person you need to understand the people who that person has close contact with (AC-4)
26. I tend to take people's behavior at face value and not worry about the inner causes for their behavior (e.g., attitudes, beliefs, etc.) (AC-5)
27. I think a lot about the influence that society has on my behavior and personality (AC-6)
28. I have thought very little about my own family background and personal history in order to understand why I am the sort of person I am (AC-7)

Appendix G

The NEO-FFI-3 (Costa & McCrae, 2010)

This questionnaire contains 60 statements. Please read each item carefully choose the answer that best corresponds to your agreement or disagreement using the scale provided below. There are no right or wrong answers.

0	1	2	3	4
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

1. I am not a worrier. * (N)
2. I often get angry at the way people treat me. (N)
3. I prefer jobs that let me work alone without being bothered by other people. * (E)
4. I rarely feel lonely or blue. * (N)
5. I experience a wide range of emotions or feelings. (O)
6. When I’ve been insulted, I just try to forgive and forget. (A)
7. I like to be where the action is. (E)
8. I often enjoy playing with theories or abstract ideas. (O)
9. I’m pretty good at pacing myself so as to get things done on time. (C)
10. I often feel helpless and want someone else to solve my problems. (N)
11. I don’t get much pleasure from chatting with people. * (E)
12. I like to have a lot of people around me. (E)
13. If necessary, I am willing to manipulate people to get what I want. * (A)
14. I keep my belongings neat and clean. (C)
15. Sometimes I feel completely worthless. (N)
16. Sometimes I’m not as dependable or reliable as I should be. * (C)
17. My life is fast-paced. (E)
18. If someone wants to start a fight, I’m ready to fight back. * (A)
19. I rarely feel fearful or anxious. * (N)
20. I enjoy concentrating on a fantasy or daydream and exploring all it’s possibilities, letting it grow and develop. (O)
21. I have no sympathy for beggars. * (A)

22. Poetry has little or no effect on me. * (O)
23. I am seldom sad or depressed. * (N)
24. Some people think of me as cold and calculating. * (A)
25. When I'm under a great deal of stress, sometimes I feel like I'm going to pieces. (N)
26. I would have difficulty letting my mind wander without control or guidance. * (O)
27. I tend to assume the best about people. (A)
28. Sometimes when I am reading poetry or looking at a work of art, I feel a chill or wave of excitement. (O)
29. At times, I bully or flatter people into doing what I want them to. * (A)
30. Too often, when things go wrong, I get discouraged and feel like giving up. (N)
31. I generally try to be thoughtful and considerate. (A)
32. I am a very active person. (E)
33. I work hard to accomplish my goals. (C)
34. I have little interest in speculating on the nature of the universe or the human condition. * (O)
35. I am a cheerful, high-spirited person. (E)
36. I really enjoy talking to people. (E)
37. I shy away from crowds of people. * (E)
38. I never seem to be able to get organized. * (C)
39. Some people think I'm selfish or egotistical. * (A)
40. When I make a commitment, I can always be counted on to follow through. (C)
41. At times, I have been so ashamed I just wanted to hide. (N)
42. I'm better than most people, and I know it. * (A)
43. I am a productive person who always gets the job done. (C)
44. I often feel tense and jittery. (N)
45. I often come into situation without being fully prepared. * (C)
46. I would rather go my own way than be a leader of others. * (E)
47. I seldom notice the moods or feeling that different environments produce. * (O)
48. I think it's interesting to learn and develop new hobbies. (O)
49. I have a clear set of goals and work toward them in an orderly fashion. (C)
50. At times I have felt bitter and resentful. (N)

51. I am intrigued by the patterns that I find in art and nature. (O)
52. If I don’t like people I let them know it. * (A)
53. I strive for excellence in everything I do. (C)
54. I have a lot of intellectual curiosity. (O)
55. I waste a lot of time before settling down to work. * (C)
56. I believe letting students hear controversial speakers can only confuse and mislead them. * (O)
57. I try to be courteous to everyone I meet. (A)
58. I try to perform all tasks assigned to me conscientiously. (C)
59. I often feel as if I’m bursting with energy. (E)
60. I laugh easily. (E)

Appendix H

Problem Construal Questionnaire

Instructions: Below you will find three social problems that are commonplace in the 21st Century. Please write a paragraph or two (or more) describing what you see to be the cause(s) of the following social problems. Also in your paragraph(s), once you have outlined the cause(s) of these issues, please describe how society can solve these problems. Please list as many solutions as you can.

Problem 1: Homelessness is a well-known social problem facing a large number of people. Please write a paragraph or two outlining the causes of homelessness as well as how society may address this problem. There are no right or wrong answers.

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Problem 2: Climate Change is also well-known social problem facing a large number of people. Please write a paragraph or two outlining the causes of climate change as well as how society may address this problem. There are no right or wrong answers.

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Problem 3: Addiction is another well-known social problem facing a large number of people. Please write a paragraph or two outlining the causes of addiction as well as how society may address this problem. There are no right or wrong answers.

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Appendix I

The Marlowe-Crowne Social Desirability Scale

Instructions: Listed below are a number of statements concerning personal attitudes and traits. Read each item and decide whether the statement is *true* or *false* as it pertains to you personally (socially desirable responses are shown in parenthesis)

1. Before voting I thoroughly investigate the qualifications of all the candidates (T)
2. I never hesitate to go out of my way to help someone in trouble (T)
3. It is sometimes hard for me to go on with my work if I am not encouraged (F)
4. I have never intensely disliked anyone (T)
5. On occasion I have had doubts about my ability to succeed in life (F)
6. I sometimes feel resentful when I don't get my way (F)
7. I am always careful about my manner of dress (T)
8. My table manners at home are as good as when I eat out in a restaurant (T)
9. If I could get into a movie without paying and be sure I was not seen I would probably do it (F)
10. On a few occasions, I have given up doing something because I thought too little of my ability (F)
11. I like to gossip at times (F)
12. There have been times when I felt like rebelling against people in authority even though I knew they were right (F)
13. No matter who I'm talking to, I'm always a good listener (T)
14. I can remember "playing sick" to get out of something (F)
15. There have been occasions when I took advantage of someone (F)
16. I'm always willing to admit it when I make a mistake (T)

17. I always try to practice what I preach (T)

18. I don't find it particularly difficult to get along with loud mouthed, obnoxious people (T)

19. I sometimes try to get even rather than forgive and forget (F)

20. When I don't know something I don't at all mind admitting it (T)

21. I am always courteous, even to people who are disagreeable (T)

22. At times, I have really insisted on having things my own way (F)

23. There have been occasions when I felt like smashing things (F)

24. I would never think of letting someone else be punished for my wrong-doings (T)

25. I never resent being asked to return a favour (T)

26. I have never been irked when people expressed ideas very different from my own (T)

27. I never make a long trip without checking the safety of my car (T)

28. There have been times when I was quite jealous of the good fortunes of others (F)

29. I have almost never felt the urge to tell someone off (T)

30. I am sometimes irritated by people who asks favours of me (F)

31. I have never felt that I was punished without cause (T)

32. I sometimes think, when people have a misfortune, they only got what they deserved (F)

33. I have never deliberately said something that hurt someone’s feelings (T)

Appendix J

Demographics Questionnaire

Instructions: Please indicate your demographic information below. These demographic questions will remain confidential, and will not be used to identify you as a participant.

Age: _________

Gender: M F Other (please circle one)

Year of Study: _______

Major: __________________________

Ethnicity: (please check all that apply)

- □ Caucasian
- □ African American
- □ First Nations (Aboriginal)
- □ Hispanic
- □ Asian
- □ Other: _________________

Appendix K

Cover Letter

Dear Potential Participant,

I am a second year Graduate student in the Department of Psychology. I am conducting a study with Dr. Mirella Stroink that investigates the relationship between individual differences in the systems thinking paradigm and psychometric intelligence.

In this study, you will be asked to complete an online questionnaire package that contains a variety of psychometric measures. This package will ask you to indicate your level of agreement with a series of statements in each of the questionnaires. These statements will relate to different thoughts and feelings you might have as well as some of your opinions and behaviours. You will also complete a basic measure of personality as well as psychometric intelligence. Please note that this measure is not intended for diagnostic purposes and as such, you **will not** receive a full personality report nor a full-scale IQ score. However at the conclusion of this study you may access a summary of the full results by contacting the principal investigator, Dr. Mirella Stroink, by e-mail at mstroink@lakeheadu.ca. The study will take up to 1 hour to complete and you will be provided with a link that will send you to a brief demographic measure for bonus mark purposes. Note that this brief measure will not be used to link your name with the responses you provide. Once you have completed this study you will receive a bonus mark in your psychology course.

This research has received approval from the Psychology Department's Delegated Research Ethics Committee. Participation in this study will not result in any harm to your psychological well-being. Dr. Mirella Stroink and myself will be the only people allowed access to the information you provide. Your responses to the questionnaires are **anonymous**. Your name or other identifying information will not be asked on any of the measures. The information you provide will be securely stored at Lakehead University for 5 years.

Participation in this study is **voluntary**. If you **do not wish to complete** any part of this study you are not obligated to do so. You are also free to withdraw from the study at any time without penalty. If you are willing to take part in this study, please indicate your consent by following the instructions on the following screen.

Your participation in this study is greatly appreciated, and if you wish to learn more about this study please contact myself at jrandle@lakeheadu.ca, Dr. Stroink at the contact information above, or the Department of Psychology at (807) 343-8441.

Thank you for your cooperation

Appendix L

Electronic Consent Form

This research is an investigation into the relationship between the systems thinking paradigm and educational attitudes and beliefs. You will be asked to complete one survey package. This survey package contains numerous questionnaires that assess both the systems thinking paradigm and some of your various attitudes and beliefs concerned with the current educational system. These questionnaires will also assess your perceived academic experience including achievement measures. Jason M. Randle is conducting this research under the supervision of Dr. Mirella Stroink of the Department of Psychology.

By signing this form I indicate that I understand:

1. That I am a volunteer and can choose not to answer any questions or withdraw at any point without penalty.
2. That there is no anticipated risk of physical or psychological harm to me as a result of my participation in this study.
3. That the information I provide will be completely **anonymous** and **confidential**, and will be securely stored in the Department of Psychology at Lakehead University for five years.
4. That I may receive a summary of the research findings of the project by request once I have completed the study.
5. That I must be 18 years of age or older to participate in this study **-or-** if I am under the age of 18, but not younger than 16, I must be a student enrolled at Lakehead University in order to be eligible to participate

By clicking the option below and proceeding to the survey I hereby indicate my consent to participate in this research. If you do not wish to participate in this study please exit this browser window now.