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Adolescent Cognition as a Dynamic System : Examining Complex Cognition, Concepts and Context

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Adolescent Cognition as a Dynamic System:

Examining Complex Cognition, Concepts and Context

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Abstract

The transition to adolescence is characterized by the rapid development of many interacting social, emotional, and cognitive processes. Adolescent development is organized around developing successful peer relationships and peer interactions which can improve social standing, define group memberships, and develop a social identity. In the first manuscript, I identified cognitive complexity as an important underlying developmental concept to adolescent development and established a theoretical foundation. Cognitive complexity was explored through a dynamic systems approach which examined the interacting processes of development in addition to outcomes. In the second manuscript, secondary interviews (N = 24) were analyzed in a multi-stage process. I found that while youth moved toward greater integrative capacity, and more complex cognitive systems, changes were not necessarily linear and multiple trajectories were indicated. These trajectories were further explored in the final manuscript which triangulated empathy items in the survey sample (N = 102) with cognitive system classifications in the interview subsample (n = 21). Empathetic concern increased between waves in the survey sample, pointing to a positive trajectory in empathy development. Empathy was also related to the youth cognitive system classification trajectories but was clearest for those moving from complex classifications to simple classifications. Decreased scores in differentiation and integrative capacity, and in either affective empathy or empathetic concern predicted which youth would move from complex to simple classifications compared to youth who retained a complex classification. Future research is indicated in further exploring the interconnections of these concepts in adolescent populations.

Keywords: Dynamic Systems, Adolescent Development, Cognitive Complexity, Integrative Capacity, Empathy

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Dedication

To my family and friends. Your support of my hopes and dreams have made them possible.

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Chapter 1: Introduction

The beginning of adolescence is loosely determined by cognitive, physical, psychological and social changes, and increased investment in personal identity. Early developmental theorists defined adolescence as a transitional period between childhood and adulthood; Erikson (1963) understood adolescence as "…a psychosocial stage between childhood and adulthood, and between the morality learned by the child, and the ethics to be developed by the adult" (p. 245). Similarly, while Piaget (1971) noted that adolescents had the developmental capability to move past concrete reasoning to a formal operational stage of abstract reasoning, he encountered significant variation in the rate and ages that abstract reasoning developed. However, cognitive development occurred at varying pace for different children, and not all adolescents developed formal operational thought by the end of adolescence or even adulthood.

Siegler's (1979) replication of Piaget's research similarly concluded that adolescents have the developmental potential for abstract reasoning. However, he noted that the development of abstract reasoning was determined less by age or stages of development, and more by learning to use rules in increasingly complex situations. This conclusion erodes the assumption that psychological and cognitive processes develop in a directly linear fashion. It also calls into question the assumption that developmental processes can be understood in isolation from one another; development must be understood as a coactional system that simultaneously considers social, psychological, cognitive, and physical development embedded within environmental contexts.

In addition to a more systemic understanding of adolescent development, a more nuanced understanding is warranted. Examination of adolescence as a developmental period, rather than simply a transition to adult maturation has highlighted the influence of adolescent experiences in lifelong developmental trajectories, and how much more there is to understand about adolescent developmental processes. Compared to a century ago, adolescence has earlier onset in nearly all populations in the world, with greater differences in post-industrial countries (Sawyer et al., 2018). The onset of adrenarche or the first hormonal changes associated with puberty may now occur between the ages of 6 to 9, followed by physical changes; on average, girls enter puberty around age 11, while boys enter puberty around age 13. General perception of the endpoint of adolescence has also been expanded as understanding of cortical maturation has increased; while basic brain functions such as those tied to physical perception and movement mature between infancy and childhood, executive and emotional systems are not at peak developmental capacity until much later. These two systems codevelop from childhood when executive systems begin to mature leading to the ability to logically solve problems and make decisions, and cascades into the development of affective systems such as heightened social and emotional awareness in adolescence (Huttenlocher, 1990; Larsen & Luna, 2018). The integration of these two systems results is not considered to be fully optimized until the late 20s; this integration results in emotional regulation abilities, including the ability to logically make decisions in emotional environments.

Greater awareness of cognitive developmental patterns during late adolescence has led many developmentalists to expand the definition of adolescence into what was formerly considered adulthood (Sawyer et al., 2018). The result has been an expansion of understanding of development around adolescence, including newly identified developmental periods, many of which overlap with one another in specified age boundaries (e.g., emerging adults, young adults, youth). Despite differences in definition, these theories all recognize the expansion of development formerly associated with adolescence into the 20s, with most agreeing on 25, when cognitive development is optimized for most individuals, as an average cut off for adolescent development. The lengthening of the period associated with adolescent development has encouraged theorists to deepen earlier understandings of adolescent psychological, social, and cognitive developmental processes.

Coactional Adolescent Development

As understanding of developmental processes during adolescence has increased, the understanding of developmental processes as interdependent has become more accepted. More recently, a move toward relational and systems understandings in developmental science has highlighted the need to understand contexts, processes, and coacting systems within human development (Overton, 2015). Human developmental processes may be conceptualized as active, open, self-organizing, and self-regulating systems. The interconnected relationships between adolescent cognitive development, and coacting social and physiological processes contribute to a deeper understanding of the development of concepts as well as cognitive systems of interconnected concepts.

Cognitive systems are composed of sets of elements and constructs which an individual relates to one another in some way. Cognitive systems may be considered complex when they "contain a relatively large number of elements…integrated hierarchically by relatively extensive bonds of relationship" (Crockett, 1965, p. 49). In other words, highly differentiated, integrated, and organized cognitive systems are considered highly complex. However, these elements may be present to greater or lesser degrees depending on the contexts in which a cognitive system develops and subsequently operates.

While the development of complexity within a cognitive system is tied to the ability to see concepts as interconnected, the capacity of cognitive systems to operate is dependent on context. During adolescence, cognition coacts with social contextual factors to reorganize cognitive and conceptual understandings around individual and group identities (Steinberg, 2005; Walton et al., 2012). The introduction to other perspectives, and the ability to distinguish similarities within them increases complexity in a cognitive system (Wright, 2012). Higher connection and belonging with others leads to increased perspective taking abilities, prosocial attitudes, and higher empathy (Burleson, 1984; Decety & Cowell, 2014; Wright, 2012).

Goals and motivations guide behavior through organization and optimization of the cognitive system. The development of cognitive systems is highly enmeshed with the development of others within a social network, and those with whom an individual feels they belong (Nigg, 2017; Walton et al., 2012). The social nature of cognitive development during adolescence necessitates the inclusion of others in the very heart of what an individual considers to be the self, or identity development. The development of cognitive affective and social cognitive capabilities is essential to positive intergroup relationships and social cooperation; development of these capabilities in an indication of a well-adjusted individual and is an important component of positive life trajectories (Carlo & Padilla-Walker, 2020). The more an individual can integrate information and articulate different points of view, the more an individual demonstrates the skills necessary to optimize personal goals through social interactions in their everyday lives (Yeager et al., 2012). Feelings of belonging in everyday contexts increase approach emotions toward others, leading to higher prosocial skills and behaviors and greater engagement and involvement with others (Walton et al., 2012).

Although the development of complex cognitive systems is highly dependent on social and emotional contexts, physiological factors enable the development of cognitive complexity during adolescence as well; cognition is most plastic during infancy and early adolescence (Blakemore & Mills, 2014; Crone & Dahl, 2012). Although plasticity and processes of development in infants and adolescents demonstrate parallels in growth, the developmental goals differ; while young children seek self-autonomy through movement, adolescents seek emotional and social autonomy (Goodvin et al., 2015). Therefore, while the three manuscripts which make up this dissertation focuses on adolescent cognitive development, underlying processes which pertain to infant cognitive flexibility may be used to illustrate concepts which have been underexplored in adolescent cognitive flexibility and complexity.

Present Study

The purpose of this dissertation is to enable a clear understanding of the concept of cognitive complexity and its relationship to related systems of development which contribute to positive youth outcomes. In particular, the overarching goals of this dissertation are to: 1) build a cohesive theoretical grounding of cognitive complexity measurement in a process relational worldview; 2) develop a systemic method of measuring complex cognition using secondary interview data; 3) explore connections between cognitive complexity and empathy in an adolescent population.

This dissertation is made up of three manuscripts that collectively explore the importance of cognitive complexity to adolescent cognitive development. The first manuscript examines the multiple theories of cognitive complexity in several disciplines and seek a relational understanding of its development. The second manuscript builds upon the theoretical foundations of the first paper to examine multiple measures of cognitive complexity, develop a system of measurement, and demonstrate its use in secondary pilot program interview data from the Inspire Aspire: Global Citizens in the Making (I > A) study. The third manuscript provides an exploration of the relationship between cognitive complexity scoring and a survey measure of empathy in the same dataset.

Manuscript 1: A Tale of Two (or More) Disciplines: Integration, Differentiation, And Complexity

Understanding how people form impressions and perceive the world around them have been the bases for some of the most enduring questions in philosophy, physiology, psychology, and developmental science. Although Aristotle considered person-context relationships in his conception of human character and capabilities, human perception, motivation, and behavior became much more mechanistic following Descartes. The Cartesian-split mind/body disconnection which followed limited understanding of motivation, the development of character, and the processes through which people learn and behave to the mind without considering the context in which people are situated. Following the cognitive revolution in the early 1950s, more relational and developmental systems perspectives which considered the coacting influences of environment and individual development began to emerge (Miller, 2003).

In this first manuscript, I establish a theoretical base of relational developmental cognition. Specifically, I explore some of the basic premises in philosophical, theoretical, empiricist, and idealist understandings of complexity in cognition. I assert that complex cognition is an essential theoretical understanding which has been linked to cognitive processes and developmental outcomes in many parallel disciplines. I argue that diverse operationalization of cognitive complexity and cognitive systems developmental processes have emerged in several parallel fields because cognitive complexity is an important cognitive process. However, divergence in epistemological and ontological positioning in cognitive science has led to a fragmented understanding of cognitive complexity and its role in human development and cognition.

The many perspectives which contribute to the current understanding of cognition and complexity may be better understood through relational theories of human development (Overton, 2013). Relational developmental Systems (RDS) is a metatheoretical perspective that allows a relational investigation of concepts between disciplines by considering multiple perspectives and conceptions of concepts. An RDS perspective recognizes parallel lines of research may exist and be relevant to a particular topic. This could manifest in disciplines of study having concepts which investigate the same or similar phenomena as one another but have labelled the concept with different names, or that different disciplines have the same name for a concept, but vastly different operational definitions. Parallel research in developmental systems may also have emphasized isolated developmental periods without considering how phenomena ma be applicable to other periods of development.

In the case of cognitive science, especially around the study of cognitive complexity, all three situations are relevant. While there are many relational theories of development, dynamic systems theory (DST) as conceptualized by Thelen and Smith (1996) offers a unique and flexible understanding of cognitive development which enables a clearer understanding of developmental cascades and trajectories of development. Adolescence is a time of cognitive reorganization and increased social outreach in which group identity, social hierarchy, and cognition shape personal identity (Crone & Dahl, 2012). Greater autonomy seeking and cognitive flexibility marks adolescence as a pivotal developmental period during which exposure to diverse opinions, thoughts, and perspectives may be more likely to contribute to the development of complex cognitive systems. Complex cognitive systems support cognitive processes which consider multiple perspectives, and integrate multiple aspects in order to articulate and form goals, and personal identities (Blakemore & Mills, 2014). Specifically, the following research questions are proposed:

1) How does cognitive complexity fit with the field of cognitive science?
2) How is cognitive complexity in adolescence represented in the current corpus of research?
3) How can the understanding of cognitive complexity in multiple cognitive paradigms contribute to a holistic understanding of cognitive complexity?

In this manuscript I make a theoretical argument for the importance of understanding the development of cognitive complexity in adolescence and proposes a relational approach to understanding the pluralistic and fragmented state of cognitive complexity across multiple disciplines and paradigms. The theoretical grounding and understanding in this manuscript provide the foundational work for a corresponding measurement tool of cognitive complexity. The goal of Positive Youth Development (PYD) programs is to enhance or encourage the development of cognitive systems to inform perception and prosocial values (Callina et al., 2015). Therefore, understanding the development of complexity in youths' cognitive systems becomes imperative in understanding how programs impact youth.

Manuscript 2: Developing Measurement and Youth: Cognitive Complexity Measurement in Context

The second manuscript considers the theoretical implications of the first manuscript to develop an appropriate system of measurement for adolescent cognitive complexity. Theories and measures of cognitive complexity are fragmented. Lack of consensus around the operational definition of cognitive complexity and differences between disciplines in the study of concepts around complexity have contributed to parallel lines of research and multiple measures of complexity. Despite differences in how complexity was measured, there are many similarities in outcomes; studies using various measures of cognitive complexity have linked the construct to prosocial behavior, perspective-taking, and self-regulation. A clearer understanding of the concept and its measurement could help explain how these outcomes develop, and how they might be best measured.

This manuscript seeks to develop an understanding of several measures of cognitive complexity which are associated with these positive youth outcomes. I will also explore how cognitive complexity might be measured in secondary interview data. Measurement of cognitive complexity is usually done in structured, primary data collection settings; however, the concept may be conceived more flexibly to measure how complexity develops in particular cognitive domains. For example, as the Inspire Aspire program was interested in the development of values, goals, and inspiration in youth, complexity could be measured in interviews about those subjects if the measurement system was flexible enough to allow this. Such a measurement system could offer a more nuanced understanding of how target positive outcomes may develop in youth.

Therefore, this manuscript will examine how measures of cognitive complexity which were designed to examine a social interpersonal domain (e.g., Crockett, 1965), may be applied more broadly. This study has two related goals: to present cognitive complexity as a platform that can inform positive youth outcomes, and to illustrate the measurement of this construct in a population of Scottish youth (ages 12-14) who participated in the Inspire Aspire program. Youth who completed the survey at W1 and W2 and participated in both W1 and W2 interviews were included in this study (*N* = 24). Interviews were coded and concept maps were created from interviews. These maps were then scored for complexity at W1 and W2. Results and implications are discussed.

Manuscript 3: Connections Between Cognitive Complexity and Youth Empathy Trajectories: A Preliminary Investigation

The third manuscript explores connections between empathy development and the development of cognitive complexity in youth. Empathy and cognitive complexity are related constructs that contribute to prosocial development in youth (Silke et al., 2017). Both are often explored as precursors to prosocial development and may be linked concepts that enable one another. The affective component of empathy allows a vicarious experience of another person's experience and serves as a motivator, while cognitive complexity is the structure of mental constructs an individual relies upon to understand and differentiate the connection between self and others and engage in perspective taking behaviors (Cuff et al., 2016). Perspective taking is a component of cognitive empathy and empathetic reflection. It is also linked to higher cognitive complexity.

Despite the importance of empathy for understanding other prosocial behaviors, its trajectory of development and interaction with other prosocial precursors is not well understood. A general understanding of empathy development posits that affective empathy, the motivating component of empathy, develops prior to cognitive empathy, which allows the differentiation of one's own experiences from the experiences of others. While some investigations have linked empathy and cognitive complexity, they have often viewed them as completely separate constructs (e.g., Youngvorst & Jones, 2017). This may be due in part to the limited measurement of interpersonal domains of complexity using Crockett's (1965) method of measuring the complexity of a description of a liked and disliked individual. While this measure likely captures an important domain, it is limited in scope, and may not best translate to cognitive empathy or motivate helping behaviors.

This preliminary investigation allows an exploration of the concepts of cognitive system complexity scoring in interview data to trends of empathetic concern in larger survey data. This manuscript builds on the prior manuscript to examine the connections between youth cognitive complexity in goal setting and purpose domains, and a measure of empathetic concern included in the survey that all youth took. While connections in the survey data and the interview data cannot be directly correlated, an examination of the trends in empathetic concern, and a closer look at how complexity scoring trajectories may be connected to potential trajectories of empathetic development in a smaller subsample allows a more nuanced understanding of how these constructs may codevelop and interact together. Because the survey population was small (N = 102), and the study design was pretest-posttest, the implications of this investigation are exploratory and limited.

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Chapter 2: A Tale of Two (or More) Disciplines: Integration, Differentiation, and Complexity

Cognitive processes inform social interactions, identity development, and perception of reality and impact and are impacted by every part of the everyday lives of individuals (van Geert, 2011). Cognitive processes include logical reasoning, decision making, emotional regulation, and the development of a theory of mind and the associated executive functioning capabilities. Within and across these areas of cognition, constructs are created by individuals to represent individual perceptions of reality. How individuals perceive and develop links between concepts is embedded in individual and shared contexts and contributes to how they understand and interact with the world around them (Walton et al., 2012) . In particular, the development of basic cognitive reasoning is underpinned by the development of personal constructs or schemas by individuals in their everyday lives and their relation to one another in a system of constructs (Kelly, 1955).

A system of constructs is a framework which individuals develop to interpret and make sense of the world around them. These frameworks are informed by individual experiences which shape perceptions, social interactions, and the ability to see constructs as similar or dissimilar to one another. The concept of cognitive complexity may be understood as a representation of how these perceptions are connected and related to one another within and across these states of cognition. Specifically, cognitive complexity is defined as the degree of differentiation and integration present in an individual’s articulated perspective, or the cognitive capacity available within developmental and environmental constraints (Crockett, 1965).

The development of cognitive complexity is action based—a system of constructs becomes more complex through exposure to diverse information, contexts, and perceptions, but it may do so more easily during periods of greater plasticity such as adolescence. In particular, cognitive processes which relate to social and emotional processes develop rapidly during this developmental period (Goodvin et al., 2015). While cognitive complexity can apply to many cognitive systems, those most relevant to adolescence include those related to motivations, goals, and emotional regulation abilities in social contexts. Therefore, a clearer understanding of how cognitive complexity develops within these processes can help elucidate how important social processes like emotional control and empathy are related to complexity, and how they may contribute to overall adolescent development.

Despite the relative importance of this area of study, the current understanding of the development of cognitive complexity has proceeded separately in several disciplines; often, interdisciplinary work in core constructs is restricted by epistemological and ontological differences. While diverse perspectives contribute to rich conversations and advance scientific theory, such divisions can obfuscate theoretical advancement when operational definitions are unclear.

Conceptual Complexity: Structure, Function, and Capacity

A lack of conceptual clarity around cognitive complexity persists in cognitive scientific disciplines. While constructivist accounts focus on how constructs, processes, and interconnections between representations form and interact dynamically, information processing theories are descriptive of the function or capacity of a cognitive system to operate in a static moment. These paradigms consider complexity in different structural and functional ways which can complicate interpretation of complexity across disciplines. However, if clearly defined, both paradigms contribute to a clearer understanding of how systems of constructs develop into a cognitive system, and how well a cognitive system may react or adapt based on both structure and functional ability.

Constructivist narratives define cognitive complexity as the degree to which complex relationships between concepts within a cognitive system have developed (Bieri, 1951; Kelly, 1955). The development of complexity is the result of the dynamic interaction of relationships, experiences, and perceptions within a social network of concepts. The constructivist understanding of cognitive complexity refers to the cognitive infrastructure that individuals constantly cocreate in interaction with other systems and processes in everyday life (Crockett, 1965). It also refers to how such concepts may be used to interpret future interactions, classify past experiences, and identify with the experiences of others.

Many information processing accounts take a different approach to understanding complex cognition, often assigning complexity to the task, and the ability of the person approaching the task to simplify the task (e.g.. Halford et al., 2014; Wildemuth et al., 2018). While information processing accounts differ, most recognize the ability to reduce complexity as a positive ability. However, reduced cognitive complexity in constructivist accounts would be considered maladaptive. Within this paradigm, complexity in cognitive processes is defined as the “number of variables that must be bound into a representation to perform that process” (Halford et al., 2014, p. 96). This kind of complexity is a description of the function of a cognitive system, rather than a description of the architecture of the cognitive system. the cognitive system, but a function of a cognitive system. Task complexity refers to the ability of an individual to integrate parallel processes through segmentation and chunking to reduce cognitive load and demand (Halford et al., 2014). Task complexity is only one type of complexity used to describe cognition: cognitive capacity and process complexity are also often incorrectly grouped with task complexity and referred to as "cognitive complexity" while retaining the notion of reduced complexity. In fact, they all work together in this paradigm such that adaptive cognition is the ability (i.e., cognitive capacity) to simplify complex tasks (i.e., task complexity) with use of parallel processes (i.e., process complexity).

On the surface, a level of reconciliation can be reached in the definitions between these two paradigms. Constructivist theories describe complexity in a cognitive system as a function of the number of available cognitive representations and the relationships of those variables to one another through integration and differentiation of concepts (Crockett, 1965). The individual with a complex cognitive system may examine relationships between variables and may use more or fewer parallel processes for the same task under varied circumstances depending on the context and resources available (Christoff & Owen, 2006). Therefore, a complex cognitive system has greater cognitive capacity and is therefore more capable of reducing task complexity; higher cognitive system complexity yields better outcomes because an interconnected cognitive system allows associations which reduce task complexity.

Although the definitions of complexity can be clarified to describe different components of cognition, the lack of conceptual clarity is only one part of the division between paradigms. The paradigms differ in fundamental ways in how they understand systems. While information processing-based theories have their roots in Cartesian frameworks which emphasize isolating component parts to understand a system on the premise that a whole is made up of the sum of its parts, some constructivist theories lean heavily into Aristotelian relational understandings of systems which posit that the whole is greater than the sum of its parts (Lewin, 1947; Overton, 2015). While many Cartesian theories increasingly recognize the role of environment in shaping development, the isolationist and dualistic approach to methods and in understanding systems is the same. Thus, Cartesian mechanistic theories regard complexity as something undesirable which can be increased through differentiation and reduced through integration, while relational constructivist frameworks understand complexity as increasingly integrated, yet differentiated understanding—such that a system produces a new level of complexity through interaction with the various parts of the whole.

To this end, it is useful to understand the ontological and epistemological positioning in which the variants of cognitive complexity as a construct developed. I will delineate a clear worldview and theoretical framework as a foundation on which to interpret and facilitate a cohesive dialogue between disciplines and operational definitions around cognitive complexity. Within this framework, I will first specify my theoretical positioning and provide several useful theoretical perspectives which may help unify theories of cognitive complexity development.

Beyond Transmission Mentality in Developmental Cognitive Science

The study of human development has been dominated by biogenic and psychogenic dualistic split-mechanistic perspectives (e.g., nature vs. nurture; mind vs. body; Overton, 2013). The Cartesian-split debate of nativism vs. empiricism has defined the brief, divergent history of developmental cognitive science. This debate is concerned with both the origin of cognitive concepts in either the internal or external environment, and the influence of internal and external processes on the structure of cognitive development and behavior. Nativism locates the origin of cognitive processes internally as *a priori* instincts and structures which are gradually activated or unlocked. In contrast, empiricism takes the philosophical position that all concepts originate in external experiences and processes which are enacted on the individual to create cognitive processes, behaviors, and functioning. Theories within these paradigms vary in how closely they conform to pure nativism or empiricism; for example, neonativism recognizes the influence of the external environment on internal structures, but still retains the assumption that internal structures account for the origin of development, cognition, and the external manifestation of behavior (Carey, 2009).

Theoretical attempts to reconcile differences between both nativist and empiricist paradigms have ignored the shared assumption that concepts are predetermined and enacted on the individual rather than constructed through interacting developmental processes and environmental influences. Indeed, there is perhaps more similarity between these two paradigms then proponents of either would readily admit; information processing, neuroscientific, and many constructivist traditions share the assumption that “information can pre-exist the processes which give rise to it” (Oyama, 1985; p. 13). This worldview is unidirectional and does not consider cognition to be a true product of an interacting system. A true developmental account of cognition must transcend rather than reconcile the animosity between nativism and empiricism and understand cognitive development from a systemic and coactional perspective.

Process-Relational Worldview and Relational Developmental Systems

Both nativist and empiricist accounts of cognitive development are reductionist and unidirectional. Neither is well-suited to the study of cognitive development, a process which is constantly co-created between persons, prior experiences, and embedded contexts. A process-relational worldview regards the developmental moment as part of a fused process which has transformed the individual into a different product and is unable to be reduced (Overton, 2013). Within this worldview, knowledge in not transmitted from pre-existing external circumstances or from pre-existing internal core cognitions, rather, developmental processes are cocreated and, in turn, co-contribute to active construction of complex connections and relationships in representations of reality (Witherington, 2015). Neither internal nor external influences originate causal pathways; instead, mutual influences inform systemic reactions which result in developmental changes and transitions.

A process-relational approach to cognitive development can be better understood systematically through Relational Developmental Systems (RDS) metatheory. Relational Developmental Systems metatheory is a collection of theories specific to different developmental processes which posit that mutual influences between person and context are understood as essential interacting components which contribute to human developmental processes (Lerner & Callina, 2013). Mutual person-context relationships make up metanarratives in RDS, making RDS a specific application of the process-relational worldview. Thus, a process-relational approach allows for a flexible and systemic understanding of cognition that can reconcile the contributions of multiple disciplines to the concept of cognitive complexity while RDS metatheory allows for a systemic and coactional understanding of the development of cognitive complexity as a developmental process. RDS metatheory encompasses several developmental theories which recognize relative plasticity in development and emphasize normative processes of development and thriving across the lifecourse. Dynamic Systems Theory (DST) falls under the RDS metatheoretical umbrella and is useful in understanding cognitive development in young children. DST concepts may be useful in understanding the development of cognition in adolescent populations.

Dynamic Systems Theory and Positive Youth Development

Dynamic Systems Theory (DST; Thelen & Smith, 2006) is well-suited to understanding the codeveloping processes of cognition during adolescence. Much as developmental processes codevelop and help shape one another, so do theories. In particular, the tenants of DST help describe the processes of development within a positive youth development framework.

Development can be thought of as the path that is take between one developmental moment and the next, rather than the destination itself. Because development is at the core of DST, the outcome is not the sole focus, rather, the process and all the contributing components that engender developmental change (Thelen & Smith, 2006). Within DST, increased complexity is understood as “an increase in the number of different parts and activities, and relations among them” (p. xiv). Systems move from small and simple to connected and complex. For example, understanding the process of goal development in adolescents necessitates an understanding of the contributions of many parts of adolescent cognition, including the resources which an individual might use to move toward creating and achieving goals. Resources may include people that they find inspirational, things that they do every day to reach their goals, their environments, and motivations that they have for achieving those goals. However, the developmental timescale is also important. Because adolescence is a time of social reorganization and reorientation toward peers, emotional regulation and perspective taking abilities are necessary cognitive skills (Crone & Dahl, 2012). The need for these new skills creates instability in which an individual must assemble the skills needed to move toward a new stable system of interaction with peers in order to continue to achieve goals.

This represents the element of self-organization within developmental systems; individuals are open systems who self-organize in non-linear and dynamic ways through mutually influential contextual resources and constraints (Witherington, 2017). During key developmental periods, moving toward new systems of stability is necessary; continued stability at these times is not adaptive. For example, the child who does not develop the ability to take the perspective of their peers may be perceived as selfish or short sighted. The inability to change in this situation will not help the child in forming goals for themselves that are compatible with social others.

The idea of self-organizing systems which move toward complexity is strongly grounded in the notion that adaptive systems which have been used in the past are the foundations of future systems (Thelen & Smith, 1996). A system is dynamic in that it is dependent on prior states, and in those future states which are dependent on it. This assumption necessitates the principle of continuity in time. As systems are built on components of prior systems, these components are related to one another in complex ways, all codeveloping on different timescales, and all influencing one another. For example, the development of logical reasoning in children is one component of the later ability to think critically, or to make decisions in emotionally meaningful environments. The development of logical reasoning begins much sooner than the other processes, yet it is nested within them all the same as an essential component. Thelen (2005) argues then, that the study of development necessitates understanding of how components interact on a short time scale may cascade into the developmental changes that researchers seek to understand.

Developmental systems are “softly assembled” (Thelen & Smith, 2006), meaning the relationships between the elements of the systems are comprised of varying degrees of stability and flexibility and are most mutable to changes during certain periods of development. Thelen (2005) described flexibility within a stable system as being able to walk, and add an additional element to this task, for example, walking in different kinds of shoes, or talking at the same time. Walking is a stable process for most adults, yet it is made up of and dependent on multiple interactive components. Elements which change the basic function of walking, such as walking in heels, may be added to the stable process of walking as an expression of the flexibility of the stable system. Similarly, stable systems are the default system which best enables someone to reach a goal given current constraints; for example, crawling is one of the first stable systems for young children to physically reach their goals. If a child is still mastering the core stabilization and balance needed to walk, and that child is motivated to get to something quickly, they may revert to the established stable system of crawling to do so. This does not mean that they have regressed to a prior state, rather, they are simply moving toward the more stable system temporarily while still moving toward walking as the long-term stable system due to its greater long-term efficiency. Thus, patterns are assembled and selected in response to context.

Notably, development is an open system which is dynamic and must lose stability in order to shift from one stable system to the next (Thelen & Smith 1996). Open systems are in constant states of change in variability at the microlevel—a small child crawls around an object that is in their way. These variabilities result in dissolution and formation of new component parts to the system (e.g., learning to crawl backwards). Thus, the system maintains stability at the macrolevel, while increasing levels of complexity through changes at the lower levels of the system (Witherington, 2017). Stability is lost when the interplay of processes exceeds a certain range, or when a new concept is introduced to which the system must adapt (e.g., discovery of furniture as a method of pulling up to walk).

For adolescents, the growing importance of social standing and peer relationships introduces a new element in which the adolescent must develop a new system of stability (Crone & Dahl, 2012). This component affects many areas of the adolescent's life. It impacts the ability of the adolescent to make decisions in emotionally challenging or consequential environments. Therefore, a better understanding of peers is necessary to move toward a state of stability. This is achieved through the further development of emotional regulation, the development of theory of mind capabilities, and understanding of others' emotional states such as empathy. During periods of rapid development, stability and complexity decreases as systems reorganize into systems with greater relative stability and complexity; this dynamic flexibility results in U-shaped trajectories in developmental systems (Gershkoff-Stowe & Thelen, 2004). Thus, developmental systems are in continuous processes of self-organization across multiple timescales and prior developmental stages in order to provide the foundation for new developmental outcomes.

While DST has guided theoretical advancement in infant cognitive and behavioral development, less work has focused on the development of cognitive systems in adolescence. Rapid cognitive development during infancy and early childhood provides the foundation for steady gains in cognitive development throughout middle childhood and for a second period of rapid cognitive development and reorganization during adolescence. Understanding cognitive developmental processes during adolescence involves a simultaneous understanding of mutual processes which impact youth: social reorientation, physiological changes following pubertal onset, and the environmental systems in which these changes take place. These interacting developmental processes must be interpreted jointly as they are mutually influential and continuously produce new effects through interaction (Gershkoff-Stowe & Thelen, 2004).

Most theories of adolescent development have focused on maladaptive behaviors. However, DST posits that developmental theories should encompass all outcomes; adaptive outcomes must also be considered as results of the path of development. This is an area of intersection where the tenants of positive youth development theories fit well with the tenants of DST. Positive youth development theories emphasize the contributions of contextually based adolescent strengths to coacting processes which may cascade into positive developmental trajectories (Lerner & Callina, 2013). Therefore, a positive youth developmental approach will be used to examine how adolescents develop complexity within systems of development related to adolescent goal development. Relational considerations in PYD theories allow holistic depictions of adolescent development; to understand how youth succeed and thrive, adolescents must be recognized as more than the sum of their deficits.

Adolescent Cognitive Development as a Dynamic System

Conceptual development is studied primarily in infancy and early adolescence when cognitive flexibility is highest and most amenable to changes. Cognitive development during these times is aided by physical growth and increased need to autonomously complete tasks. In infancy and early childhood, independence is gained in basic functions such as the ability to walk, run, or eat with less assistance from parents. During adolescence, autonomy is developed in emotional regulation, ability to make increasingly complex decisions, and in the ability to form goals for the future which are independent of their parents. Conceptual development in infancy focuses on the acquisition and formation of conceptual systems.

The dynamic development of adolescent cognitive processes related to goal development and motivation is best represented through an embodied understanding of cognitive and developmental processes which includes the influences of social interaction. Nested developmental timescales during adolescence are influenced by rapid physiological development, cortical maturation, and societal expectations. Social interactions are generally underexplored as contributors to development in dynamic systems theories (Thelen & Smith, 2003); however, constructivist theoretical tenants, and the emerging field of 4E cognition offer a dialogue on social interaction which may facilitate better integration of this important developmental context in relation to the development of attainable goals for the future.

4E Cognition and Complex Connections in Cognitive Processes

The human mind and by extension, cognition, is a collection of interacting linked systems and networks of interrelated constructs which co-create concepts of the world in interaction with context, past impressions, and environment (Overton, 2015). Systems coact to perform cognitive functions such as complex decision making, information retrieval, and behavioral inhibition and activation. Disaggregating systems from one another leads to an incorrect understanding of any one system. For example, understanding the interconnections and overlaps between the perceptual system (e.g., visual, touch, auditory), the conceptual system, and reality inform how cognitive functions emerge and co-create new perceptions and conceptual understandings (Thelen et al., 2001). The understanding of these systems as interconnected co-influential contributors is an embodied understanding of cognition.

The study of embodied forms of cognition in which the mind, body, and world interact to create cognitive realities has a relatively short history, but its roots lie in the cognitive revolution of the 1950s. This interdisciplinary intellectual movement between several key fields of study resulted in the formation of the field of cognitive science. However, the field of cognitive science focused on internalist assumptions of cognition and did not recognize the impacts of environment and experience on cognitive development. In the early 1990s, embodied cognition emerged with an emphasis on the connection between mind and body (Varela et al., 1991). The idea of cognition as extending beyond the mind has become more mainstream, with an explosion of theories in the 2010s which expanded the field to include embodied, embedded, enacted, and extended (4E) ways to understand cognition (e.g., Chemero, 2011; Clark, 2011; Johnson, 2017; Rowlands, 2010; Shapiro, 2011).

4E approaches move beyond the traditional cognitivist representational and computational models of cognition and reject several key tenets of cognitivism including the idea of the brain as the central processing unit where cognition happens, the conception of cognitive processes as a-modal and isolated abstract processes which receive sensory input and produce behavioral output, and functionalist perspectives (Newen et al., 2018). Within 4E approaches, dynamical systems theories occupy an anti-representationalist stance. Although there are diverse theories of dynamic systems which have been applied to cognition, those best applied to 4E cognition operate on the assumption that cognitive systems are not able to be isolated from each other and are dynamically intertwined in environmental systems. These assumptions are predicated on the interaction hypothesis, which states that any one component of a cognitive system can only be adequately understood in relation to every other component, and the openness hypothesis, which states that cognition is a set of interacting systems which are constantly interacting dynamically with one another rather than a closed system in a state of equilibrium (Lamb & Chemero, 2018).

The concept of cognitive complexity fits well within the 4E framework of cognition as an extension of DST development of cognition. This approach means that in general, cognitive complexity does not fit well within the ‘cognitivist’ paradigm; instead, it falls into an enactivist paradigm which rejects a pure brain-based cognition and elevates the importance of context. Cognitive system complexity is one of several coacting interrelated processes which develop during adolescence. Recently, several related systems have received attention including executive functioning (EF), intentional self-regulation (ISR), emotion regulation, and empathy (Bridgett et al., 2013; Diamond, 2013; Zelazo, 2015; Zelazo & Carlson, 2012). Each of these systems contribute to a fuller understanding of the development of cognitive complexity.

The Role of Executive Functioning Skills in Adolescent Complexity Development

EF capabilities are defined as top-down self-regulatory neurocognitive skills involved in goal-directed modulation of actions, attention, and emotions (Zelazo, 2015). These capabilities include inhibitory control (the ability to control impulsive behavior), cognitive flexibility (the ability to understand multiple points of view) and working memory (ability to recall and use relevant information during a task). According to DST, these capabilities are represented by softly assembled systems, or functional developmental systems which are renegotiated within and in response to developmental changes and environmental demands (Thelen, 2005; Munakata et al., 2012; Zelazo, 2015).

Cognitive developmental systems demonstrate the most plasticity during periods of rapid change in adolescence and early childhood (Gopnik et al., 2017). The cognitive processes which mature during each of these periods have functional overlap, but also correspond to independent relational constructs of EF capabilities by adolescence (Poon, 2018). EF capabilities are dependent on two kinds of relational processing: cool abstract cognitive processes and hot affective motivationally based processes. Cool systems specialize in reflective planning in response to neutral situations and require skills in logic and critical analysis. Hot EF skills specialize in fast emotional processing; these skills are goal-directed, future-oriented cognitive processes which include emotional and motivational investment and tension between proximal goal-achievement and long-term rewards (Poon, 2018), and are associated with reward processing, emotions, and social orientation.

Importantly, while both cool and hot processes contribute to performance of EF skills, they follow different developmental trajectories. Cool EF processes, or those used in response to low stakes tasks which do not require high degrees of emotional control, develop more quickly than hot EF processes, or those used in response to high stakes and emotionally involved situations (Prencipe et al., 2011). The first period includes the rapid development of cool EF skills and occurs around age six. There is considerable evidence that early adolescence marks a second period of rapid development, this time of hot EF skills.

Rapid development and renegotiation of social orientation, cognitive organization, and cognitive control skills during adolescence suggests a period of relative plasticity and sensitivity to influence from both the internal (e.g., hormonal changes), and the external environments (Zelazo & Carlson, 2012). During adolescence, cool EF continues to improve linearly with age, while hot EF processes follow a U-shaped developmental trajectory in both delay aversion and risk-taking behaviors. In particular, poor performance on hot EF processes is most pronounced between the ages of 13 to 16 (Poon, 2018). This corroborates research which identified middle adolescence as a period of development vulnerable to risk-taking and aversion to delaying rewards in favor of long-term outcomes (Steinberg, 2005). Although adolescence is a sensitive period for EF development, understanding of EF has historically been shaped by measurement of abstract non-affective cool cognitive aspects in young children (e.g., Wisconsin Card Sort, Color Word Stroop Test) while hot affective components of EF, especially important to adolescent development, have only recently begun to be explored (Zelazo & Carlson, 2012; Poon, 2018).

Intentional Self-Regulation & Emotion Regulation

Although hot and cool EF skills develop independently, they work together to functionally adapt and navigate challenges in every-day life (Poon, 2018). This is achieved through the development of intentional self-regulation skills. Both cool and hot EF processes help regulate goal-related interactions between the individual and their environment. Intentional self-regulation abilities allow an individual to adaptively modulate EF skills to navigate the goal-directed behaviors of selection, goal-directed planning (optimization), and compensation for losses experienced in goal-related planning or activities (Urban et al., 2010). Greater ISR skill development represents the ability to both recognize and seek available resources within environmental contexts (Urban et al., 2010). Notably, there is considerable overlap in the impacts of EF skill development and in ISR which suggests that they may be coacting processes that contribute to mutual positive developmental outcomes; greater EF skills are positively correlated with a litany of desirable developmental outcomes including engagement, attention, and the ability to flexibly adopt new perspectives (Sabbagh et al., 2006).

Specifically, it has been hypothesized that intentional self-regulation abilities are the product of reactive, bottom-up processes and reflective, top-down regulatory processes which use EF skills to modulate and adapt to environmental demands (Cunningham & Zelazo, 2007). Therefore, self-regulation may facilitate the development of working memory and attention skills and greater recognition of complex connections within a cognitive system (Roebers, 2017). These complex connections allow increased flexibility in reasoning and increased cognitive control and self-regulation skills. The recognition and integration of these components results in a more nuanced evaluation of goal-directed situations which may then be integrated to form multifaceted, or more cognitively complex perspectives (Cunningham & Zelazo, 2007).

For adolescents, the development of hot EF processes may present a dynamic element to the ability to intentionally self-regulate in environments which require decision-making in social and emotional contexts. While cool EF skills may have already developed, hot affective motivationally based processes are likely still developing, which requires the renegotiation of ISR skills within this context (Cunningham & Zelazo, 2007). Therefore, an adolescent may be able to intentionally self-regulate in a situation involving critical thinking, but unable to self-regulate in a situation involving emotion regulation. Thus, emotion regulation abilities and processes are essential to the ability to develop hot executive functioning skills.

Emotion regulation is defined as processes which influence how an individual experiences and expresses emotions (Gross, 2015). Emotional regulation strategies help adaptively manage the intensity, duration, and reaction to emotions, and are important skills which support psychological well-being, and goal achievement (Aldao et al., 2015). The regulation of emotions is integral to perceptions that inform actions through the Behavioral Approach and Behavioral Inhibition Systems (BAS/BIS). The development of emotion regulation skills is a flexible process, and the capacity is informed by the contexts in which emptions are experienced (Gross, 2015; Kobylińska & Kusev, 2019). Emotion regulation is an affective process which extends beyond cognitive development to predict health outcomes related to acute stress, and risk of psychological affective disorders (Tyra et al., 2021)

Complexity as a Group of Collective Variables

EF capabilities are one component that contributes to the development of complex cognition. In particular, the kind of cognition that becomes more complex during adolescence is related to hot EF capabilities. Complex cognition develops plastically during infancy and adolescence which represent periods of increased cognitive flexibility. Thus, these developmental periods may produce the most potential for positive development in an individual's cognitive system (Nigg, 2017). Ability to articulate concepts and constructs such as moral reasoning (Decety & Cowell, 2014; Moore & Tenbrunsel, 2014), executive functioning (Nigg, 2017), affective perspective taking (Burleson & Waltman, 1988), self-regulation (Wright, 2012), empathy (Decety & Cowell, 2014; Wright, 2012), comforting strategies (Burleson, 1984), and stereotype beliefs (Wright, 2012) have been associated with greater cognitive system complexity. Additionally, higher cognitive complexity provides the foundation for higher order cognition such as advanced planning, goal development, and the ability to reason as a way to regulate action and interactions with others (Gross, 2015). Although cognitive complexity has often been conceptualized with social or interpersonal domains in mind, the concept may be applied to any domain or set of interrelated domains.

Adolescent cognition is a developmentally open system which dynamically self-organizes by moving in a sequence of complexity to simplicity to complexity (Smith & Thelen, 2003). This theoretical notion is well-represented in parallel brain developmental research; gray matter concentration peaks prior to maturation in a brain region and begins to lose gray matter as systems specialize and become more efficient (Gogtay et al., 2004). Structural maturation takes place systemically in a spreading coactional pattern of development throughout childhood and adolescence. Similarly, cognitive construct and system complexity is developed through domain coactivation throughout development.

Despite the importance of cognitive complexity in understanding adolescent developmental processes, little research has focused on adolescent acquisition of complex cognitive processes. Adolescent cognitive complexity is plastic, responsive to intervention, and is facilitated through positive social interactions and diverse knowledge acquisitions in peer and mentoring relationships. Therefore, complexity development may be a key area of focus in cognitive measurement in order to enable a better understanding of positive developmental cascades in youth.

Conclusion

The development of complexity within adolescent cognitive systems has the potential to inform both research and programs designed for youth. Adolescence is a critical period of cognitive development during which many processes codevelop as cognitive flexibility and plasticity increase (Gopnik et al., 2017; Larsen & Luna, 2018). Cognitive complexity's connection to constructs such as increased affective-perspective taking, empathy, prosocial behaviors, cognitive flexibility, and executive functioning demonstrate the potential of this construct to inform developmental cascades (Lewin-Bizan et al., 2010; Thelen & Smith, 1996). Connections between cognitive complexity could be extended beyond executive functioning, cognitive control, and cognitive flexibility, to include direct connections such as those between cognitive control and intentional self-regulation (Bohl & van den Bos, 2012; Nigg, 2017; Zhou et al., 2012). In adolescence, exploring the connections between emotion regulation or empathy and the development of differentiated and integrated cognitive systems could contribute to a fuller understanding of how EF processes contribute to multiple developmental periods in different ways.

Adolescent reorganization of cognitive systems around social hierarchies and peer relationships highlights the development of affective abilities in cognition. While EF skills have been separated into cool and hot capabilities, it is worth noting that these distinctions are similar to those postulated in empathy research. In EF research, the "cool" executive functions are characterized by critical thinking and logical capabilities in a low-stakes environment., while the "hot" capabilities represent more emotional or affective components of EF. Empathy research has found that there are different kinds of empathy including cognitive empathy and affective forms of empathy (Melloni et al., 2014). These parallels indicate that empathy may develop on a similar track of developmental timing, with more cognitive forms developing at the same time as "cool" EF capabilities, and affective components developing more in line with the developmental timing of "hot" EF capabilities.

Similarly, ISR could be better understood by examining it in context with other developmental processes. ISR is a contributor to the development of executive function capabilities which requires self-understanding and theory of mind. However, ISR can be understood as having more than one component; a cognitive control component and an emotional regulation component which develop to help individuals modulate and manage emotional experiences. The identification of hot EF capabilities as cognitive processes which develop during adolescence highlights the importance of selecting or creating measures that correspond appropriately to the developmental moments of a population.

A dynamic systems-based understanding of adolescent cognition, and in particular, the emergence of complexity in youth enables greater understanding of connected functions such as self-regulation, self-reflection, and goal setting. Such an understanding of adolescent developmental cascades allows a more complete picture of cognition, developmental processes, and adolescent maturation. Many factors closely tied to cognitive complexity are prosocial competencies which PYD programs and character education programs aim to increase (Berkowitz, 2002). Similarly, PYD programs target competencies that should lead to higher complexity in youth cognition, such as exposure to diverse contexts and perspectives, teaching cooperative and individual skills, and encouragement of involvement within the community. Cognitive complexity measurement could offer a more sensitive measure of program outcomes and demonstrate that youth are on positive developmental trajectories even in programs with short delivery periods. This could help demonstrate the value of concentrated programs on potential long-term outcomes for youth, by providing a shorter-term indicator of program effects.

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Chapter 3: Developing Measurement and Youth: Cognitive Complexity Measurement in Context

Changes in self-concept and the development of personal identity are considered key developmental markers during adolescence. Early adolescence marks a period of cognitive flexibility and reorganization of cognitive constructs around a cohesive personal and social identity (Gopnik et al., 2017; Steinberg, 2005). The reorganization of cognitive constructs, or representations through which people interpret the world into larger interconnected construct systems indicates that this developmental period may be especially important to the developmental of cognitive complexity, or the degree to which an individual has developed differentiation and integration between key constructs within a construct system.

Higher cognitive complexity in youth is associated with a host of prosocial outcomes such as moral reasoning (Decety & Cowell, 2014; Moore & Tenbrunsel, 2014), affective perspective taking (Burleson & Waltman, 1988), and greater perception of others' communication as supportive (Bodie et al., 2011). Because cognitive reorganization begins early in adolescence when cognitive flexibility is high, encouraging the development of cognitive complexity in early adolescence may encourage positive developmental cascades and trajectories. However, considerable variations subsist in the conceptualization, definition, and measurement of cognitive complexity.

Cognitive processes, representations, and organization can be difficult to measure because they are not directly observable (Ewoldsen, 2017). As a result, differences in theoretical worldviews and paradigms are often at the heart of the debate over appropriate measurement. These differences have led to parallel development of measures and concepts that have fractured our understanding of cognitive complexity and complexity measurement. The aim of the current paper is to: 1) briefly examine the roots of several main theories of cognition and their relation to cognitive complexity; 2) identify measures of cognitive complexity within those paradigms; 3) suggest measures that can be triangulated to more accurately measure differentiation, integration, and abstraction; and 4) demonstrate this measurement in a pilot program evaluation study.

Intellectual Ancestry: Cognitivism, Connectionism, and Constructivism

The first stirrings of the Cognitive Revolution began in the early 20th century, and by 1950, it marked a change in the zeitgeist within psychological sciences away from the dominant behaviorist perspective (Proctor & Vu, 2006). Behaviorism aimed to increase the credibility of psychology by establishing it as a purely objective science. Assumptions were modeled after more established fields in natural sciences such as chemistry and biology to increase credibility and introduce standardization into psychology. Behaviorists argued that only observable external behaviors in stimulus-response (S-R) relationships were legitimate representations of cognition (Watson, 1913). Radical behaviorists went so far as to account for communication behavior through stimuli, response, and reinforcement (Skinner, 1957). Behaviorism's exclusive reliance on external, chained stimulus-response (S-R) units, and its inability to recognize the contributions of conscious thought in human behavior ultimately led to major challenges to the paradigm's basic assumptions (Bargh & Fergusson, 2000). Chomsky's (1959) seminal critique of Skinner's behaviorist explanation of verbal behavior introduced a different and more complex understanding of cognition; this resulted in a paradigm shift which moved psychology away from pure behaviorism (Kuhn, 1970).

A plurality of theoretical perspectives emerged during this paradigm shift, including a return to experiential concepts explored by Wundt's (1902/1910) and Titchener (1912) and the development of personal construct psychology (Kelly, 1955). These constructivist theories built on the cognitive theoretical foundations of Piaget and Vygotsky and examined how individuals were influenced by and constructed cognition based on external realities.

At the same time, Information Processing Theories (IPT) emerged. These theories predicated the operation of the mind based on the Turing machine and machine-based learning. Simultaneously, neuroscientific theories attempted to explain brain processes and behaviors through the architecture of the brain, or by explaining behavior in connection to specific regions of the brain. This rapid theoretical expansion led to the development of isolated theoretical paradigms, theories, and measures. The result of this rapid expansion is a fragmented conception of complexity. While most measures of complexity include both differentiation and integration as main components, distinct measures are not highly correlated (Kovářová & Filip, 2015; Zhang et al., 2012). It is likely that different conceptions of cognitive complexity measure distinct, but interconnected aspects of complexity, however these connections have not been explored. Therefore, selection of measures of complexity are facilitated through alignment with theoretical positioning and a clear understanding of how differentiation and integration contribute to complexity.

Simplicity-Complexity and Grid Techniques

Bieri (1955) was the first to explicitly recognize and seek to measure cognitive complexity from the ideas present in personal construct theory (PCP). He presented a unidimensional construct of simplicity-complexity defined as "the capacity to construe social behavior in a multidimensional way" (Bieri, 1955, p. 185). Within his framework, cognitive systems ranged from simple and disorganized to complex and multidimensional. Bieri's contribution to measurement of cognitive complexity included a grid technique of matching and card-sorting which was used to determine complexity between pre-selected subjects (Bieri &

Blacker, 1956). Bieri and Blacker (1956) argued that cognitive complexity was formed through interpersonal experiences and was partially generalizable to other domains within the individual's perceptual system.

Zimring (1971) conceptualized differentiation and integration as orthogonal constructs rather than two sides of a coin, or opposites on a single spectrum. He argued that integration was incorrectly conceptualized; a person with only a few developed cognitive dimensions should differ from an individual who has many cognitive dimensions, constructs, and elements which they see as highly interconnected and thus inseparable. Neimeyer (1992) extended these ideas in the structural quadrants method (SQM) which provided a coding and graphical depiction of complexity with four quadrants. This method was expanded again by Botella and Gallifa (2000) to match grid methods of measurement, such as Bieri's grid index. However, Botella and Gallifa's conception of cognitive complexity was highly structural and required Rep-grid assessments, which are limited.

Recognition of the orthogonal relationship between differentiation and integration contributed to a more nuanced understanding of the functional or performative aspects of cognitive complexity; however, structural processes are not accounted for in these measures. Grid techniques are limited in two important ways: 1) they provide limited choices which are deductively determined rather than provided by personal motivations of participants; and 2) they are executed with few real-world implications. This is problematic in the measurement of adolescent cognition because they may fail to capture the developmental changes which occur within hot EF cognitive processes, and instead only capture the steady continued improvement of cool EF maturation. Measures which are more closely aligned with interpersonal and social domains may be better suited to the developmental realities of an adolescent populations.

Sentence and Paragraph Completion Techniques

Conceptual systems theory is an organizational personality theory introduced by Harvey and colleagues (1961). In this theoretical framework, conceptual complexity is a personality variable that reflects ability to process and categorize information. This application of cognitive complexity was widely disseminated in highly visible scientific fields such as Education, Criminology, Anthropology, Clinical Psychology, and Political Science. Methodologically, it has been used in sentence completion test and paragraph completion test measures to score secondary textual data (Baker-Brown et al., 1992). Suedfeld and Coren (1992) define differentiation as the ability to discern more than one dimension or perspective, and integration as the ability to combine these dimensions and components as larger parts of a superordinate structure.

The Role Category Questionnaire

Crockett's (1965) theory of cognitive complexity recognized the importance of everyday life and situations in the development of complexity in cognitive systems. As a proponent of personal construct psychology, Crockett integrated tenets from Kelly's (1955) personal construct theory with principles from developmental psychology in his theory of cognitive complexity. In particular, Crockett was influenced by Werner's (1957) orthogenetic principle which states, "wherever development occurs it proceeds from a state of relative globality and lack of differentiation to a state of increasing differentiation, articulation, and hierarchic integration" (p. 126). This developmental principle guided Crockett's (1965) definition of cognitive complexity as the number of constructs in a cognitive system (differentiation), their integration with one another, and the degree of abstraction that is found between constructs and in connecting constructs to one another. Construct differentiation is measured as the number of unique constructs elicited about a subject, and construct abstractness is coded for the frames of reference used in conceptualization. Crockett believed personal constructs were embedded in individual context; the measure associated with this theory, the role category questionnaire (RCQ), provided an inductive approach to measuring cognitive systems which was absent in the grid techniques.

Crockett's (1965) RCQ measure offered participants free-response to polar interpersonal questions (i.e., a description of a liked pupil, a description of a disliked pupil). The utilization of proximal individuals who participants had personal, emotional, and motivational connections to correspond to the contextual nature of Crockett's theory of the development of complexity. Crockett identified childhood and adolescence as the main periods of complexity development. Because Crockett believed that reality was largely constructed through interaction with others (i.e., external to internal), his measurement focused on interpersonal construct development; he theorized that there was some degree of generalizability from the interpersonal construct system to other domains within the cognitive system.

Crockett's (1965) RCQ is considered developmentally appropriate for adolescents (Burleson, 1984; Zhang et al., 2012). While grid techniques are positively and linearly correlated with age, the RCQ is not, especially in early childhood. It may be that the RCQ is a better measure of hot EF cognitive capabilities while grid techniques are a better measure of cool EF processes. The RCQ's ability to account for hot EF processes gives it a developmental advantage over grid techniques which are less able to do so. As a measure, the RCQ has high test-retest reliability (i.e., Chronbach's alpha consistently above 0.90) and is independent from intelligence and verbal abilities (Koesten & Anderson, 2004; Kovarova & Filip, 2015; O'Keefe, Shepherd, & Streeter, 1982; O'Keefe & Sypher, 1981; Zhang et al., 2012).

Developing Measurement

Complexity measurement should be developmentally appropriate (e.g., account for both hot and cool EF processes), and include developmental processes which interact with cognitive development during adolescence such as social, physiological, and neurological systems. Therefore, a more flexible measure of cognitive complexity which can be adapted to secondary interview data could offer valuable insights into the development of complexity. This could allow measurement of complexity in contexts other than the interpersonal context and may be a useful interpretive tool for understanding the processes and trajectories of development which lead to prosocial outcomes.

The RCQ offers a developmentally aligned measure that is well-tested in adolescent populations and considered a good measure of differentiation (Zhang et al., 2012). Differentiation is understood as the number of constructs an individual identifies in a verbal impression (Crockett, 1965; Lewin, 1947). However, the measurement of integration presents two main issues: disaggregation of integration from differentiation in measurement, and lack of consensus on what constitutes integration. Although Crockett defined a process to code integration, it is highly correlated with the RCQ measure of differentiation. As a result, the RCQ is usually only used to measure differentiation (Crockett et al., 1974; Burleson & Waltman, 1988). In addition, differentiation and integration are sometimes scored together as components to a single score, which makes disaggregation of the concepts difficult. For example, the Paragraph Completion Test, which scores written or verbal impressions, includes varying levels of both differentiation and integration components for each of its 7 scoring categories, but does not differentiate integration from differentiation (Baker-Brown et al., 1992).

Because integration is usually considered to be a component of organization of constructs within the cognitive system, it is inherently dependent on differentiation. However, integration and differentiation are terms used in relation to complexity in many contexts including applied mathematics (e.g., measure theory, information theory), dynamical systems, neuroscience, and complexity science. In calculus, integration can be understood as the area beneath a function. In simplified terms, integration in this context is a calculation of the volume or area of small portions of the area under a function which are then added together. This helps one understand the function which is described in the dynamic processes by estimating the total variation of a dynamic process (Kouropatov & Drefus, 2013).

When applied to cognitive systems, integration in this context can refer to a person's ability to acknowledge and reconcile the presence of multiple components in relation to a construct, and both tolerate and reconcile similarities and differences based on increased awareness of contextual influences. Similar definitions have been adopted in dynamic integration theory (DIT), which defines integration in cognitive-affective structures as the capability to both recognize multiple affect states and to tolerate and make sense of dialectical tensions between multiple viewpoints and contradictory desires (Diehl et al., 2018), and in Relational Dialectics Theory (RDT) which conceptualizes integration in terms of increased connection (Baxter, 2011). Both theories are process-focused dynamic systems theories, which describe ongoing processes of meaning-making and development. Therefore, integration will not be understood as reduction or simplification of cognitive concepts, but as a process through which nuance is discovered through the connection and melding of sometimes contradictory constructs within a cognitive system.

Therefore, integrative capacity can be understood as the ability of an individual to identify multiple connections between constructs and think about constructs from multiple contextual positions and perspectives. In the present study, pupils were asked to respond to questions about goals, values, and people that they found inspirational. The ability of an individual to identify and integrate these constructs within their personal constructs, and through the lens of multiple perspectives (e.g., effects on peers, contributions of family members, personal expectations) to formulate personal definitions of purpose is the integrative capacity described in the present study.

Present Study

The Inspire Aspire: Global Citizens in the Making Program (I > A) is an in-school character education program which is designed to help youth define personal goals and find purpose through identifying inspiring figures and values which they admire. Youth were interviewed about their goals and inspirational figures before and after the program was administered, providing secondary interview data which was able to be analyzed for complexity.

The I > A program uses multiple prosocial media sources and curricula which are designed to include well-known positive influencers, such as Olympic athletes and civil rights leaders. Past meta-analyses of prosocial media indicate a positive relationship between prosocial media exposure and prosocial behaviors (Coyne et al., 2018). However, this research indicated that the effects were strongest for emerging adults, and other research has indicated that some prosocial behaviors follow a U-shaped trajectory, with a decrease during adolescence followed by an increase into emerging adulthood (Carlo et al., 2007). DST understandings of U-shaped developmental trajectories necessitate an examination of the attractor states, or the states which both cause instability, and lead to the development of a more adaptive and developmentally appropriate stable system (Thelen & Smith, 1996). Increased peer importance and social cognitive reorganization processes impact the incidence of prosocial thoughts, such as empathetic concern, but prosocial actions may not be realized until later in adolescence as the cognitive system finds stabilization through better emotional regulation abilities and increased hot EF capabilities which allow decision making in emotionally impactful situations.

Self-understanding is an important component in the development of the emotional regulation abilities needed to translate prosocial cognition into behavior (Goodvin et al., 2015). As the I > A program encourages exploration of the self in relation to others, it is expected that self-understanding increases over time in the program, and youth begin to make connections between the inspirational actions of others, and their own goals, values, and purpose, which could result in higher complexity (i.e., differentiation and integration). Although the extant literature suggests a positive relationship between measures of complexity and prosocial youth outcomes, there is not a clear understanding of how a measure of complexity might relate to the processes which contribute to the development of complex cognitions about goals, motivations, and inspirational figures. Therefore, an exploratory analysis of cognitive complexity will be conducted with the goal of better understanding the following research questions:

RQ1: Do differentiation and integration increase between waves?

RQ2: What developmental trajectories of cognitive complexity emerge as patterns for youth following program implementation?

Methods

Participants

Interview participants were Scottish S2 pupils (approximately 7th grade U.S. equivalent) who participated in I > A and agreed to be interviewed. Twenty-four pupils who participated in structured telephone interviews both pre- and post- program implementation were included for analysis. Participants were White (100%), and the majority lived in two parent homes (parents were either married or cohabiting; 75%). Participants were between 12 and 14 years old at the first wave (M = 13) and half of the participants identified as female (50%).

Consent forms were provided to all participating students in eleven classrooms. Six classrooms returned consent forms for student interviews. We randomly selected up to five consenting students per classroom for interviews. If fewer responded to the interview scheduling, additional pupils were randomly selected from the consented pupils in the classroom. If the quota within a classroom was not met after these efforts, additional consented pupils from classrooms who had already reached their quota were selected.

Procedure

Pre-program interviews ranged in length from 8.45 to 23.00 minutes (*Mdn* = 11.25), and post-program interviews ranged from 8.00 to 16.93 minutes (*Mdn* = 11.45). All interviews were recorded with the consent of parents and pupils and transcribed verbatim. Pupils were asked about inspirational figures, values they identified as important, and future goals.

Secondary qualitative analysis is considered appropriate when data fit well with the purpose of the research goals of another research question (Corbin & Strauss, 2014; Hinds et al., 1997). The original purpose of the interviews was to develop a more complex understanding of participants' descriptions of inspirational figures, personal strengths, goals, and future-mindedness prior to and following implementation of I > A in their classrooms, which fits well with the goals of the present study. Qualitative analysis was conducted using methods based on Grounded Theory analytic principles, with the goal of forming an individual theory of each participant's construct system. Utilizing a multi-stage process, constructs and cognitive systems were identified by two coders using constant comparative analysis (Olson et al., 2016). Next, cognitive systems were mapped into individual theories (Corbin & Strauss, 2014). Maps were then scored for differentiation and integrative capacity. Finally, scores were classified using the SQM's graphical representation of an orthogonal relationship between differentiation and integration. Hereafter, integration will be understood to mean integrative capacity unless specified otherwise.

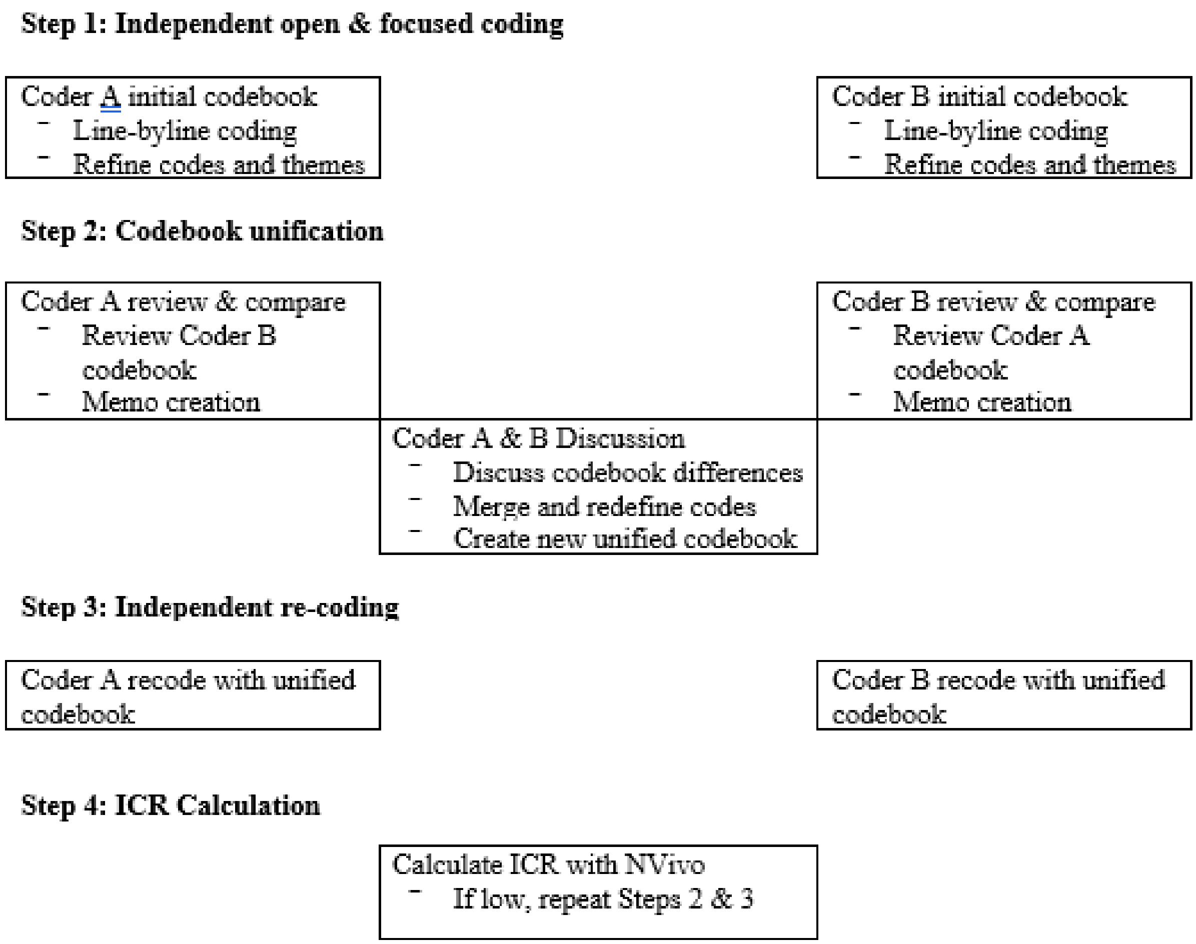
Construct Identification

Constructs and cognitive systems were identified in each interview using thematic constant comparative analysis (CCA; Corbin & Strauss, 2014; Olson et al., 2016). Data were analyzed by two coders (Figure 1). Initial coding of interviews was independent; codes were first formed individually using line-by-line identification of potential codes such as "I'd like to improve my confidence level" and "I'd just like to keep fit and do more exercise." Following open coding, each coder individually refined codes within the interview by merging redundant codes and re-examining the interview for missed codes. Similar initial codes were formed into categories; for example, multiple quotes concerning fitness could be conceptually labelled "Fitness". Throughout this process, coders kept memos which identified possible connections and common themes coders independently identified.

Each coder had the opportunity to review the codebook of the other coder and compare codebooks. Coders then met to discuss disagreements in coding, until consensus was reached, and synthesized the two codebooks into a unified codebook for each pupil. Finalized codebooks were then used to individually recode transcripts. Individual recodes were then used to calculate intercoder reliability (i.e., Cohen's kappa, percent agreement).

Figure 1

Constant Comparative Analysis Coding Process



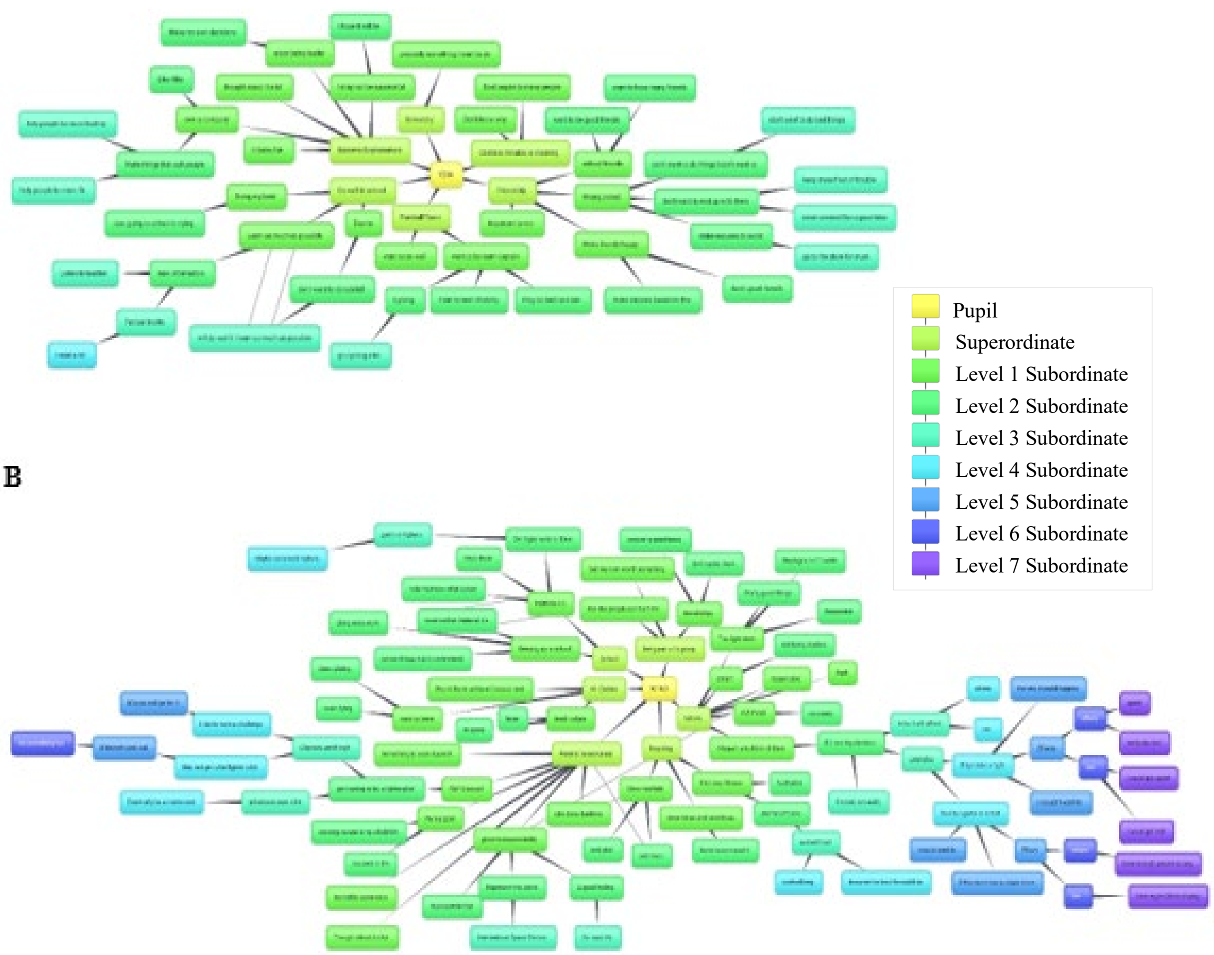
Cognitive Mapping

Unified codebooks for were used to create visual maps of youth values, goals, and inspirational figures. Identified constructs were diagrammed as cognitive maps for each pupil at both W1 and W2 using Bubbl.us, a concept mapping website, to allow cognitive map comparison (example comparison cognitive maps are illustrated in Figure 2).

Figure 2

Pre- and Post- Program Cognitive Maps for Y014

A



Note. Figure demonstrates the cognitive maps of one pupil. Each construct is represented by a bubble. Colors represent organization level of construct. Panel A: W1 cognitive map. Panel B: W2 cognitive map of same pupil.

Within each map, constructs were organized based on pupil connections and organization of concepts. For example, at W1, a participant named an inspirational figure, but could not explain in detail why that person might be inspirational to them. Therefore, the construct for inspirational figure was very simple in the map as demonstrated in Figure 3.

Interviewer: Can you name a person who you would consider to be “inspirational”?

Participant: Cristiano Rinaldo

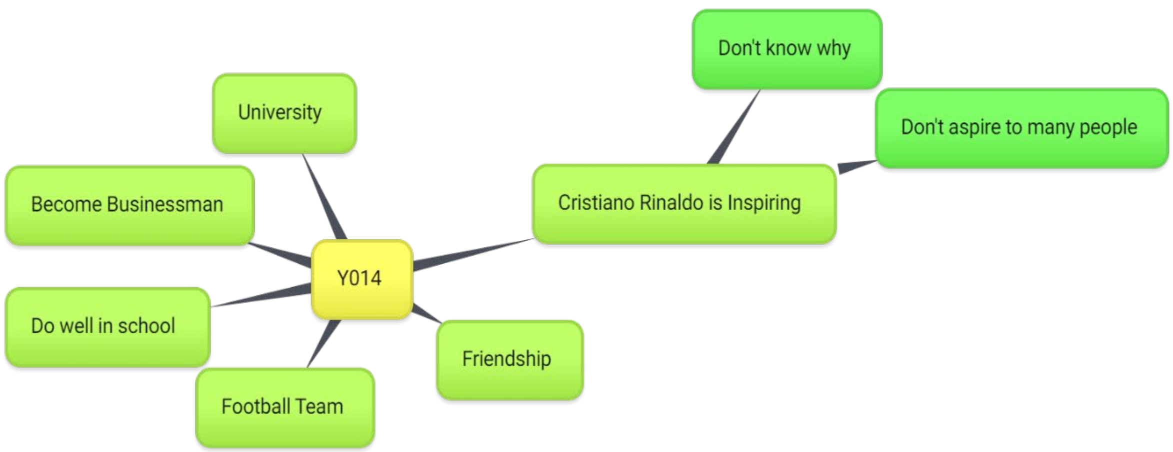
Interviewer: What about this person inspires you?

Participant: Umm, I don't know. I don't really have many people I aspire to…

Coding in this way allows pupils to construct how concepts are related for them, rather than assuming a top-down deductive structure.

Figure 3

W1 Mapping of Inspirational Figure



Note. Figure demonstrates interview identified constructs in cognitive map. Subconstructs were temporarily collapsed within superordinate constructs to focus on the Inspirational Figure construct detailed in the interview quotes.

Maps were created inductively at both waves. If a participant organized a concept differently at W2, this was reflected in the cognitive map. For example, at W1, this pupil struggled to conceptualize their personal values outside of the context of friendships.

Interviewer: How do your values guide the decisions or choices you make?

Participant: Uhm, well I think I always try and make choices that make friends happy, uh, or don't you know, upset them

However, by W2, Y014 had a much more nuanced understanding of values and how actions and behaviors might affect others.

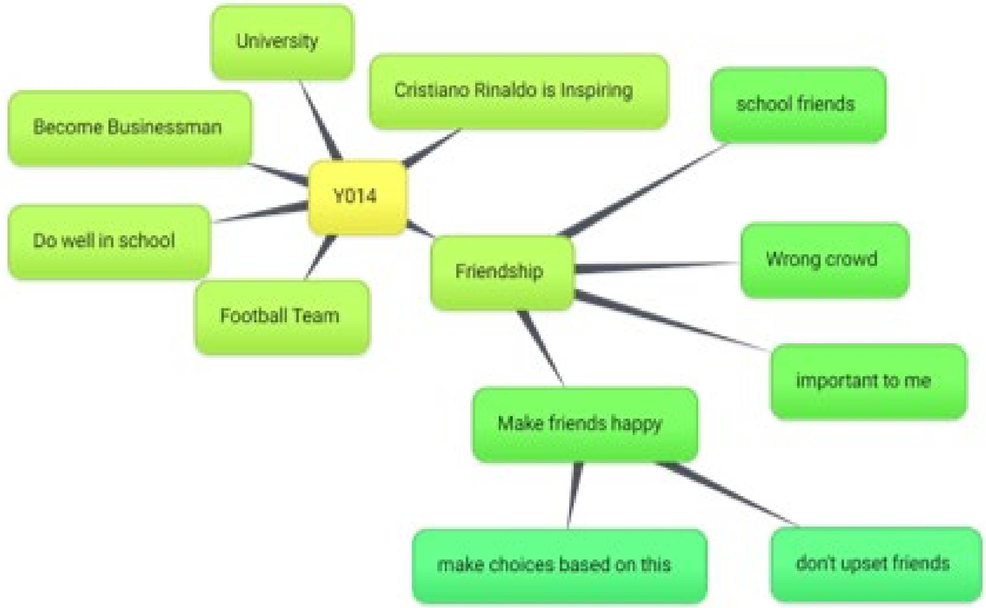
Participant: Well I always try to think, like if I try to do something I would think how that would affect me and how that will affect the people around me so if I chose to say get into a fight, I would be not wanting to do that as I would think about what would happen to other people could get seriously hurt or upset, and for me that could happen to me as well. I might get upset or seriously hurt as well so that would be something else I wouldn't chose to do again and say if it was something like play a game in a final where a team was a man down and play for them, I'm thinking that could affect me because I would have good time playing in a final and affecting other people that would be good because then they would get enough people to make up a team.

Figure 4 demonstrates how interview identified constructs at W1 and W2 were translated to cognitive maps. At W1, the pupil's concept of values was dependent on and subsumed under the concept of friendship. At W2, the construct was independent of friendship and acquired additional subconstructs and levels of meaning, as illustrated by the color changes in Figure 4.

Figure 4

Mapping of Y014 Value Guided Decision-Making

A



B

Note. Colors indicate different levels of construct organization. *Panel A*: Pupil Y014 organization of value guided decision-making at W1. *Panel B*: Pupil Y014 organization at W2.

Content Analysis

Cognitive systems identified in concept maps during CCA were scored for construct differentiation using scoring techniques adapted from the Role Category Questionnaire (RCQ; Crockett, 1965). The RCQ assessment was selected over coding systems such as the Repertory Grid Technique (Bieri, 1955) due to greater consistent reliability and validity, independence from confounding variables such as verbal intelligence and loquacity, and its superiority in use with adolescent populations (Sypher & Applegate, 1982; Zhang et al., 2012). In addition, the RCQ has been successfully adapted for use in other contexts such as health, and empathetic responding (e.g., Applegate & Delia, 1980; Burleson, 1984; O'Keefe & Sypher, 1981) which increases confidence in it as an adaptable measure. The adaptation used in this study utilizes the coding procedures developed by the RCQ to measure differentiation in personal constructs that pupils used to describe inspirational figures, values, and goals.

Differentiation. The scoring system for the RCQ (Crockett et al., 1974) was adapted to measure differentiation within program interviews. The original RCQ is designed to elucidate the interpersonal cognitive system by asking pupils to describe both a liked and disliked peer in detail. Impressions are then examined for interpersonal construct descriptions which are then coded (Crockett et al., 1974; Burleson 1984; Zhang et al., 2012). Interpersonal constructs are defined as any detail, quality, behavior, or action which the participant attributes to the peer they are describing.

The current adaptation examines construct differentiation in impressions youth make about value, goals, and inspirational figures. The analysis is also adapted for use in secondary interview data. While the original RCQ methodology asks pupils to describe impressions based on bipolar ideas of "liked" or "disliked", the current analysis adapts the measure into a relational approach rather than a dualistic approach to elicit constructs from participants by allowing pupils to determine the valence of constructs described. All constructs which pupils identified in relation to questions asked goals, values, and inspirational figures were scored, and the pupil was able to freely assign positive or negative valence to their responses. While this increases burden on the researcher to elicit and reconstruct the connections participants made between constructs, it also avoids the suggestive bias of positive or negative valence in the way participants formed ideas about the subjects. Thus, constructs can be understood as any detail, quality, behavior, or action which the participant attributes to their understanding of goals, values, and inspirational others. Therefore, each interview was treated as the impression that is typically scored for the traditional RCQ and the total number of constructs identified within the impression serves as the total differentiation index. For example, for the pupil we examined before, 51 constructs were identified by the pupil, resulting in the differentiation score for that wave.

Integrative Capacity. The calculation of differentiation is simple, which argues for a similar level of simplicity in scoring integration. Integrative capacity is defined as the ability of an individual to recognize and reconcile different perspectives and contexts in their description of their goals, values, and inspiring figures. Integrative capacity is scored by calculating the area (i.e., breadth x depth) of each superordinate construct for a superordinate construct score. Superordinate construct scores are then summed to obtain the Integrative Capacity score. Depth is identified as the largest number of levels removed from the center of each superordinate construct. Breadth is identified as the broadest number of subconstructs within a superordinate construct. Both Figure 5 and Table 1 demonstrate Integrative Capacity scoring for Pupil Y014 at W1. For example, in Figure 5, the superordinate construct for Inspirational Figure received a score of 1 as the depth value in Panel A and a breadth value of 2 in Panel B. This resulted in a value of 2 for Inspirational Figure superordinate construct. Each superordinate construct was calculated in this way to obtain the superordinate construct scores seen in Panel C. These scores were then added together to obtain the Integrative Capacity score for Pupil Y014 at W1.

Figure 5

Integrative Capacity Scoring W1

Note. Figure demonstrates integration scoring. Panel A: Depth in Inspirational Figure = 1, Friendship = 3. Panel B: Breadth in Inspirational Figure = 2, Friendship = 7. Panel C: Superordinate construct score is product of breadth and depth score for each superordinate construct. Integration score is summary of superordinate scores = 60.

[a] Superordinate construct. [b] Subordinate construct.

Table 1

P014 Superordinate Scoring W1

Superordinate Construct	Depth (*d*)	Breadth (*b*)	Superordinate Score (*d* x *b)*
Friendship	3	7	21
Inspiring Figure	1	2	2
University	1	1	1
Become Businessman	3	5	15
Do well in school	4	3	12
Football team	3	3	9

Note. The integrative capacity score is a summation of superordinate scores; P014's integrative capacity score is 60.

Analyses

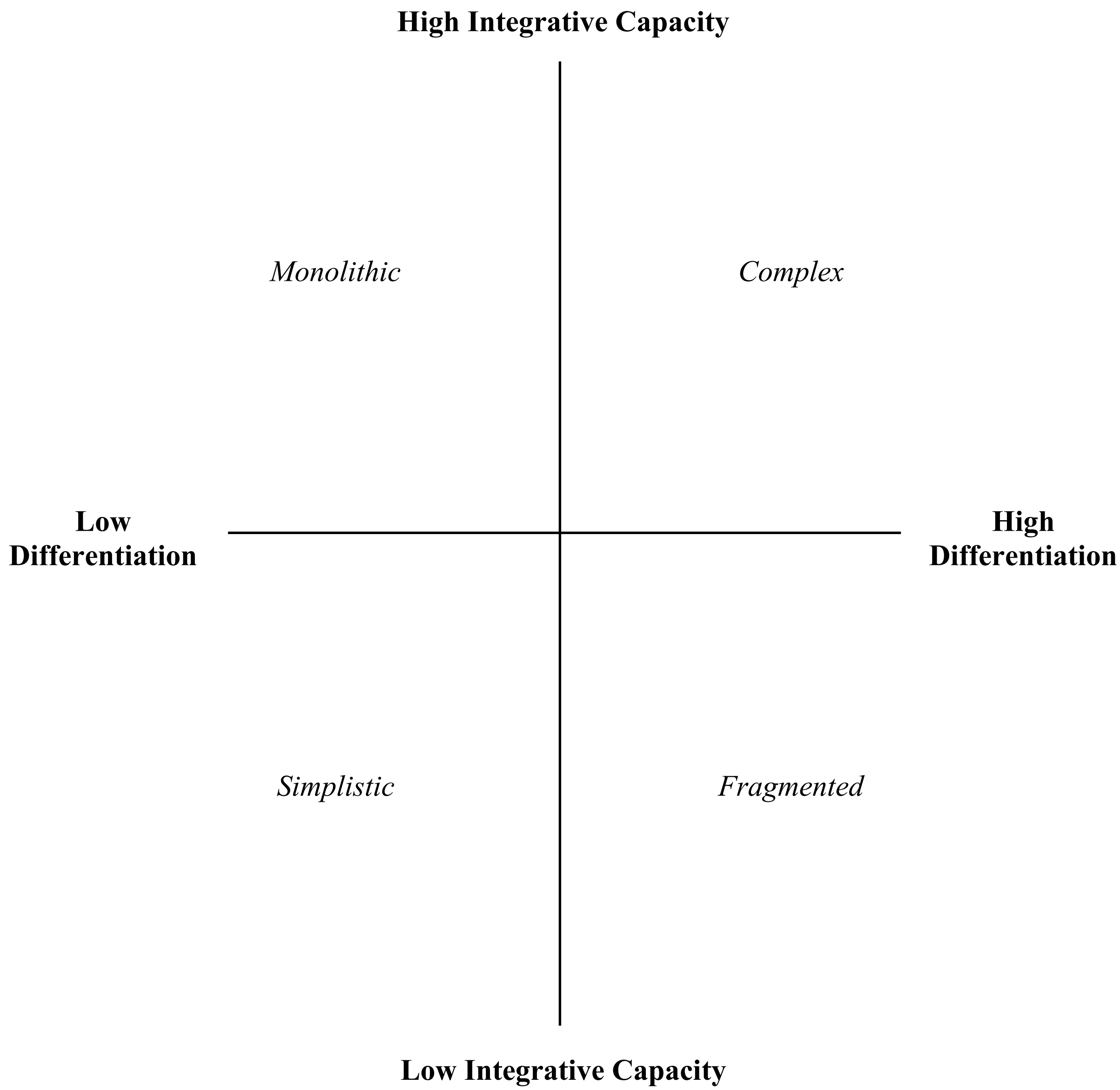
Paired *t*-tests were used to examine integration scores between W1 and W2. Post-hoc power analyses revealed that the sample was not sensitive enough to detect significance for differentiation, so it was not estimated for the population trajectory. In addition, past criticisms of the RCQ have implicated verbal loquacity as a possible confounding component of complexity measurement (e.g., Beatty & Payne, 1984); therefore, a two-tailed paired sample *t*-test was used to provide a measure of loquacity based on interview length.

Classification

Classification of cognitive systems in relation to other youth in the sample was done using the graphical representation of the Structural Quadrants Method to demonstrate the differentiation – integration matrix represented in Figure 6 (SQM; Botella & Gallifa, 1992). Pupil scores were plotted based on individual differentiation and integrative capacity scores at wave one and wave two to examine emergent trajectories to obtain classification. Low differentiation and integration scores are classified as 'simple'; low differentiation and high integration is classified as 'monolithic'; high differentiation and low integration is classified as 'fragmented'; and high differentiation and high integration is classified as 'complex'.

Figure 6

Classification of Cognitive Systems



Results

Both coders analyzed all 24 interviews at both waves An intercoder reliability (ICR) analysis demonstrated consistency between independent codes assigned from unified codebooks. Both percent agreement and Cohen's kappa were used to determine reliability in coding. Although percent agreement is not considered a rigorous statistic for most data (Hayes & Krippendorff, 2007), it provided a metric of agreement which demonstrated consistency in the volume of text contained within a code. Cohen's kappa was considered an appropriate metric of reliability because there were exactly two coders (Cohen, 1960). The resulting IRR metrics indicated substantial agreement at W1, $\kappa = 0.94$, $\alpha = 0.97$; and W2 $\kappa = 0.90$, $\alpha = 0.95$ (Landis & Koch, 1977).

Integrative Capacity

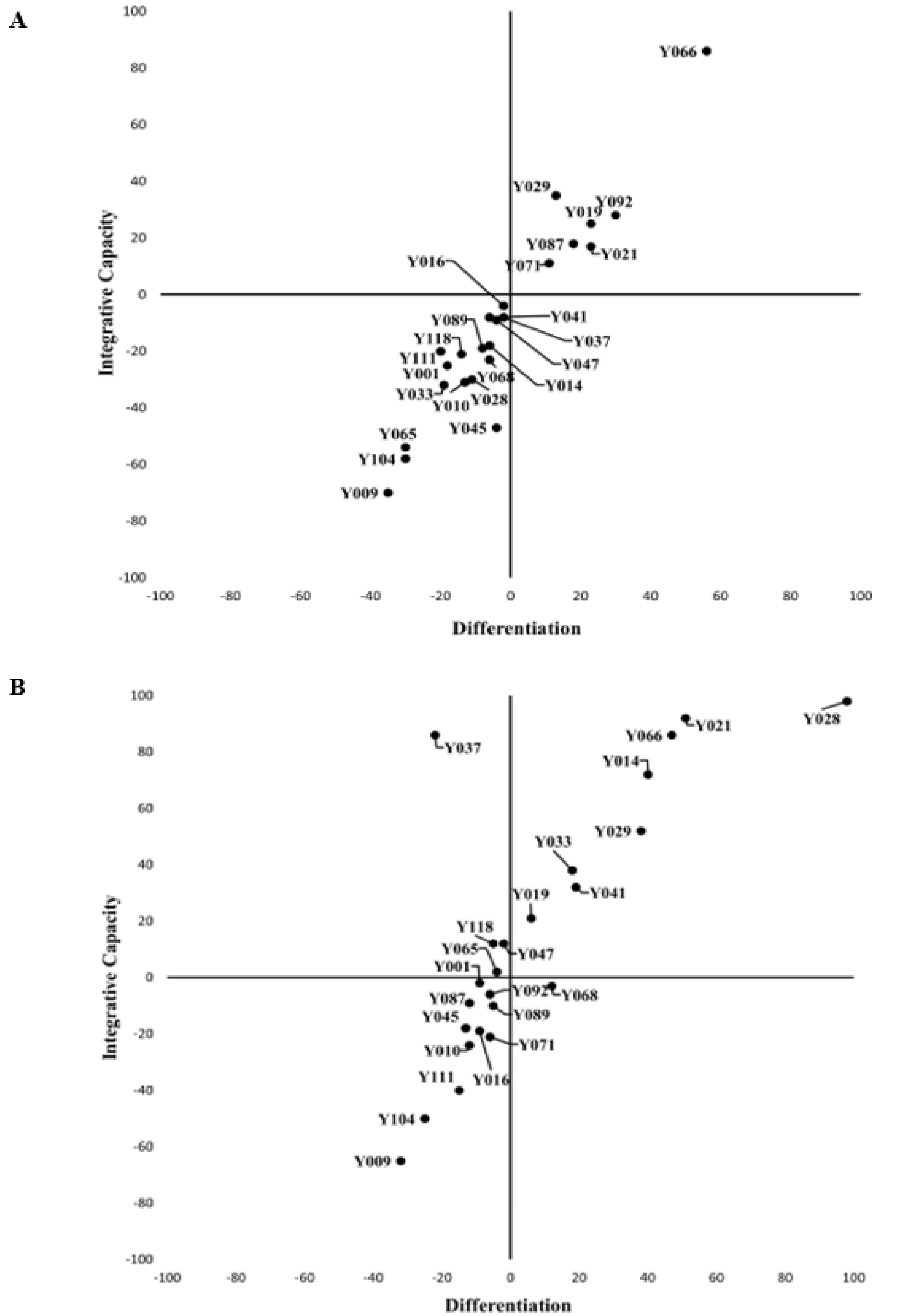
Post-hoc analysis revealed that power was sufficient at .83 to appropriately detect changes in integrative capacity. Pupils' W1 integration scores were compared to W2 integration scores using a two-tailed paired sample *t*-test. There was a significant difference between W1 ($M = 90.52$, $SD = 31.80$) and W2 ($M = 122.62$, $SD = 46.57$) integration scores ($t(23) = -1.26$, $p <.05$) with the recommendation to reject the null hypothesis. As data cannot be considered normal, a nonparametric Wilcoxon Signed Rank Test was run, with recommendation to reject the null hypothesis ($p < 0.05$).

Classification

The quadrants of the SQM were used in conjunction with differentiation and integration scores to classify cognitive systems in comparison to their peers. To graph scores, W1 and W2 were pooled and the trimmed mean was used to lessen the effects of outliers in the upper and lower 5% of the sample for integration and differentiation scores. The pooled means of these scores were then subtracted from the raw scores at wave one and wave two to determine the levels of differentiation and integration compared to peers. Low scores on differentiation are those below zero, high scores are those above zero. Figure 7 demonstrates the graphical results. For the purposes of graphing, a maximum of 100 was imposed, which moved one data point inward at W2, but did not change the classification of the youth.

Figure 7

Cognitive Classifications Between Waves



Note. Classification of cognitive systems. Panel A: W1 classification. Panel B: W2 classification.

Table 2 demonstrates trajectories youth followed between W1 and W2. Overall, 11 youth retained their W1 classification at W2, while 13 moved between classifications.

Table 2

Cognitive System Complexity Classification Change from W1 to W2

W1	W2				
	Simple	Fragmented	Monolithic	Complex	*n*
Simple	8	1	4	4	17
Fragmented	0	0	0	1	1
Monolithic	0	0	0	0	0
Complex	3	0	0	3	6
n	11	1	4	8	24

Note. Table shows the classifications of youth at each wave and the trajectories between waves. For example, looking at the first row: 17 cognitive systems were classified as Simple at W1. By W2, 8 of those who began as Simple remained Simple, 1 became Fragmented, 4 became Monolithic, and 4 became Complex. Looking at the first column: 11 were classified as simple at W2; in addition to the 8 who remained Simple, 3 who were classified as Complex at W1 became Simple by W2.

In general, youth moved toward greater degrees of complexity between W1 and W2; while 17 were classified as simple at W1, only 11 were by W2. Although three moved from complex at W1 to simple at W2, nine of those classified as simple at W1 increased differentiation ($n = 1$) to become fragmented, increased integration to become monolithic ($n = 4$) or increased both to be considered complex at W2 ($n = 4$). All of those who became monolithic were categorized as simple at W1.

Verbal Loquacity

Interview length did not vary significantly between W1 (M = 12.12, SD= 3.00) and W2 (M = 11.41, SD = 2.5) conditions ($t(23) = 0.78$, $p > 0.05$), and remained nonsignificant between W1 (M = 11.63, SD = 1.85) and W2 (M = 11.23, SD = 2.38) conditions ($t(22) = 0.63$, $p > 0.05$), when an outlier was excluded.

Discussion

The purpose of this study is to develop a method to measure cognitive complexity in secondary interview data. Understanding how cognitive systems develop and change over time could enable a better understanding of the processes of cognitive development in adolescence. While the RCQ is a well-established measure, it is often used to measure only differentiation due to measurement issues with other related constructs. However, integration is not universally understood (Kovarova & Filip, 2015). Integration measures in cognitive complexity are often enmeshed with measures of differentiation. Prior measurement of integration has understood integration as an opposite to differentiation (Bieri, 1955; Kelly, 1955). However, a relational understanding of integration does not allow this kind of reduction of a system. Components of any system interact together to form new systems which cannot then be reduced to back to isolated components or a prior system (Thelen & Smith, 1996). Therefore, integration must be understood in terms of increased nuance in an increasingly complex system, rather than simplified processes. The development of a non-reductionist method of measuring integrative capacity in a cognitive system allows the general area of a cognitive system to be better described.

Despite lacking the power to estimate a change in the measure of differentiation, change in integrative capacity was able to be measured. Post-hoc power analyses revealed that power the predictive power was sufficient (*a* = .83). The difference in integrative capacity scores was significant between waves ($p < 0.05$); significance remained after non-parametric tests were run. A generally positive trend toward greater integrative capacity for pupils may indicate that for adolescents, integrative capacity is an important contributor to overall complexity in relation to goals, values, and future aspirations.

While post-hoc power analyses revealed that the study was underpowered and unable to accurately estimate changes in differentiation between waves one and two, it is still important to estimate differentiation. The processes are fused processes and while estimating each can contribute to a better understanding of the other processes, they cannot be separated in the measure of complexity. Although the study lacked the power to detect significance in the change in differentiation for individuals between W1 and W2, codebooks and cognitive maps demonstrated that change was generally in a positive direction for youth. One explanation for smaller amounts of change in differentiation than integrative capacity could be one of differentiation and integrative capacity as processes which both interact with and build upon one another; differentiation abilities may increase more rapidly during earlier periods of cognitive development and be stable developmental process which increases at a slower rate by early adolescence. If differentiation and integration follow the pattern of other fused processes pf cognitive development, they may interact in a similar pattern as that seen in the development of EF capabilities. Cool EF processes develop rapidly during early childhood, before plateauing into stability during most of childhood, and then forming the foundation for the rapid development of hot EF processes during adolescence (Munakata et al., 2012; Thelen, 2005;

Zelazo, 2015). The processes are fused processes and while estimating each can contribute to a better understanding of the other processes, they cannot be separated in the measure of complexity.

Despite an overall trend toward more complex cognitive systems in youth (i.e., 17 youth were classified as simple in W1 while only 11 were classified as simple at W2), some youth became less complex between waves (e.g., 4 moved from complex to simple classifications). There are clearly multiple trajectories of development within the population. This finding is not surprising considering the development of new cognitive capabilities should result in the destabilization of old systems in order to accommodate new elements and capabilities (Thelen & Smith, 1996). According to a developmental systems perspective, better understanding of which elements contribute to system instability while also helping to create a new adaptive system is necessary in understanding processes of development. To more fully understand the multiple trajectories which youth are experiencing in the development of complex thinking around goals, values, and motivations, a contextual approach which considers the simultaneous development of other cognitive developmental processes is necessary.

There has been some debate about the effects of verbal loquacity on complexity scoring. Some have argued that those who talk longer will be scored as more complex than those who do not talk as long (Powers, et al., 1979). This hypothesis has been examined and refuted (Burleson, 1984). However, verbal loquacity was accounted for in the current investigation as a product of interview length. Interview length did not significantly differ between pupils at W1 and W2. One participant had longer interviews at both waves compared to the average of the other participants who were interviewed and was regarded as an outlier. When this participant was removed, interview length remained insignificant between waves. Loquacity remained relatively stable across waves, indicating that it is unlikely to impact complexity scoring. This is consistent with prior refutations of the impact of verbal loquacity on RCQ based measures of complexity.

This study adds to limited research examining the development of cognitive complexity in youth and demonstrates the potential role of cognitive integration in development during adolescence. It also adds a perspective on the definition and understanding of integration and differentiation between disciplines and underlines the importance of clear definitions of integration. While system integration may not be the only integration, it matches the conceptual level of the measurement of system differentiation represented by the total of parts.

Limitations and Future Directions

The current investigation demonstrates the development of a system of scoring and categorization of cognitive systems. This measure of cognitive complexity is broadly scored to understand the overall complexity of pupils' cognitive systems in response to questions about purpose, inspiring figures, and goals. Further investigation into differences in complexity between pupils' identified superordinate constructs and how they impact the overall scoring in relation to other outcomes and over time could offer more nuanced insight into the development of cognitive complexity. For example, a pupil may have a more complex construct system for sports at one time point, and more complex construct system in regard to career at another time point. Identifying shifts in which constructs are accessed at different time points throughout development could provide a contextually grounded understanding of this development during a crucial period of identity formation. Such an investigation could help elucidate how complexity, pupil's personal contexts, and executive functioning capabilities interact.

The present study is an exploratory examination of cognitive complexity in secondary interview data. The present study cannot differentiate potential program effects from developmental effects, so caution should be used in interpretation of these results. Furthermore, the sample size is small, and the sample is largely homogenous. While the homogeny of the sample is generally representative of the population in Scotland, caution should be used in generalizing results. Future research could explore the use of this methodology in different populations, and in larger samples.

In addition, it should be noted that complexity was measured in relation to pupils' goals, values, and inspirational figures; direct comparison of the development of this domain of complexity with measures of complexity in other domains (e.g., interpersonal) cannot be considered as equivalent comparisons. Instead, such comparisons can shed light on how complexity develops in different domains, and how these developmental processes contribute to one another and the creation of adaptive contextually based cognitive systems. Further validation of this measure with the liked/disliked peer version of the RCQ is warranted. While earlier research had trouble reconciling the RCQ with other measures of complexity, the interpersonal domain which is measured in the RCQ may be related to the goals, vales, and motivation domain measured in the current study. A clearer understanding of how the two measures relate to one another could also further understanding of the development of differentiation during adolescence. Such a comparison of the RCQ and the current adaptation of the measure of differentiation could not be done in the current study, as the data was secondary. Future research could examine complexity coding as it is done here in comparison to the verbal RCQ within the same study.

Finally, future research should examine the relationship integrative capacity and other cognitive processes which contribute to prosocial development. Elucidating connections between cognitive complexity and prosocial outcomes is useful in practical applications such as program evaluations which often have a short amount of time to deduce program and developmental effects. Such connections, when combined with study designs which control for developmental effects could provide a precursor estimation of prosocial outcomes or positive programmatic effects. Further consideration of how developmental social reorientation toward peers contributes to stabilization or destabilization of old systems in addition to the development of new adaptive systems in adolescent complexity is an important step in understanding cognitive complexity in adolescents. Given the multiple trajectories which emerged in the present study, the next step in understanding the interrelation of these developmental processes would be an exploration of the connections between trajectories of cognitive complexity about goals, values, and inspirational figures to processes of development such as empathy and hot EF capabilities.

Despite these limitations, the present study demonstrates the use of a measure of cognitive complexity which can be applied to secondary interview data. The flexibility of the measurement system allows estimation of complexity in multiple contexts, even when complexity was not explicitly measured in the primary investigation. This study also highlighted the estimation of integrative capacity in relation to goals and values as a key contributor to change in complexity classification for adolescents. While generalization is limited, further exploration of development of complexity during adolescence is encouraging and has the potential to positively impact both basic and applied research.

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Chapter 4: Connections Between Cognitive Complexity and Youth Empathy Trajectories: A Preliminary Investigation

The concept of empathy is integral to the study of cognition, psychology, and social interactions. It is recognized as a prosocial competency, an intrapersonal factor which may indicate prosocial behaviors, or behaviors which benefit social others (Carlo & Padilla-Walker, 2020). Empathy has been linked to cognition from the earliest days of psychology as a discipline. The term itself arose most notably as a concept used in absolutist-relativist disputes during the Enlightenment era. The first emergence of the concept can be traced to the debate between absolutism and relativism that developed between Immanuel Kant and his former student Johann Gottfried Herder. Herder's philosophy and epistemological positioning rejected most absolutist ideas arguing instead for an interconnected understanding which rejected the rigid divisions between subject and object.

Herder's ideas represented some of the earliest theoretical approaches to embodied cognition; his ideas were strongly connected to the concept of sensation as a product of human embeddedness and inseparability with nature or environmental contexts. His perspective on the connection between sensation and cognition was one of interconnected inseparability and was something he considered to be foundational to his epistemological beliefs (Ganczarek et al., 2018). Kant contended that sensation was too subjective of a phenomenon and argued for more objectivity in their very public dispute; Kant's resentment of Herder's popularity was likely the catalyst that led to a critical relationship between the two men, and likely had more to do with the success of Herder's *Ideas for a Philosophy of Humanity* and the neglect of Kant's own work *Critique of Pure Reason* which were published around the same time. Nevertheless, Kant's characterizations of Herder's work on sensation as subjective likely influenced the translation and understanding of the concept of empathy as a subjective concept.

The German word most often translated into empathy, einfühlung, or "feeling into", was coined in the dissertation of Robert Vischer regarding aesthetics (Ganczarek et al., 2018). However, Theodore Lipps is most often credited with creating a framework to study empathy. Lipps (1906) built on the works of Herder and proposed empathy as a supporting concept to his theory of knowledge. Lipps conceptualized knowledge as organized into three distinct domains: external objects, self-knowledge, and knowledge of others. He further suggested that knowledge had three sources in cognition: perception, introspection, and empathy. By Lipps' definition, empathy can be seen to some degree to be a perception of the life of another person and their experiences. In translating the work of Herder, Titchener (1909) translated the German word einfühlung to a term that he coined: empathy. This concept was meant to combine some of the meaning of feeling into with the word pathos which is defined as "an element in experience or in artistic representation evoking pity or compassion" (Miriam-Webster, 2021). The word pathos was itself borrowed from the Greek word páthos which describes a state of emotions in the context of misfortune, suffering, and enduring and has been used in English since the 16th century. These influences helped shape how we define and study the concept of empathy in psychology and has limited the study of empathy as a response to negative emotions rather than the broader range of emotions and feelings which the term was originally coined to represent.

Titchener's 1909 translation and incorporation of the term from its origins, lent itself to his own structural approach to representations and sensations in cognitive science. Titchener's philosophy centered on identifying and categorizing the most basic foundational aspects of the structure of mental processes. He believed that understanding basic principles would necessitate an understanding of higher order processes and representational systems. His translations of key works often were not direct translations and lent themselves to the personal theories and ideas which Titchener held. Indeed, much of Wilhelm Wundt's work was translated by and filtered through Titchener's theoretical interpretations (Wundt, 1902/1910).

Wundt, an early constructivist and represeantationalist, rejected reductionist accounts of consciousness. In many ways, the structuralism of Titchener differed from the introspection of Wundt. While Titchener applied a very strict interpretation of introspective analysis, Wundt had a more fluid understanding of the relationship between emotions, perceptions, and actions. However, the interpretation by Titchener to the growing field of psychology in the United States led to a somewhat biased understanding of these terms, and the theories of early German psychologists. Thus, the term empathy was coined by Titchener as an interpretation of these works and entered the American Psychological scene through a more structural lens, and less emphasis on the embodied components of his predecessors.

A Relational Understanding of Empathy

Within the concept of empathy, cognitive and affective components are distinct but codependent components that contribute to the experience of empathy. Specifically, cognitive empathy is an ability to understand the feelings of another person in relation to one's own theory of mind (Blair, 2005). Affective empathy is the ability to feel the feelings of another person when seeing them in an emotional state (Eisenberg et al., 2006). These components are foundational to a complete definition of empathy and are often measured separately.

Empathy has been defined many ways, however, Cuff and colleagues' (2016) review of empathy definitions landed on a more complete conception of the complex construct. A relational developmental adaptation of this definition will be used to define aspects of empathy throughout this paper. Therefore, empathy may be defined as an affective (i.e., emotional) response, informed by mutually influential processes of previous emotional learning and current contextual influences. Thus, empathetic processes are not exclusively top-down or bottom-up processes, rather, they represent a complex interplay of emotional regulation and executive function abilities. This interplay of capabilities produces a response of cognitive empathy based on individual perception and emotional understanding.

Cuff and colleagues (2016) include a stipulation that the individual must be able to differentiate certain theory of mind (TOM) aspects of empathy, however, I will not include that distinction in an examination of an adolescent population. Theory of mind, or the ability to recognize one's own thoughts and emotions as distinct from another person's is a connected and contributing developmental process related to cognitive empathy which develops throughout childhood and adolescence (Goodvin et al., 2015). The presence of theory of mind in empathetic concern and reasoning abilities is indicative of better emotional control abilities but is not inherent in the definition of empathy itself.

Despite the varied conceptions of empathy across disciplines, it is understood that empathy is highly interdependent with other cognitive developmental processes and cannot be isolated. In addition, empathy is highly dependent on context and prior knowledge of the situation or peoples involved. For example, in a study which showed participants people in pain alongside a vignette about the person who was experiencing pain, people felt less empathy for people who they perceived as unfair, and more empathy for people to whom they felt they had a social similarity or connection. Context and connections, therefore, are important in motivating an empathetic response. These differences extend beyond a divide between research and practice applications. The complex definition of empathy highlights the many components of the construct, as well as the highly interdependent nature of empathy processes with other codeveloping and fused processes of development.

The Development of Empathy and Cognition

Empathy is an embodied action at the intersection of cognition, behavior, emotion, and social interaction. The development of empathy begins early in life, with a form of emotional contagion seen in infants, emotional reflection (Goodvin et al., 2015). For example, if a caregiver is upset, a baby is likely to cry until emotional regulation capacities have developed. This form of emotional contagion lacks a theory of mind but is a direct reflection of a social other on which the baby is dependent. This form of emotional contagion is furthered by the development of emotional perception, or the ability to recognize emotion in facial expressions, within the first five months, and the development of social referencing abilities by the end of the first year of life (Saarni et al., 2006). Social referencing abilities include interpretation of emotional cues into meaning and developing a perceptual base through which to interpret vocal cues, facial expressions, and behaviors of those around them.

Social recognition, referencing, and emotional perception abilities are important developmental capabilities for young children (Saarni et al., 2006). These skills are essential in early emotional sense-making and help young children learn to read social cues, develop self-understanding, and the understanding of the self as distinct from others. Thus, the early processes that form the foundation TOM processes in early childhood contribute to the development of empathy through interactions with caregivers and peers. Similarly, the relationship between TOM capabilities and peer experiences are fused developmental processes which predict the development of early prosocial behaviors; the ability to recognize the needs of others contributes to positive peer interactions such as sharing (Caputi, Lecce, Pagnin, Banerjee, 2012).

Emotion Regulation, Executive Functioning, and Peer Relationships

Similarly, capacity for emotional regulation grows as self-understanding and emotional understanding increase throughout childhood (Eisenberg et al., 2006). Self-regulatory abilities such as self-soothing, and support seeking behaviors depend on recognition of emotional arousal, and an attempt to modulate the experience of emotions. These capabilities are a part of the development of executive functioning (EF) capabilities in early childhood, which rapidly increase between the ages of 3 to 5, and again in early adolescence (Poon, 2018). Interestingly, social relationships are most stable following periods of rapid EF development; studies of mutual friendship in children indicate that these connections are most stable between the ages of 5 and 10, with decreased stability between ages 10 and 14 followed by increased stability between 14 to 18 years of age (Poulin & Chan, 2010).

Throughout early adolescence, peer interactions become more complex and take on additional roles and meanings, and youth become more adept at establishing shared meaning with peers (Rubin et al., 2015). Empathy is a social process which requires the use of emotional understanding, perception, and the management of emotional contagion. Empathetic abilities increase as the ability to understand the self and others.

Self-Compassion and Personal Distress

The importance of TOM capabilities in empathetic processes is perhaps most salient when examining the effect of personal distress on the emotional response of helping behavior. When an individual cannot separate feelings of personal distress from the distress of another, helping behaviors are greatly reduced (Carrera et al., 2013). The ability to separate oneself from the vicarious experience of others is an important aspect of empathetic response. This TOM capability is also related to the ability to take the perspective of another person. Indeed, perspective-taking is sometimes considered to be an aspect of cognitive empathy (Cuff et al., 2016).

The ability to distinguish between the self and others also requires self-understanding. In particular, the ability to feel self-compassion has been linked to higher helping behaviors. One study of self-compassion's relation to empathy found that those with higher self-compassion had higher helping behaviors and simultaneously lower empathy (Welp & Brown, 2014). However, a follow up study found that greater self-compassion was only linked to feeling less personal distress rather than less empathy toward the person in need. Therefore, self-compassion is linked to empathy in that it can enable helping behaviors while keeping the emotional contagion of personal distress minimized. This concept highlights an interaction between theory of mind, self-awareness, and perspective taking which all contribute to an expression of empathy.

Connections of Empathy to Cognitive Complexity

Empathy itself is a concept that touches multiple cognitive processes and the expression of empathy is an ability that arises from the interaction of these cognitive processes in a flexible and context dependent way (Melloni et al., 2013). In particular, the expression of empathy involves at least three processes which are connected to cognitive, affective, and social abilities: affective arousal, perspective taking, and emotion regulation. These components are strongly connected to executive functioning abilities, which are then connected to cognitive system complexity to varying degrees (Bridgett et al., 2013). Therefore, empathy and cognitive system complexity are related processes which may be dependent on one another during cognitive development in adolescence. Indeed, work on executive functioning which has touched on cold and hot EF processes notes that the modulation for hot EF processes is dependent on emotional and social situations in which the adolescents were asked to do tasks which had consequences to their everyday lives (Zelazo & Carlson, 2012). Therefore, there may be a unique connection between increased empathy and cognitive system complexity that allows adolescents to develop personal and social understandings which can lead to decreased personal distress, increased self-understanding, and increased ability to take the perspective of others, and increased helping behaviors in youth.

The connections between cognitive complexity and empathy underscore that both may be parts of a number of cognitive systems which are both antecedent and contemporaneous to prosocial behaviors (van der Graaf et al., 2014; van der Graaf et al., 2018). Some of these processes may include EF processes, and foundational cognitive affective processes. The many facets of empathy underscore that such precursors are not simple, and different aspects may develop unevenly or facilitate the development of other aspects (Silke et al., 2018). In addition, environmental and contextual elements moderate the availability and saliency of constructs.

The Present Study

The present study builds on a measurement system of cognitive system complexity in a population of early adolescent youth to better understand the connection between various kinds and degrees of cognitive system complexity and a short form measure of empathy. The connections between executive functioning abilities in both empathy development and cognitive system complexity development make it likely that a connection between the concepts may exist, but what that connection may be in early adolescence is less clear. However, greater ability to take the perspectives of others is a requisite of empathetic responding, and greater perspective taking is linked to higher cognitive system complexity. This study seeks to explore in depth connections between complex cognition and empathy processes in youth interviews and understand trajectories of the development of empathy and cognitive system complexity. Therefore, the following research question and hypothesis are proposed:

RQ1: How are more complex forms of cognitive systems (i.e., fragmented, monolithic, complex) related to empathetic responses over time?

H1: Empathy at W2 will be higher than empathy at W1

Methods

Sample

Participants were Scottish S2 pupils (approximately 7th grade U.S. equivalent) who participated in the Inspire Aspire: Global Citizens in the Making Program (I > A), completed surveys at W1 and W2 and responded to the questions related to empathy (N = 102). A subset who also completed interviews at both waves was included to examine the measures of cognitive system complexity (n = 21).

Survey participants were 43.6% male, 12-14 years old (M = 13), mostly White (96.1%), with 2.9% reporting that they were Asian, and 1.0% of participants reporting that they were a part of multiple groups. Most participants indicated that their parents were married (74.5%). The full sample of interview participants were twenty-four pupils, however, three did not complete the survey at W2, and were thus excluded from analysis for a final interview subsample of 21 participants. Interview participants were White (100%), the majority lived in two parent homes (parents were either married or cohabiting; 71.4%), were between 12 and 14 years old (M = 12.95) and approximately half of the participants identified as female (47.6%).

Procedure

The present study uses a mixed methods approach to explore the connections between cognitive system complexity and self-reported empathetic responses in pre- and post- program surveys. Surveys were administered to students in 11 classrooms in Scotland before and after implementation of the I > A program. A subsample of interview participants was selected from these classrooms. Interview consent forms were provided to all participating classrooms, and six out of eleven classrooms returned signed consent forms. Up to five students per classroom who had consented to be interviewed were randomly selected for interviews. These students were followed up with and invited to schedule an interview with a team member. If students did not respond to interview scheduling attempts, additional pupils were randomly selected to replace them from the consented pupils in the classroom. If five students within a classroom did not respond to scheduling attempts, additional consented pupils from classrooms who had already reached their quota were invited to be interviewed.

All interviews were recorded with the consent of parents and the assent of pupils and transcribed verbatim. Interviews covered a range of topics related to figures they found inspirational, important values, and goals for the future. These interview data were initially collected with the purpose of better understanding how pupils selected inspirational figures, personal strengths, and goals, and assess future-mindedness before and after the Inspire Aspire program. For my examination of cognitive complexity, I used secondary qualitative analysis, meaning interviews were collected as part of the prior investigation with different research aims and goals. However, data were well suited to the current investigation, and aligned well with my research goals (Corbin & Strauss, 2014; Hinds et al., 1997).

A multistage process was used to identify constructs, code, score, and analyze participant interviews at both W1 and W2. While I provide a brief description of the process, and Figure 8 provides a flow chart of the stages of analysis, a detailed description is provided elsewhere (See Doubledee, 2022).

Stage 1: Construct Identification

Constant comparative analysis (CCA) methods were used to identify and code participant interviews (Doubledee, 2022; Olson et al., 2016). Participant interviews were scored separately for W1 and W2. Constructs and cognitive systems related to personal goals, inspirational figures, and values were identified using constant comparative analysis (CCA) methods to create unified codebooks (Doubledee, 2022; Olson et al., 2016). Data were analyzed by two coders and achieved acceptable levels of agreement at W1, $\kappa = 0.94$ $\alpha = 0.97$, and W2 $\kappa = 0.90$ $\alpha = 0.95$ (Landis & Koch, 1977).

Stage 2: Cognitive Mapping

Unified codebooks for each pupil were used to create maps of the constructs into systems. These systems reflected the constructs and relationships between constructs which pupils used to describe their goals, values, and inspirational figures. Separate maps were created for each wave for each pupil. This allowed a visual representation of the system of cognitive constructs, and an in-depth view of the complexity and connections between constructs.

Stage 3: Content Analysis

Cognitive construct systems were scored using a content analytical scoring of cognitive complexity, measuring both differentiation and integrative capacity. Differentiation is understood as the number of constructs an individual identifies in a verbal impression (Crockett, 1965). Differentiation was measured using the RCQ; the number of constructs which the pupil identified served as the differentiation index (Crocket et al., 1974; Doubledee, 2022).

In the present study, integrative capacity is defined as “the ability of an individual to recognize and reconcile different perspectives and contexts in their description of their goals, values, and inspiring figures” (Doubledee, 2022, p. 56). Integrative capacity is, therefore, not measured as a reductive component of cognition, but instead, as an increasingly nuanced system of constructs. This measure of integrative capacity is designed to calculate an estimate of the capacity an individual has for 2-dimensional integration by using a very simple formula to calculate the area of each superordinate construct (i.e., depth x breadth) and then adding the values from each construct to one another to obtain the final Integrative Capacity index. Thus, a differentiation score and an integrative capacity score were calculated for each pupil at each wave.

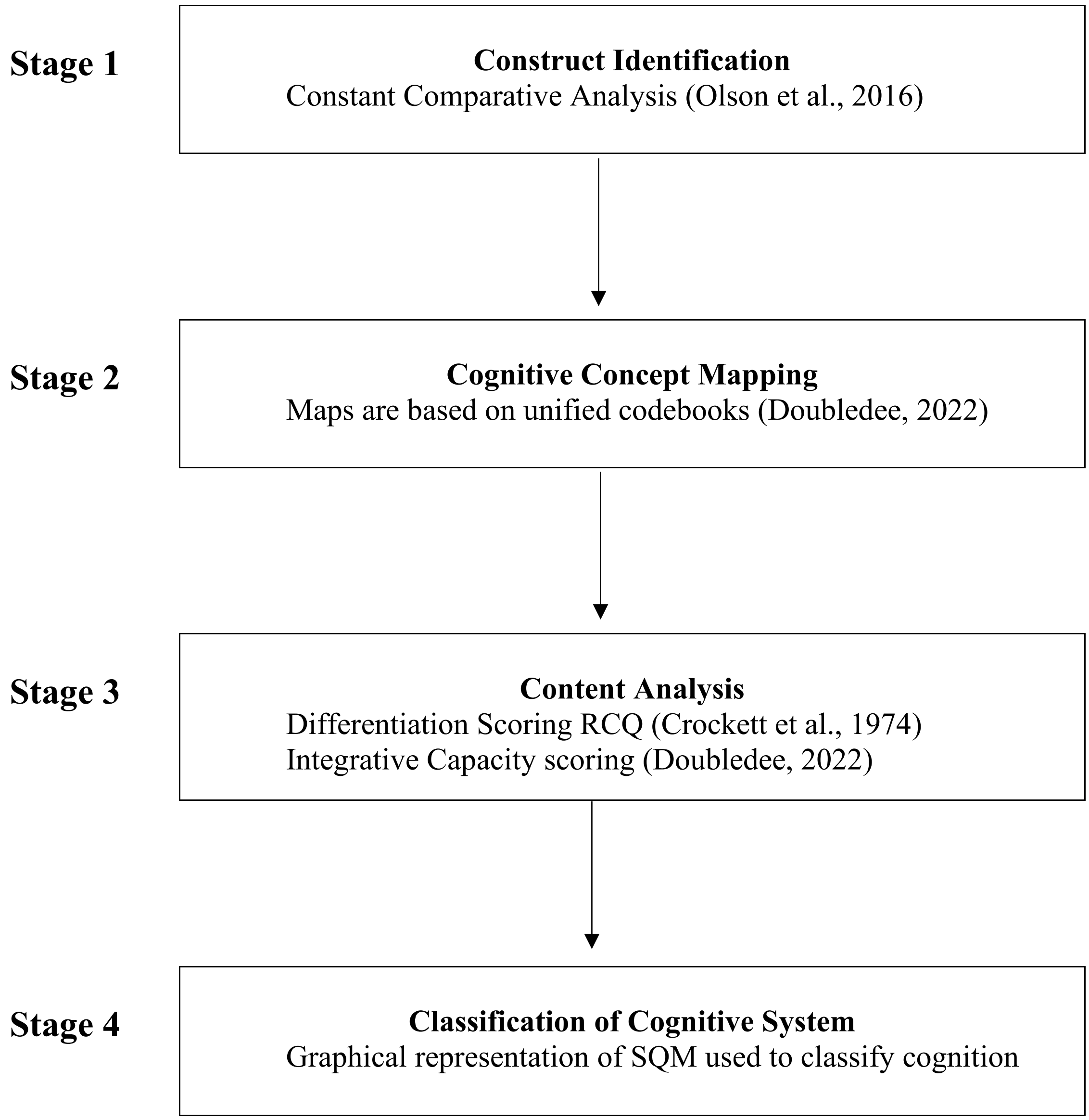
Stage 4: Classification of Cognitive Systems

Cognitive system classification was assigned based on Structural Quadrants Method (SQM), quadrants, but not the rep-grid scoring used by Botella and Galliffa (1992). Low differentiation and integration scores are classified as ‘simple’; low differentiation and high integration is classified as ‘monolithic’; high differentiation and low integration is classified as ‘fragmented’; and high differentiation and high integration is classified as ‘complex’ (Figure 6).

Raw scores from W1 and W2 were pooled for differentiation and integrative capacity separately. Because two outliers were present, the upper and lower 5% of the mean was trimmed. The trimmed means of these scores were then subtracted from the raw scores at W1 and W2 to determine the levels of differentiation and integration compared to peers. Therefore, scores are determined based on a mean score of peers’ performance on the same tasks. In the transformed data, low differentiation and integrative capacity scores are below zero, high scores are above zero. A maximum of 100 was imposed to graph youth this moved one data point a little bit at W2 but did not result in a different classification for the youth. Youth were classified separately at W1 and W2, and trajectories for each pupil were examined across waves. Similar classification trajectories (e.g., complex to simple) were examined together to identify emerging patterns.

Figure 8

Multistage Coding and Analysis Procedure for Cognitive Complexity



Note. Process of coding and analysis reflects the methods used to code, score, and analyze participant interviews. Each interview participant was scored at both W1 and W2. For a more in-depth explanation, see Doubledee (2022).

Empathetic Concern and Affective Empathy

Empathy was measured using three items included in the survey. These items were adapted from two different measures of empathy and were used to measure the construct "caring" as part of the positive youth development scale (Geldhof et al., 2015). However, the items represent two different components of empathy. Two of the items may be scored together, namely *When I see another person who is hurt or upset, I feel sorry for them*; and *When I see someone being picked on I feel sorry for them* (Eisenberg et al., 1996). Although originally used as a measure of sympathy, these items have been adapted and used to measure affective components of empathy. The final item, *When I see someone being taken advantage of, I want to help them* is derived from another scale to measure empathetic concern, and will be measured separately (Davis, 1983). Participants were asked to rate how well each statement described them from 1, *not very well* to 5, *very well*. While single items of empathy may not be enough to elucidate the processes of empathy, they may give an indication of the relation of empathy to cognitive complexity development.

Analyses

Post-hoc power analyses were performed to determine if samples were sensitive enough to reliably measure effects for selected measures. This was done for both the affective empathy and empathetic concern measures in the survey sample (N = 102) and for differentiation and integration in the interview subsample (n = 21). Next, paired t-tests were examined between W1 and W2 scores on integration and empathetic concern measures in the survey sample. The overall trend of empathy scores in the survey population was examined. Empathy scores were then matched to interview participants and examined in relation to cognitive classification trends in the interview subsample.

Results

Empathy

Despite a somewhat small effect size (*d* = .27) the item for empathetic concern had sufficient power in the sample of 102 for a one-sided t-test at .80 power, and a two-sided t-test at .78 power. I felt confident enough to consider the two-sided *t*-test but kept in mind that the power was slightly low. There was a significant difference between W1 ($M = 3.93$, $SD = .870$) and W2 ($M = 4.16$, $SD = .829$) empathetic concern scores at the $p<.05$ level of significance. This indicated that pupils were more likely to endorse higher scores for wanting to help others at W2 than at W1. Therefore, the null hypothesis for H1 is rejected. Sample size is not large, and the normality assumption is violated; therefore, a nonparametric related samples Wilcoxon Signed Rank Test was run to compare integration scores. Results remained significant ($p < 0.05$), and the null hypothesis is rejected. The affective empathy items had a small effect size (d=.09) and were not examined in the survey population. Both empathetic concern scores and affective empathy scores were matched to interview participants to examine their relationship to changes in cognitive classification to determine if any patterns emerged.

Differentiation and Integrative Capacity

Cognitive differentiation and integration were measured in the interview sample ($n = 21$). The measure for differentiation had a small effect size ($d = .34$) and there was not sufficient power to meaningfully interpret results. However, the measure of integrative capacity has a large effect size ($d = .81$) and is robust enough to be interpreted. There was significant difference between W1 ($M = 90.52$, $SD = 31.80$) and W2 ($M = 122.62$, $SD = 46.57$) integration scores ($t(20) = -2.86$, $p< .05$). A Wilcoxon Signed Rank Test recommended that the null hypothesis should be rejected ($p < .05$).

Cognitive System Classification

Cognitive system classifications generally moved toward more complex cognitive systems between W1 and W2. Fourteen participants had simple cognitive system complexity at W1, while only 8 were classified as simple at W2. However, while participants moved toward more complex cognitive systems, the trajectory of movement was not always unidirectional. Five remained simple between W1 and W2. Four moved from simple to monolithic, and one moved from simple to fragmented. Three participants remained complex between waves and three moved from complex to simple. One participant was classified as fragmented at W1 and became complex at W2. Four participants moved from simple to complex at W2 (Table 3).

Table 3

Cognitive System Complexity Classification

W1	W2				
	Simple	Fragmented	Monolithic	Complex	*n*
Simple	5	1	4	4	14
Fragmented	0	0	0	1	1
Monolithic	0	0	0	0	0
Complex	3	0	0	3	6
n	8	1	4	8	21

Note. Table shows the classifications of youth at each wave and the trajectories between waves. For example, looking at the first row: 14 cognitive systems were classified as Simple at W1. By W2, 5 of those who began as Simple remained Simple, 1 became Fragmented, 4 became Monolithic, and 4 became Complex. Looking at the first column: 11 were classified as simple at W2; in addition to the 8 who remained Simple, 3 who were classified as Complex at W1 became Simple by W2.

The Relationship between Empathy and Cognitive Complexity Classifications

Integrative capacity and Empathetic Concern increased between W1 and W2. To further explore the trajectories in cognitive system classifications, a closer examination of the smaller sample with the addition of empathy scores for the interview subsample was done. This examination helps elucidate the possible connections and contributions of empathy to trajectories of cognitive system classification.

Change scores between W1 and W2 were calculated for differentiation and integration. For differentiation, change scores ranged from -36 to 37 with an outlier of 109 (M = 5.2, SD = 21.2). Integrative capacity ranged from -34 to 130 (M = 30.1, SD = 46.4).

Of the 21 youth who were interviewed, 15 had higher integrative capacity scores at W2. Of the remaining six, five decreased in integrative capacity; one was classified as a simple cognitive system at W1 and W2, one was classified as complex at both waves. The remaining three moved from complex at W1 to simple at W2.

Differentiation increased for 15 of the 21 youth participants and decreased for six. One participant who decreased in differentiation increased in integration and moved from simple to monolithic. Two were complex at waves one and two. The remaining three moved from complex to simple between waves one and two.

Complex Cognitive System Trajectories

Six individuals were classified as complex at W1 and three remained complex at W2, while the other three were classified as simple at W2. One individual moved from a classification of fragmented to complex. Notably, no one who was rated as complex at W1 rated themselves above 4 in wanting to help someone.

Complex to Complex. Of the three who remained complex between W1 and W2, all changes in differentiation and integrative capacity were within one standard deviation except one participant's differentiation change score which was one standard deviation lower than one standard deviation; this individual rated themself highly on both integrative concern and affective empathy at W1 (i.e., 4 and 5 respectively, and there was no change in these ratings between waves.

Complex to Simple. Three of those who were complex at W1 became simple by W2. All three had negative changes greater than one standard deviation in both differentiation and integrative capacity. Two also lowered their rating of empathetic concern from 3 to 2, indicating that it did not describe them well. The final individual who decreased from complex to simple rated themselves as a 4 on empathetic concern at both waves. However, a closer look at the affective empathy items showed that this individual dropped their rating from 4 to 2.5, one of the lowest scores of all 102 participants.

Fragmented to Complex. The only individual scored as having a fragmented cognitive system at W1 moved to a complex cognitive system by W2. This participant increased in both integration and differentiation by more than one, but less than two standard deviations for both differentiation and integrative capacity. This participant rated themselves as a 4 at both waves on empathetic concern and dropped their rating from 4 to 3 on affective empathy scores.

Simple Cognitive System Trajectories

Fourteen participants were classified as having a simple cognitive system at W1. Four became complex at W2, five remained simple, four became monolithic, and one became fragmented. Most participants who remained simple between waves, and those who moved from simple to fragmented or monolithic had changes in differentiation and integrative capacity within one standard deviation of the mean. Most participants who moved from simple to complex had changes greater than one standard deviation of the mean. Of the participants who ranked themselves as 5 in empathetic concern at W1, all had a simple cognitive system.

Simple to Simple. Of the five who remained simple between waves one and W2, all changes were within a standard deviation for both differentiation and integration. Y001 increased in empathetic concern from 3 to 4 and increased slightly in differentiation and integration. Changes in empathy scores were mixed; one participant had a positive change in affective empathy from an average rating of 3 to 5, but the rest did not change by more than one.

Simple to Complex. Four participants moved from simple to complex cognitive classifications. Two had changes greater than one standard deviation for both differentiation and integrative capacity, and relatively stable ratings of empathy between waves. One did not have changes greater than a standard deviation in differentiation or integration and was relatively stable in empathy ratings. This individual had higher W1 differentiation and integration scores than the other three, so less change was needed in the complexity of their cognitive system to change. The final individual had changes in differentiation scores greater than one standard deviation; this individual also increased their rating of empathetic concern from a 2 at W1 to a 5 at W2.

Simple to Fragmented and Simple to Monolithic. One individual who moved from simple to fragmented most closely resembled the change scores of those who remained stable. This individual had higher scores at W1 than many others who were classified as simple; while the changes in integrative capacity and differentiation were positive, they were within one standard deviation of the mean. Empathy scores for this individual were also largely stable.

Four participants moved from simple to monolithic between waves one and two. For three of these participants, all changes in integration and differentiation were positive, but within one standard deviation of the mean. Empathy ratings for these individuals were relatively stable. The final participant decreased in differentiation greater than one standard deviation, and simultaneously increased in integrative capacity greater than two standard deviations of the mean. This individual did not have large changes in empathy scores.

Discussion

Empathy processes share many cognitive capabilities with executive functioning and cognitive system complexity; they are codeveloping processes which overlap with one another in early adolescence. However, there is very little research which explores how these different cognitive systems interact or work together over time. Chapter three demonstrated that integrative capacity was important in increasing cognitive system complexity for goals, values, and inspirational figures (Doubledee, 2022). This study builds on those findings and attempts to better understand youth trajectories in cognitive complexity system classifications between W1 and W2 by exploring self-ratings of empathy in the larger survey population (N = 102), and triangulating empathy ratings with changes in cognitive system classifications in the interview subsample (n = 21).

Overall, youth cognitive systems moved toward increasing complexity and integrative capacity. In the larger sample, there was a similar positive trajectory for empathetic concern. These trends are consistent with the principle of self-organizing systems. However, a more nuanced understanding of system flexibility emerges when considering trajectories within the overall pattern. Considering empathetic concern and affective empathy scores together with cognitive system complexity classification and integration and differentiation scores highlights the softly assembled nature of cognition in adolescence. When the complexity of the cognitive systems related to goals, values, and inspiration were considered together with empathetic concern, indications of instability and cognitive flexibility in youth cognitive systems became apparent.

While the construct for affective empathy did not have the power to detect change accurately, empathetic concern was robust enough to be explored in the sample of 102 youth. Therefore, only empathetic concern was examined for a larger population trend in the full sample. Empathetic concern increased significantly between W1 and W2 for the sample of 102 youth. The measure for empathetic concern seems to lack sensitivity to detect more than a broad difference. This is almost certainly due in part to the use of a single item to represent the construct, but the sample also lacks variability in self-response scoring. For example, for empathetic concern at W1, 95.1% of participants scored themselves 3 or above, and 71.6% of the sample scored a 4 or a 5. At W2, 96.1% of the sample scored themselves 3 or above and 83.4% scored themselves a 4 or a 5.

Positive directionality in the survey sample is not necessarily a good indication of trajectory changes within the population, however. A closer look at the interview subsample provided more nuance to the changes which youth experienced when describing goals, values, and inspirational figures. Similarly, while integrative capacity increased significantly between waves in the interview subsample, and changes in cognition system complexity classification generally moved toward more complex classifications, trajectories of complexity classification were not all positive.

Cognitive complexity classification is made up of differentiation and integrative capacity. While integrative capacity had a larger effect size and is likely more volatile during this developmental period, differentiation scores are also examined for patterns when considering trajectory changes in the interview subsample. Similarly, while empathetic concern had a large enough effect size in the interview population to be measured, affective empathy did not. Neither was robust enough to examine in a *t*-test for the interview subpopulation. Nevertheless, an exploratory examination for themes and patterns does not necessitate significance. The goal is to explore and identify potential patterns for exploration within youth complexity trajectories related to goals, values, and inspirational figures. Therefore, both empathetic concern and affective empathy scores were considered when examining youth trajectories. Such an examination can indicate what may be related to trajectories, as well as provide a preliminary indication of what sample sizes may be needed when examining youth construct systems in future studies.

Seven trajectories emerged between W1 and W2: Simple to Simple (n = 5), Simple to Fragmented (n = 1), Simple to Monolithic (n = 4), Fragmented to Complex (n = 1), Complex to Complex (n = 3), and Complex to Simple (n = 3). Pupils fell into Complex or Simple classifications at W1, except for one pupil who was fragmented. Only those who changed from Complex to Simple moved from more complex to less complex cognitive systems. This indicates that these youth may be undergoing a destabilization of the system which was formerly used to describe goals, values, and inspirational people (Thelen & Smith, 1996). It is interesting to note that while classifications moved from Simple to Monolithic and Simple to Fragmented, and Simple to Complex, no participants moved from Complex to Monolithic or Fragmented. This indicates that while development between simple and complex systems may be more gradual, those who move from Complex to Simple decrease rapidly. For those who decreased from Complex to Simple, all had decreases in differentiation and integrative capacity greater than one standard deviation of the mean difference, and a decline in either empathetic concern or affective empathy items. This indicated a possible connection between empathetic capabilities and the ability to think about goals, values, and inspirational figures in complex ways; while patterns of empathy were clear in this trajectory, they were often les clear in other trajectories.

The stable classifications (i.e., Simple to Simple, Complex to Complex) had very little change in differentiation and integrative capacity with the exception of one participant who remained complex but decreased differentiation by more than one standard deviation from the mean difference score. While those who moved from Simple classifications to more complex classifications all had stable or positive in empathetic concern and affective empathy scores, many of those who remained complex, and those who remained simple had slight changes in both positive and negative directions, as did the individual who moved from Fragmented to Complex. This suggests that empathy development may be a potential indicator of the disruption in cognitive systems, and lead to changes in classification. Because youth experience cognitive reorganization toward greater emphasis on peer and social relationships (Eisenberg, 2006), fluctuations in classifications such as moving from complex to simple classifications may be indicators of the development of more adaptive systems, or simply an indication that new social considerations are being made in regard to goals and values.

Within the interview sample, empathetic concern and affective empathy scores were more likely to be stable between waves than to increase or decrease; 52.4% of participants retained their W1 score for empathic concern, and 47.6% retained their W1 score at W2 for affective empathy, compared to 19% and 28.6% who increased scores and 28.6% and 23.8% who decreased scores on empathetic concern and affective empathy respectively.

While the relationship between empathy scores, and measures of cognitive complexity on cognitive score classification were clear for those declining in complexity between waves, a clearer understanding of the connections between empathy and complexity may be better elicited in a more complete measure of the different components of empathy. Two of the three participants who decreased from complex to simple cognitive systems initially ranked themselves as a 3 on empathetic concern and decreased this rating in addition to differentiation and integrative capacity scores at the second wave. The third participant decreased on integration, differentiation, and the affective measure of empathy. This may indicate that having a complex cognitive system regarding personal goals and inspirational figures may not be enough to guarantee continued complexity; those who were complex but indicated they may not be willing to help others who are being taken advantage of at W1 simplified their cognitive systems in both integrative capacity and differentiation by W2.

Interestingly, all who ranked themselves at a 5 on empathetic concern at W1 were classified as having simple cognitive systems. Those who ranked themselves at 5 on empathetic concern at W2 had been classified as having simple cognitive systems at W1. This could indicate that more complex individuals have a more nuanced understanding of empathy and themselves and perhaps are more accurate in rating themselves.

Limitations and Future Directions

The present study sought to better understand the relationship between empathy and cognitive system complexity. While it is useful to examine a small sample in detail to better understand how to scale up and explore relationships in larger data, the inferences to a larger sample are limited. Identified trajectories in the present sample should be examined further in larger samples. In addition, the sample size limited the power to interpret several measures which could have provided a clearer and more multifaceted understandings of the interconnected cognitive systems which were explored. In general, when it is expected that there is little variability on a measure, a larger sample is needed to detect change reliably.

The concept of empathy has been narrowly applied to negative emotional states in the extant literature, and this is reflected in the available measures of empathy. Focus on negatively valenced emotional empathy may have the unintentional consequence of overgeneralizing results to positive empathetic responses; empathy is a response to all emotional states, and corresponding networks may differ depending on the emotion which the individual responds to. Empathy is not often conceptualized as the ability to understand positive emotions in another person (Cuff et al., 2016). Measures of empathy which reflect the strengths of youth to understand both the positive and negative emptions of peers have a long way to go in representing a holistic system of empathetic capacity and responding. Development of measures which capture empathy in a wider variety of contexts in both positive and negative valenced emotions could contribute to a better understanding of social, emotional, and cognitive development. This may be accomplished by extending theory and research which has focused on infant emotional response contagion, and adolescent peer contagion. For example, Fowler and Christakis (2009) found that happiness spread dynamically in a large social network of adults, and Dishion and Tipsord (2011) noted that it was likely that adolescent helping behaviors were contagious in their examination of the literature. Similarly, van Workum and colleagues (2013) noted that adolescent happiness in peer networks was somewhat peer dependent. The application of social network models to populations, as well as conceptualizing positive emotions in our definitions of empathy can help expand our understanding of how empathy and prosocial behaviors develop and how ideas and information are exchanged within networks.

In the present study, I was limited to the use of one and two item measures in the measurement of empathy. There are substantial limitations in using single items as measures of a construct. Concerns with single item scales include low content validity (McIver & Carmines 1981), a potential lack of sensitivity, and inability to measure reliability with Cronbach's alpha. While I was unable to estimate Cronbach's alpha in this circumstance, the use of the item in prior measurements of empathetic concern provide some validity to the use of the item as a measure. Regarding sensitivity, the power analysis indicated that the effect size was robust enough to confidently interpret results. While a measure with more items would have been preferred, the use of a single item in secondary pilot data should not preclude results. A single item may be adequate to measure a construct in some circumstances; in particular, measures of empathy often have highly correlated items making single item use less egregious (Konrath, Meier, & Bushman, 2017). Future studies should include more items to measure empathetic concern and several other aspects of empathy which may contribute to cognitive system flexibility during adolescence.

Examining trajectories, processes, and interacting systems of stability and instability is important in understanding development. While much of the extant developmental literature is focused on developmental outcomes, development itself does not have such endpoints. Understanding context and processes by which people reach outcomes of interest is important to understanding development more holistically. Overall, the present study offers an exploratory examination of empathy scores and youth complexity classification trajectories between two timepoints. Empathetic concern increased between waves one and two, demonstrating a trend toward greater empathy in youth. Future research should examine the relationship between measures of empathy and these trajectories to better understand how youth move between classifications during early adolescence. Research which includes more than two timepoints could examine how fluid or stable such classifications are during early adolescence from a dynamic systems theoretical perspective.

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Chapter 5: Discussion and Conclusions

The transition to adolescence is characterized by the rapid development of many interacting social, emotional, and cognitive processes. Adolescent development is organized around developing successful peer relationships and peer interactions which can improve social standing, define group memberships, and develop a social identity which establishes autonomy from caregivers. Adolescents develop social reasoning abilities during this time which allow them to facilitate adaptive interpersonal interactions with people of all ages. The development of these capabilities is guided by values which take on an additional meaning during adolescence as social reasoning abilities increase and gain more depth and understanding. Adolescents' ability to reframe values and goals in new developmentally meaningful contexts provides additional motivation and significance which helps adolescent achieve long-term goals.

Changes in the contexts in which adolescents apply values and goals points to the role of inspirational others in inviting youth to consider possibilities during a time of increased cognitive flexibility. This increased cognitive flexibility allows youth to associate and integrate formerly disparate concepts together to form new meanings and ideas together with peers. The current collection of manuscripts has attempted to highlight some of the processes which are important to adolescent recontextualizing in relation to goals, values, and inspirational figures by developing in inductive measure of how youth consider these subjects and examining them in both as individual systems and in the larger system of peer trajectories.

Social Reorientation and Cognitive Flexibility in Adolescence

In the first manuscript, I outlined a contextual history of the development of the study of cognition and reiterated, as many others have done, that adolescence is a period of flexibility and increased capacity for flexibility in social-cognitive and social-affective development (Crone &

Dahl, 2012). Social-cognitive capabilities include perspective taking abilities, and social reasoning, while social-affective development is represented by affective skills which promote social competence, such as empathy, and increased salience of peer affiliation. Social re-orientation toward peers requires the adaptation of social reasoning skills and cognitive control skills to encompass increasingly complex social interactions.

While development is a continuous process, there are periods of increased capacity and potential for changes which have lasting impacts on how we perceive, interpret, and form systems to adaptively interact with the world in which we are embedded (Crone & Dahl, 2012). During these times, developmental processes are neither linear nor gradual as systems which were once stable must adapt to coordinate and organize processes together in new ways (Thelen & Smith, 1996). The early years of development are often used to characterize such changes; an infant learns to walk by reorganizing the processes which helped the infant crawl to work together in new ways. The child uses its environment to accomplish these goals, pulling up on a coffee table assists the child in developing core stability, but it also assists by providing additional stability while core muscles develop, and learn to operate together with increasingly coordinated and developed leg movements. During this time, young children also learn how to connect emotions, such as seeing an object that they really want, to modulate which system of movement they use. If a young child wants an object badly, they will revert to the more stable system of movement, crawling, to obtain it quickly. However, they will continue to develop the walking system of movement as it is the more long-term adaptive system. A child learns how to walk most quickly when they are helped to do so. Adults help young children learn how to walk, thereby contributing to enhancement of the developmental capacity of the child. Parents hold the hands of their children, help them develop core and leg muscles, and coordination abilities and provide goals and motivations for children to learn this capability.

Adolescence is a similar period of heightened malleability in the development of multiple interacting processes (Prencipe et al., 2011). The presence of positive, supportive influences during this developmental period can help youth develop the capabilities needed to flourish as they move into adulthood (Silke et al, 2018). Positive youth development programs aim to focus on the strengths of youth in helping youth develop positive understandings of themselves and their potential roles in society. However, in comparison to early childhood development, the exploration of adolescent developmental processes as flexible opportunities to guide youth has only recently begun to be explored. While researchers understand that prosocial outcomes and social competencies are essential to well-rounded adults, understanding when developmental processes may be stable enough to measure such outcomes reliably is challenging. This makes identification of underlying processes which contribute to the development of adaptive systems important.

I identified cognitive complexity as a promising area of study which can help explain the interaction of underling processes of development such as executive functioning, perspective taking and cognitive affective capabilities such as empathy. I explored the theoretical underpinnings of complexity and posited that a relational theory which can describe the interactions and embeddedness of these systems within one another was most appropriate (Overton et al., 2013). As adolescence is a time of rapid change, I argue that it is best characterized through a dynamic systems approach, which incorporates non-linear understandings of developmental processes and methods (Thelen & Smith, 1996).

A Closer Look at Cognition

Cognition is not an isolatable process; it is inherently interactive with environment, contexts, the self, and others (Overton, 2015). The development of terms like social cognitive and social affective development necessitates the recognition of cognition as something beyond mental processes, as an embedded interaction between many interacting processes which allow a person to feel the emotions and understand the perspectives of another person. Processes associated with cognition are inherently dependent on how our brains and bodies are physically structured as well as the environment and contexts in which we are situated. If the point of understanding cognition in general and simplified terms is to understand and inform behavior, the two cannot be separated as they inform one another.

While it has been said that trying to understand cognition in isolation leads to an incomplete understanding of cognition, I argue that it leads instead to an improper understanding. Characterizing an isolated understanding of cognition as incomplete implies that such understandings can be built upon to become complete. I argue that analyzing components in isolation is useful only on the surface of description, but not in describing how elements interact in a developing, constantly evolving, system.

As an example, consider another context. Let us say that I am a baker interested in understanding and creating the best bread texture. I take the time to study and develop a nuanced understanding of flour. This leads me to understand that white wheat flour has gluten which helps develop the texture of the bread. This understanding is not useful unless I also take the time to understand how flour reacts, changes, and contributes to the system of baking the bread. Although gluten is present in white wheat flour, its presence alone does not produce a risen loaf of bread. I must develop the gluten in bread through a kneading process. Kneading dough properly changes the structure of the dough into a network of gluten strands which trap gases from the fermentation process (i.e., the rising process produced by the leavening agent) into little pockets which, when baked, contribute to the final bread texture.

While a knowledge of flour is useful, one must also understand the interacting processes that occur while baking bread. Without understanding the contexts (e.g., oven temperature, humidity, placement position in the oven) and concomitant processes (e.g., kneading, fermentation) in which the bread is baked, one cannot say that understanding the nuances of the flour will lead to a good loaf of bread. Similarly, I cannot isolate the flour from the bread for study after it has been baked. It is a product which contains flour; however, the process of development has transformed it into a new product which cannot be re-isolated into its component parts.

A dynamic systems-based theoretical approach to understanding cognition was proposed in the first manuscript to examine the systems of development which surround complex cognition (Thelen & Smith, 1996). The underlying processes of cognitive functioning have implications for developmental and theoretical advancement, especially in adolescent cognitive development. During adolescence, hot executive function (EF) processes begin to develop, which are differentiated from cool EF processes which develop more rapidly in early and middle childhood (Meuwissen & Zelazo, 2014; Poon, 2018). Many measures of cognition are well attuned to these earlier developed cool EF processes; however, hot EF processes include motivational aspects which many EF measures are not designed to capture. These processes are closely tied to social and motivational aspects of adolescence, and they overlap strongly with the development of empathy related systems of cognition. Indeed, EF capabilities, empathy, and complexity may all contribute to a better, more holistic understanding of adolescent cognition.

However, at present, the connections between these systems are not well understood empirically. Establishing a better understanding of cognitive system complexity and its connection to related concepts and cognitive systems is essential in understanding how complexity develops in adolescent cognitive systems.

Complexity Scoring and Cognitive System Classification

In the second manuscript, I examined the various ways which cognitive complexity has been measured and developed a system of measurement which was theoretically aligned with a relational DST perspective (Thelen & Smith, 2006). I developed a system which can be used to identify cognitive systems related to constructs asked about in secondary interview data through a multistage process. This process begins with coding secondary interviews using constant comparative analysis and develops unified codebooks which can then be made into cognitive maps and scored for differentiation and integration (Olson et al., 2016). Differentiation scoring was based on the Role Category Questionnaire (RCQ; Crockett, 1965) and an adapted measure for integrative capacity.

Integrative capacity increased significantly between waves which underscored the importance of integration and interconnectedness in the development of cognitive system complexity. Youth moved toward more complex cognitive systems between W1 and W2, and cognitive integrative capacity significantly increased between waves. I was also able to note that youth followed different trajectories of development over the course of the program implementation. While youth generally moved toward complexity, some youth moved from Complex classifications at W1 to Simple classifications at W2. The patterns of development indicated that youth might be experiencing developmental changes which necessitated the destabilization of old cognitive systems of considering goals and values, and the formation of more adaptive systems which better integrated and incorporated influences of social-cognitive and social affective changes.

The Connection Between Empathy and Complexity Scoring

The final manuscript explored how social-affective processes might influence the development of complexity in youth, particularly the classification of youth cognitive systems. Empathy is a developmental process which is highly connected to perspective-taking abilities, as well as EF capabilities for adolescents (Carrera et al., 2013; Decety & Cowell, 2014; Melloni et al., 2014). Therefore, items which measure two different components of empathy, empathetic concern and affective empathy, were explored in relation to cognitive system classifications.

For this study, both a larger survey sample (N = 102), and an interview subsample (n = 21) were triangulated to develop insights about youth trajectories. Empathetic concern increased significantly between waves in the survey population, indicating a general trend toward greater empathetic thoughts during adolescence for the population. Empathy scores were then matched to the interview subsample and examined in relation to cognitive system classifications.

Empathy did seem to have an impact on youth complexity classifications. In particular, lower scores on empathy measures predicted changes in youth classifications. When participants were classified as complex at W1 and scored themselves lower on empathy measures, they further declined in empathy by W2, and moved to a Simple classification. Those who retained their classification (i.e., simple to simple, complex to complex) between waves had slight changes in integration and differentiation scores, while the most notable changes were in those who moved between classifications. Empathetic concern and other empathy measures may be an indicator of cognitive system recalibration toward more prosocial cognitive systems in adolescence. Overall, the results supported a dynamic systems approach to understanding cognitive development in adolescent populations (Gershkoff-Stowe & Thelen, 2004).

This exploration of youth complexity trajectories allowed a closer examination of how several processes which contribute to youth cognitive system complexity may develop over time within their own personal construct systems. It offers an interesting examination of how understanding interacting systems and contributing constructs may contribute to a better understanding of the phenomena of interest. This approach is in contrast to isolationist perspectives that purport to best understand developmental trajectories by isolating phenomena.

Conclusions and Future Directions

The current understanding of systems and processes with facilitate complex cognitive system development in personal goals, values, and inspirations is underdeveloped. Understanding the processes of development as interacting and codeveloping is imperative during rapid periods of development such as adolescence. While some processes have been explored, the fragmented nature of these concepts often obfuscates a clear relationship between processes. Recently, understanding of many of these concepts has improved, leading to more complex understandings of development during adolescence. This is seen in the identification of hot EF capabilities which develop most rapidly during adolescence and their developmental distinction from cool EF processes which develop on a different timeline (Bunch & Andrews, 2012). Similarly, understanding the concept of empathy as having both cognitive and affective components clarifies which kinds of empathy may be present in adolescent populations. While such distinctions add complexity to definitions by identifying areas of study which have yet to be explored, they also highlight areas of overlap between processes. For example, the perspective-taking necessary for empathetic concern overlaps with Theory of Mind Development (Goodvin et al., 2015). This overlap demonstrates the interconnection and codevelopment of concepts and processes; understanding development as interlinked processes, rather than a single outcome.

Dynamic systems theory (DST) advocates for a contextual and holistic understanding of contributing systems of coactional development (Thelen & Smith 2006; Witherington, 2017). Indeed, considering several systems in tandem can lead to a better understanding of several processes at once. For example, when isolating complexity from empathetic concern, you can learn general things about both in a population; integrative capacity increases in a pre-post study design, as does empathetic concern. General classification of cognitive systems become more complex between waves. However, there are several trajectories within each pattern of cognitive system classification when considered in conjunction with scores and empathetic concern at both waves. Looking at this phenomenon in a more holistic way can make patterns more visible and contribute to a better understanding of the development of perspective taking, empathy, and cognitive system complexity in adolescence.

Future research on cognitive complexity in youth goals and values should utilize both a larger sample size, and a research design which can better separate and understand the unique contributions of both development and program effects. The pre-post design used in the measure development and data construct exploration in this series of studies is not able to elucidate which effects are due to which interacting systems. A quasi-experimental design such as a switching replications design could contribute to a better understanding of why empathetic concern and integrative capacity increase between waves, and if those changes are more likely to be due to developmental or programmatic effects or some interaction between these contexts.

More constructs related to hot EF capabilities should be explored in relation to cognitive system complexity (e.g., self-reflection, intentional self-regulation) in much more depth. This is an area of research that has some attention, but deserves more (Zelazo, 2015; Zelazo & Carlson, 2012). Additionally, multi-item measures of empathy should be used to more fully explore the connections between different kinds of empathy (i.e., cognitive empathy, empathetic concern, affective empathy) and cognitive system complexity. While one item measures of empathy are useable in exploratory and pilot studies of a concept, they lack construct validity, and reliability is unable to be estimated which complicates interpretation (Konrath et al., 2018). In addition, the developed measurement system should be examined side by side with original measures of complexity such as the Role Category Questionnaire (RCQ; Crockett, 1965). A study which includes an administration of the RCQ and an examination of youth interviews would allow for an examination of how interpersonal cognitive construct system complexity is related to the cognitive construct systems which youth build in relation to personal goals, values, and inspirational figures.

Although many studies adopt theoretical principles from dynamic systems theory, far fewer implement the ideas inherent in DST in their work (van Geert, 2011). For example, DST is focused on the process as much as the outcome of development. While it is important to understand and espouse the ideas of DST, incorporating DST principles into research methodology and measures is more challenging (Witherington, 2011). In the three manuscripts presented here, I have attempted to follow the spirit of DST as well as espousing the theory. By examining trajectories of development and how codeveloping systems may contribute to one another, the next steps in understanding how pupils may form systems for understanding goals and values is much clearer. In particular, the degree of complexity which a pupil considers these concepts may be intertwined with the development of social affective processes such as empathy. There is no single pathway in development, and each moment is a product of the moments and contexts which came before it. Examining multiple trajectories of development has the potential to inform not only developmental outcomes, but the processes that interact to create them.

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