

# Envisioning a New Foundation for Gifted Education: Evolving Complexity Theory (ECT) of Talent Development

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## Abstract

This article presents a new theory of talent development, evolving complexity theory (ECT), in the context of the changing theoretical directions as well as the landscape of gifted education. I argue that gifted education needs a new foundation that provides a broad psychosocial basis than what the notion of giftedness can afford. A focus on talent development rather than giftedness should be based on a theory of talent development that is truly developmental, treating the developing person as an open, dynamic, and adaptive system, changing oneself adaptively while interacting with environmental opportunities and challenges. To introduce ECT, I first delineate the meaning and significance of four dimensions or “parameters” of talent development undergirding this new theory: domain, person, development, and culture. I then describe how ECT explicates the developmental processes and transitions as the result of human adaptations to environmental opportunities and challenges. More specifically, ECT uses the constructs of characteristic and maximal adaptation to elucidate how domain, person, development, and culture jointly shape a particular line of talent development, and how cognitive, affective, and social processes interact to push and sustain a critical transition from characteristic adaptation to maximal adaptation, eventually leading to high-caliber performance and creative productivity. I finally discuss the theoretical contributions and practical utilities of ECT for future research and practice.

## Keywords

characteristic versus maximal adaptation, evolving complexity, biology versus culture, talent development, developmental stages and transitions

Talent development is a theoretical movement in the field of giftedness and gifted education. It is not new and can be traced back as early as 1950s (e.g., Witty, 1958), but it is gaining momentum at the policy and practical level worldwide (e.g., The Talent Support Model in Europe; Csermely, 2015). It poses challenges to a long-standing tradition in gifted education, the Gifted Child Paradigm (Dai, 2011; Dai & Chen, 2013; Subotnik, Olszewski-Kubilius, & Worrell, 2011). The ongoing “paradigm shift” is predicated on a deep change in how we understand human potential and ability. We have gone beyond a static capacity view of human potential in general and intelligence in particular as fixed; instead, we see human exceptional competence as diverse and shaped in a dynamic interaction with the environmental opportunities and challenges (Dai & Sternberg, 2004). We have gone beyond a purely cognitive view of “giftedness” in espousing a broader scope of what constitutes giftedness, encompassing a range of endogenous and exogenous forces (Dai & Renzulli, 2008). Talent development, in this sense, provides a broader psychosocial basis for gifted education than what the notion of “giftedness” can afford. Evolving complexity

theory (ECT) is developed in this context to provide a new theoretical model of talent development that reflects the above trend and can be used to guide educational policy and practice.

## Motivation for a New Theory

About 10 years ago, I started to think about talent development as an evolving process for a person, initially in a somewhat chaotic state and increasingly differentiated, which can best be described as a process of *evolving complexity* (Dai, 2010), hence ECT. There are strategic and methodological considerations for theorizing about talent development. We

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can use the traditional, reductionist trait approach, tracing development of exceptional human competence back to basic components, endogenous as well as exogenous (e.g., Gagné, 2005a). However, a component theory, in its way of simplifying the realities, does not take into consideration how these components interact at the system level and how the developing system evolves as a whole (Ziegler & Phillipson, 2012). Specific to talent development, the reductionist approach lends itself easily to dichotomizing the role of nature and nurture, even polarizing debates on the respective role of nature and nurture (e.g., Ericsson, Nandagopal, & Roring, 2005 vs. Gagné, 2009), when, as a matter of fact, nature and nurture never work alone developmentally without some interaction and reciprocation (Horowitz, 2000, 2009).

A developmental approach takes a more integrative approach to the nature–nurture problem: how nature is nurtured (i.e., mediated by social–cultural factors), how nurture reveals nature (e.g., gene–environment interactions and differential outcomes), and how nurture surpasses or transcends nature (e.g., structural and functional changes at neural, cognitive, and behavioral levels as a result of systematic training). A dynamic, developmental approach treats *emergence* (i.e., the emergence of new structural and functional properties through development) as a fundamental tenet of human competence, avoiding any radical reductionist explanation of gifts and talents as static and innate, genetically predetermined (Dai, 2005). In short, a truly developmental theory of talent is by nature nonreductionist and organismic; that is, treating the organization of the person as a whole with higher order organizational properties and principles not reducible to lower level components and operational rules. The notion of evolving complexity reflects this fundamental organizational principle in talent development.

## Major “Parameters” of Evolving Complexity of Talented Persons

It is widely accepted that there are talented individuals who demonstrate the superior ability to perform technically difficult tasks or produce intellectual, artistic, and technical products that are considered novel and valuable (i.e., creative; Bloom, 1985; Ericsson, 2006; Simonton, 2005). However, how do we explain these feats and contributions as the result of a developmental process, beyond claiming that these individuals are gifted and talented? To understand the developmental process involved, ECT posits four essential parameters or dimensions in defining its scope: domain, person, development, and culture.

### *Domain: Foundational, Cultural, Professional, and Personal*

The term *domain* implies specific categories of object or action; it helps define structures, functions, contexts, and

boundaries of a functional entity. In the context of talent development, Feldman (2003, 2009) proposes the notion of *developmental domains* as a continuum from the universal (i.e., shared by all human beings) on one extreme to the unique on the other extreme. ECT proposed three categories of domain along this continuum.

**Foundational Domains.** Early competences children demonstrate are universal, reflecting species-specific, biology-based capacities that have an evolutionary basis, and vary within species through genetic variation and selection. With extensive learning and development, children acquire conceptual structures, master symbol systems and cultural tools, and accumulate world knowledge, which transform basic human capacities into many ways of competencies in culturally valued knowledge and skill domains, some of which lay the *foundation* for more specialized training and can become one’s career endeavor and life passion (Coleman & Cross, 2005). At least five foundational domains of human effectivities can be identified: *expressive* (expressing oneself through imaginative play and artistic means, such as writing, drawing, acting, singing, dancing,), *technical* (making tools and gadgets to enhance effectiveness and efficiency), *intellectual* (reasoning, understanding, explaining, theorizing using mathematics, logic, visual–spatial imaging, or literary means), *social* (achieving practical purposes through effective communication, negotiation, collaboration, and leadership), and *psychomotor* (executing and coordinating body movements to accomplish complex physical tasks as in the case of most competitive and extreme sports and complex surgical operations).

These basic (i.e., universal) forms of human competence or agency may be reminiscent of the theory of multiple intelligences (Gardner, 1983). However, it should be noted that multiple intelligence emphasizes innate capacity or faculty, whereas the five forms of human agency postulated by ECT emphasize effectivities, which are dynamically shaped in the person–environment transaction. To use the language of ecological psychology, it is the affordances and constraints of a cultural activity (e.g., comprehending a passage, figuring out number relations, or listening to a piece of music) that “affords” the development and expression of a talent as well as “constrains” how this form of agency is structured and developed. In other words, while a “musically gifted” child finds an expressive outlet through music, a piece of music the child is listening to serves as a scaffold for his or her sense of melody and rhythm. By the same token, as a “mathematically gifted” child relishes the intellectual power of quantitative reasoning, the logic of quantitative reasoning acts as a scaffold to a cognitive structure of mathematics for the child. At the neural level, the child’s unique musical sensitivity (or mathematical inclination) is likely shaped through a process of self-organization in that many music-relevant (or mathematics-related) parts of the brain are activated and

orchestrated to process relevant information: simply put, a new “machine” (be it music pattern perception or quantitative reasoning) is being made of many existing parts. In this sense, a music talent or a mathematical ability is constructed and self-organized through relevant experiences, albeit the fact the neural substrates of these various parts of music or mathematical processes reveal individual differences in the genetic makeup (O’Boyle, 2008). Extended stimulation and training lead to structural and functional changes at cognitive as well as neural levels (Gaser & Schlaug, 2003). In this sense, music or mathematical talent, just like other talents, is developed through a probabilistic epigenetic process, rather than innate or preordained (Gottlieb, 1998).

**Professional Domains.** As children gain a solid grounding in foundational domains, they will be gradually ushered into various highly advanced or specialized courses of development in cultural institutions where more specialized skills are honed to a highly sophisticated and advanced level. As a result, their development becomes *nonuniversal* and increasingly unique (Feldman, 1994). Csikszentmihalyi (1996) defines professional domains this way:

[e]ach domain is made up of its own symbolic elements, its own rules, and generally has its own system of notation. In many ways, each domain describes an isolated little world in which a person can think and act with clarity and concentration. (p. 37; see also Gee, 2007)

A professional domain is regulated by social institutions and gatekeepers, which constitute a *field* with norms governing a community of practitioners who devote their life to the domain in question, whether it is teaching or engineering. Professional domains can be roughly divided into two broad categories, *performance* and *production* domains (Subotnik et al., 2011; Tannenbaum, 1997). A music performer performs or *reproduces* a piece of music with skills and personal expressiveness, whereas a music composer *produces* music. Although there are many musicians who do both, a distinct mode of functioning while producing as opposed to performing can still be discerned. In general, *performance domains* are concerned less with symbolic meanings, theoretical explanations, and practical and technical innovations, and more with the mastery and execution of skills at a high level of expertise. When we identified a mature talent in either a performance or production domain, we are likely referring to someone who has gone through extended professional development; their talent represents a much higher level of evolving complexity compared with those we identify in foundational domains. This is why, when we identify gifted children as compared with gifted adults, we use different criteria (Siegler & Kotovsky, 1986).

**Personal Domain.** Personal domain refers to a unique, personalized organization of knowledge, skills, dispositions, and

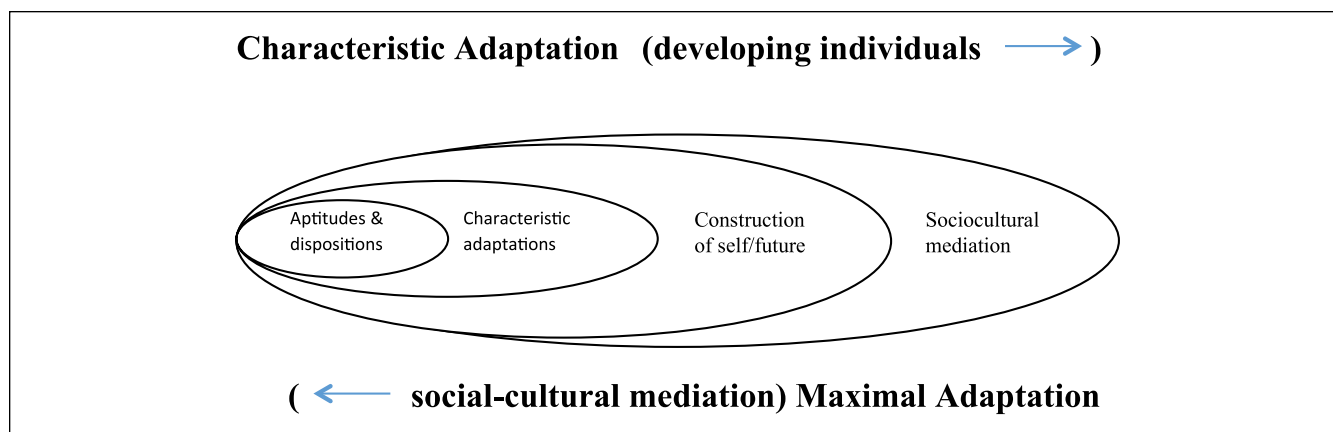
values that help create what Bruner (1979) called “an interior culture” (p. 116). A personal domain of thoughts, life themes, foci, and visions determines the direction and scope of one’s mental life, or what Ziegler (2005) called “subjective action space” (p. 417), or a “unique type of representations . . . of the world” (Shavinina, 2009, p. 231). Personal domain is intimate, even idiosyncratic in a sense, and therefore, always unique. It denotes one’s individuality that is highly robust throughout one’s life (Edelman, 1995), often indispensable for creativity (Gruber, 1986; Gruber & Wallace, 2001). Whatever one gains from foundational or professional domains undergoes a personal transformation to make it one’s own. With the onset of adolescence and beyond, one explores and expands a personal action space, and carves out a personal niche over time, a process ECT identifies as *characteristic adaptation* (CA). Through the transformation of professional knowledge and skills, one specializes in or develops a unique line of work, and relentlessly perfects one’s trade, which ultimately helps achieve great scholarship, artistry, athletic prowess, and solve important intellectual, technological, and social problems (i.e., creative productivity), a process ECT identifies as *maximal adaptation* (MA).

### Person: Evolving Complexity Through a Multilevel Analysis

As suggested in the previous section, all talent development occurs in a personal context, revealing the meaning and valence of a particular line of talent development to a particular person. This makes ECT a person-centered theory rather than domain-centered theory. It is the person, with the influence of biology and culture, who organizes and transforms his or her domain experiences. The “interior culture” one creates is what ultimately matters as to how talent is used, and knowledge transformed, for productive or performance purposes.

A major assumption underlying ECT is that the person is an open, dynamic, and adaptive system, undergoing changes in oneself in multiple ways while interacting with the world. These changes are captured through a multilevel analytic framework presented in Figure 1, which shows how the evolving complexity of the developing person builds up through development. At Level 1 are *aptitudes and dispositions* in foundational domains. Aptitudes are more of an ability construct, and dispositions more of a personality construct. They are stable traits developed and calibrated in early years of life. Thus, we might identify a child or adolescent’s profile of aptitudes and dispositions in foundational domains vis-à-vis affordances and constraints of a wide range of cultural activities, including but not confined to formal education (Lohman, 2005).

A particular profile of aptitudes and dispositions can be conducive to a science or art career trajectory (Feist, 2006;



**Figure 1.** The developing person driven by both endogenous and exogenous forces from a multilevel analytic point of view (adapted from Dai, 2010).

Lubinski, 2010). However, it is CA—the characteristic way the person seeks certain developmental opportunities that fit one’s strengths and needs—that dynamically shapes the self-organization of aptitudes and dispositions in foundational domains in carving out a particular developmental niche (Wachs, 2000). Thus, CA represents a higher level organization of personal adaptation. CA is predicated on the assumption that “human lives vary with respect to a wide range of motivational, social-cognitive, and developmental adaptations, contextualized in time, place, and/or social role” (McAdams & Pals, 2006, p. 208). Compared with trait-level aptitudes and dispositions, CA is a more holistic, organismic construct, more contextually and dynamically situated in specific social contexts.

Beyond CA in development, Level 3 captures a unique human tendency to purposefully initiate and sustain a particular line of talent development. I label it “construction of self and future” to highlight its purposive (top-down), proactive, and deliberate nature in self-engendered changes as compared with the more situational, spontaneous, self-organized (bottom-up) nature of CA. Finally, at Level 4, all these developmental changes, engendered bottom-up or top-down, can be understood in a broader context to reveal the social-cultural mediation of these developmental processes (see more detailed description in the section on “culture”). Together, this four-level analytic framework reveals the main endogenous and exogenous forces propelling talent development.

## Development

The term *development* implies some gradual structural and functional changes in the organization of the person. Talent development surely fits this definition and is an integral part of individual development, though this aspect is often neglected by mainstream developmental psychology, which tends to focus on “universal” aspects of human development

(Feldman, 1994, 2003). This tendency is partly attributable to the neglecting of adaptive aspects of human development (Fischer & Bidell, 2006). From the biological perspective, each person has a niche potential that is different from others (Wachs, 2000); indeed, even among the identified gifted and talented, differential niches are the norm rather than exception (Lubinski, 2010). On the cultural end, certain human traits are selected by culture as more important and cultivated more fully than others. ECT attempts to elucidate these two adaptive mechanisms underlying talent development, using two central explanatory concepts: *characteristic adaptation*, which is discussed above, and *maximal adaptation*.

In the context of talent development, CA refers to *spontaneous self-organization of inner resources in response to environmental opportunities and challenges, resulting in a unique developmental trajectory or pathway*. It clearly builds on a personal profile of aptitudes and dispositions, which are *developmentally instigative* (Bronfenbrenner & Ceci, 1994), but represents a more self-organized response to environmental opportunities and challenges. A person may have aptitudes and dispositions suitable for many lines of talent development, but how they are organized in response to environmental opportunities and challenges involves a selection process that could be unconscious but reflecting a calculation of the probability of success, personal payoff, and opportunity costs. In contrast, MA involves *purposeful acts to perfect one’s trade and surpass oneself once a course of action is set*; therefore, MA is more self-directed and intentionally sustained, often facilitated by life circumstances and intimately related to deliberate efforts of “constructing self and future.” Both CA and MA operate at the personal level, and both have short-term and long-term developmental consequences for the person as a whole.

When talent development is concerned, a critical task is to define the developmental timing of CA and MA, and stages and transitions thereon. In the expertise literature, there is a well-documented “10-year rule” (Chase & Simon, 1973;

Ericsson, 2006); that is, it takes roughly 10 years or 10,000 hours of serious work and intensive training or practice (i.e., MA) to become an expert in a professional field. This, of course, does not mean that MA is confined to institutionalized professional practice; it can happen to those school age individuals whose level of knowledge and skills are sophisticated enough for engaging in advanced, cutting-edge work, such as conducting an innovative research project while still in high school, inventing valuable products and procedures, or reaching a high level of performance in music by adult professional standards while still a teenager. Nevertheless, given the typical developmental progression, ECT considers the timing as well as processes of two critical developmental events, the emergence of CA and the transition from CA to MA, as crucial in shaping a unique talent trajectory and pathway.

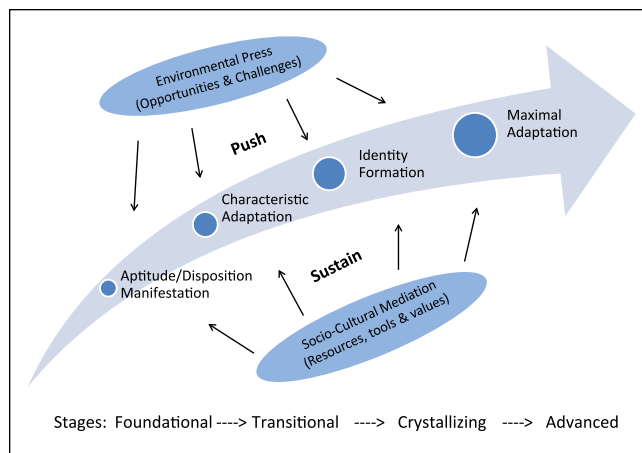
### Culture

Culture is an intimate part of talent development from the very beginning. In the context of ECT, I define culture broadly to encompass *all cultural experiences and tools that allow children and adolescents to make meaning of the world and function as members of society*. More specific to talent development, culture provides rich experiences and support for children to develop expressive, intellectual, social, technical, and psychomotor competencies through formal and informal education. First, culture invents pedagogy and technology to make learning and skill development more effective and efficient for everyone. Second, culture inculcates values by making certain human characteristics and activities more distinct and prestigious; thus, shaping the way aptitudes and dispositions are expressed and organized through CA. Third, culture also expresses itself in terms of standards of excellence through social mechanisms, such as institutionalizing social recognitions to honor high achievers, or professional gatekeepers to maintain rigor and integrity. In short, culture provides values, standards, and prestige, as well as tools, technologies, and resources for talent development and ultimate achievement (see Barab & Plucker, 2002; Plucker & Barab, 2005).

In sum, by incorporating the dimensions of domain, person, development, and culture, ECT ultimately attempts to explain how biology and culture work together (instead of separately) to produce a highly capable person along a culturally valued line of work.

### ECT: A Process Account of Talent Development

In the previous section, I delineate the meaning and significance of four main dimensions that define the scope, components, core ideas, and boundaries of ECT. However, a theory of talent development needs to explicate how the evolving complexity of a talent is dynamically shaped over time



**Figure 2.** A schematic representation of evolving complexity theory of talent development.

through a prolonged developmental process with identifiable processes, stages, and transitions. This account should be detailed enough to afford testable hypotheses and empirical investigations, as well as to guide educational provisions and interventions. In the following section, I first describe how elements of domain, person, development, and culture work together as a dynamic system. I then identify distinct stages of talent development, and describe how cognitive, affective, and social processes work in a reciprocal manner to facilitate developmental transitions and changes at critical junctures of talent development.

Figure 2 is a schematic representation of ECT. The arrow represents the developing person, with all his or her endogenous resources, interacting with two kinds of exogenous forces: environmental press (opportunities and challenges) on the one hand, and sociocultural mediation of human action (resources, tools, and values) on the other. That ECT starts with “environmental press” (Murray, 1938), rather than with a “talent” or “gift,” distinguishes itself from trait theories of gifts and talents (e.g., Gagné, 2005a). *Environmental press* refers a situation that evokes a need within the organism that has adaptive consequences. To use the language of ecological psychology, environmental press *affords* certain opportunities to learn, to develop, to control, to enjoy, to achieve certain personal ambitions, but at the same time sets constraints and demands (i.e., challenges) that need to be met in order to materialize the affordances in question. The nature of such person–environment transaction determines, first and foremost, that a talent is not innate but the result of self-organized, self-directed adaptive responses to environmental opportunities and challenges. I use the “push” metaphor to denote this need-evoking process.

Figure 2 also shows sociocultural mediation of human action as the other side of exogenous forces, mainly through resources, tools, and values and support that are important for helping the developing person to achieve desired goals.

**Table 1.** Four Stages of Talent Development (TD) and the Nature of Talent, Affect, and Social Conditions and Processes at Each Stage.

Stages of talent development	Developmental tasks that initiate and sustain TD	The nature of affect that sustains TD	Social conditions that sustain TD
The advanced stage	Doing cutting-edge work and develop a personal niche	Vision/perseverance	Institutionalized standards and norms; <i>modus operandi</i>
The crystallizing stage	Making commitment to a line of serious work	Identity/commitment	Serious participation mentorship
The transitional stage	Exploration/expansion of a personal action space	Interest/self-efficacy selective affinity	Autonomy support; opportunity structure
The foundational stage	Developing basic aptitudes and dispositions	Agency/willpower	Typical/optimal condition evocative interaction

Even some basic aptitudes (e.g., musical sensitivity) and dispositions (e.g., curiosity) are socioculturally facilitated (e.g., artistic and intellectual stimulation). I use the “sustain” metaphor to denote this indispensable support function (Plucker & Barab, 2005). Taken together, the dynamic interplay of “push” and “sustain” is the main mechanism for talent development.

From a life span developmental perspective, as a first approximation, ECT assumes that individuals in their life time go through a progressive course of learning and talent development experiences, in the order of informal learning experiences (e.g., those facilitated at home or initiated by oneself), followed by formal education, advanced training, and ultimately cutting-edge work in particular domains. We can roughly view the long-term talent developmental process as characterized by the emergence of CA, followed by a graduate transition to MA. This is not to say that MA does not exist in early phases of development. Rather, as well-established in both the personality and educational psychology literature, in loosely structured environments typical in early stages of human development, developing persons tend to develop their own “agendas” and pursue their own interests while interacting with formal and informal learning experiences (see Figure 1). As a result, individual differences are more likely to show through (Ackerman, 2013; Buss, 1989). The tenet of differential development (i.e., developing persons become increasingly differentiated in skill sets, values, and dispositions over time) is also supported by the principle of nonuniversal development (Feldman, 1994), and the scoop model of differential development that shows a fan-spread developmental effect (Gagné, 2005b; McCall, 1981). In contrast, MA is the norm in highly regimented environments characterizing most advanced training and professional strivings (as suggested by the backward arrow in Figure 1), and is more likely to take place when CA becomes insufficient and new kinds of “push” (high expectations) kick in, making the transition from CA to MA critical and pivotal; ECT attempts to explicate how this transitional process works.

To account for the development of talent over time, ECT postulates four stages of talent development (Foundational, Transitional, Crystallizing, and Advanced), each featuring

distinct central developmental tasks, and affective and social conditions that sustain talent development (see Table 1). They represent a cascade of developmental events with the early developmental changes paving the way for later developmental changes, which are yet contingent on new “pushing” and “sustaining” forces. To use music again for illustration, demonstrating music-related aptitudes and dispositions (Stage 1, Foundational) is one thing, and pursuing a musical interest (Stage 2, Transitional) is another; becoming a musician (Stage 3, Crystallizing) or exploring a new form or personal style of musical expression (Stage 4, Advanced) is even more so. The game changes, so to speak, as the person moves to later stages of talent development. As mentioned earlier, of the central importance to ECT is the emergence of CA (Stage 2) and the transition from CA to MA (Stages 3 and 4).

To explicate the “push–sustain” mechanism necessary for the developmental transitions and changes, ECT postulates three interacting processes: cognitive, affective, and social.

### *Emergence of CA*

Earlier, I define CA as spontaneous self-organization of inner resources in response to environmental opportunities and challenges, resulting in a nonuniversal developmental trajectory or pathway. Defined behaviorally, CA can include any niche-picking behaviors, such as taking certain electives, joining a math or history club, an a cappella group, or finding kindred spirits. Specific to talent development, ECT views a unique patterning of abilities, interests, self-concepts, and personal preferences as evidence of CA, which helps shape a particular talent trajectory and pathway. For example, Lubinski and Benbow (2006) found in their longitudinal studies that differential patterns of mathematical, verbal, and spatial abilities, coupled with interests, can predict long-term talent trajectories and pathways, as well as creative contributions (see Wai, Lubinski, & Benbow, 2005). Ackerman (2003) used the construct “aptitude complexes” or “trait complexes” to identify a constellation of abilities, interests, self-concept, and personality among samples of highly selective college students. He was able to find four clusters of distinct organization of aptitudes and dispositions, which are

predictive of one's knowledge structure and other learning outcomes.

Developmentally, CA becomes prevalent when the person reaches adolescence and gains increasing autonomy, which allows the person to actively seek certain environments (e.g., books, friends, places, social media). This is in contrast to the Foundational Stage (roughly encompassing preschool and elementary school years), when children's actions are more regulated by parents and teachers, and their aptitudes and dispositions are *developmentally instigative* in the *evocative* sense, in that children's talent propensities are recognized and encouraged by adults (the culture behind) for further development. In the Transitional Stage, with newly gained autonomy and the opening up of a diverse range of opportunities, developmentally instigative characteristics become more *active*: adolescents seek out environments that permit the exploration and expansion of a personal action space (or *subjective action space*; Ziegler, 2005). A hallmark of CA in talent development is the emergence of personal interests (Barron, 2006; Hidi, Renninger, & Krapp, 2004), indicative of an increasing tendency of the developing person to gravitate toward certain ideas, objects, and activities, what can be called *selective affinity* (Dai & Renzulli, 2008). The process is facilitated by another endogenous factor, cognitive maturity and sophistication, which enables the person to develop a better self-awareness of personal strengths (e.g., the ease of learning in certain domains) and weaknesses, likes and dislikes via social comparison (Bandura, 1986; Festinger, 1954). Cognitive maturity (e.g., Piagetian hypothetical thinking) also leads to an augmented sense of *possible selves*: What kind of person one can be and what is hypothetically possible (Markus & Nurius, 1986).

The emergence of personal interests is developmentally instigative in a new way: It becomes a force of self-sustained learning and talent development. In Barron's (2006) study, adolescents did not just carry out projects ordered by teachers; they pursued their own interests in Internet technology across the boundaries of home, school, and community. In Csikszentmihalyi, Rathunde, and Whalen's (1993) study, adolescents pursued their own artistic and scientific activities independently. In this sense, they truly become the producer of their own development (Lerner, 2004).

In sum, new opportunities and increased choices with more autonomy evoke an endogenous need to carve out a developmental niche in the midst of a sometimes dazzling array of possibilities, which is the basic push-sustain mechanism of CA. An adaptive principle underlying the selective process is comparative advantages among age peers that enhance the chance of success (see Simonton, 2005, for a similar account of comparative advantages in shaping a talent trajectory).

### Transition From CA to MA

Self-explorations and CA in the Transitional Stage naturally lead to the Crystallizing Stage when a vision of what one can

be (i.e., construction of self and future becomes more self-conscious) is achieved, and a deep commitment to a particular line of intensive work over a prolonged period of time is taking shape. It marks the onset of making MA to task demands and holding oneself to much higher personal standards of performance or productivity.

What "pushes" the person toward MA is cognitive in nature, the increasing cognitive demands and challenges as talent develops. For any talent domain, the learning curve typically gets steeper; CA for even the talented can reach a point of plateau or diminishing returns. Bamberger (1986) studied the "crisis" of those musically talented teenagers whose intuitive approach to music (i.e., CA) has to be replaced by a more analytical mode of processing. Among the early college entrants in a highly selective science, technology, engineering, and mathematics program in my studies (Dai & Li, in press; Dai, Steenbergen-Hu, & Zhou, 2015), despite their academic talent, many struggled in acquiring the *modus operandi* of doing science, to think like scientists, to develop a mathematical disposition, to reach a level of technical sophistication not expected of amateurs. "Natural" talent often takes the form of unique domain-specific intuitions, whether in music or academics. However, in her treatise on "beyond modularity," Karmiloff-Smith (1992) argued that mental representation of knowledge ultimately goes beyond an implicit process to reach a consciously and technically controlled level of mastery. In other words, it takes MA to reach a more sophisticated level of knowledge representation necessary for cutting-edge work in the Advantage Stage of talent development (see also Bamberger, 1986; Wineburg, 1991). In short, at the advanced level, CA is simply not sufficient.

The endogenous process that helps sustain talent development efforts is affective in nature. Although there is a continuity of intrinsic academic motivation (a manifestation of CA) that maintains the academically talented adolescents' efforts during the Transitional Stage (Gottfried, Gottfried, Cook, & Morris, 2005), it is not sufficient. Many academically highly talented early college entrants in my study (Dai et al., 2015) switched to a coping mode when academically challenged in college. However, what "sustains" their effort is their personal (affective) growth, in terms of developing an identity (i.e., a future self) conducive to a firm commitment to a specific line of work (see Dai et al., 2015, for a more detailed account of the cope-and-grow model of affective development). I label this process of commitment-making a Crystallizing Stage, after the pervasive findings of "crystallizing experiences" among eminent scientists and artists reported by Walters and Gardner (1986; see also Freeman, 1999).

Cognitive demands and affective contingencies, however, cannot be fully understood unless placed in the context of serious participation in a domain of professional practice, often involving a community of like-minded individuals (Csikszentmihalyi, 1996). Such a social environment "pushes" participants to work on the edge of their competence (Bereiter & Scardamalia, 1993). In the meantime, the



social–cultural mediation through its pedagogical and technical support as well as the modeling of values and attitudes (e.g., through mentorship) provide cognitively enabling conditions as well as affective support and inspiration. Compared with the emergence of CA, which is by and large endogenously driven, as suggested by the interest-based self-sustained learning and development, the basic mechanism of MA is endogenously driven by future possibilities, as well as exogenously driven by the norms and expectations of a community or culture in which the person is participating. In short, ECT postulates the reciprocation of social, affective, and cognitive processes that moves the talent development to the Advanced Stage, characterized by engagement in advanced, cutting-edge creative work in production domains and high-level expertise in performance domains. This process sometimes necessitates the search for a personal niche that maximizes one's contributions. In other words, CA continues on a new level (see Table 1). The following quote is from an early college entrant I studied (Dai et al., 2015) who recounted, several years after graduation, how lab work in his junior and senior college years changed him as a student, a developmental transformation from being a “good student” (i.e., CA) to being an aspiring scientist (toward MA):

From the freshmen year up to the lab work, what we had learned from physics classes is sheer knowledge. I didn't understand until I got the lab experience that what kind of ability I need to possess, not just what I know, but what [problems] I have to deal with. In previous years I had no clue what research looks like, the process of problem finding and problem solving, which you cannot get from physics lessons. I gradually learned this. Then my attitude toward learning and methods of study [changed], and I was more and more interested in physics, more and more appreciative of its beauty. At the beginning, what you see are formulas and theorems, but gradually you found the logic behind, the process that led to their discovery, which was fascinating. Then you approached the knowledge from this angle, not just treating it as fixed formulas, but taking it as a whole, and see what's behind. (A quote from an interview, Dai et al., 2015, p. 83)

### **Theoretical Contributions and Practical Utilities of ECT**

In a nutshell, ECT explains how four essential dimensions (domain, person, development, and culture) jointly shape a particular line of talent development through cognitive, affective, and social processes interacting to create patterns of adaptive behaviors (characteristic and maximal), leading to high-caliber performance and creative productivity. The four stages of talent development work like a cascade of developmental events, with emergent new properties at each stage further propelling a particular line of talent development. In ECT, how biology and culture, nature and nurture, the endogenous and exogenous, work together to advance talent and creative productivity is explicated as an evolving process of adaptation with increasing organized complexity.

### **Theoretical Contributions**

There are many research-based theoretical accounts of talent development. They can be roughly divided into two kinds: trait models, by and large based on psychometric, long-range prediction studies (Feist, 1998, 2006; Gagné, 2005a; Lubinski & Benbow, 2006; Simonton, 2005), and process models, typically based on more up close investigation of the person in-context and developmental processes (Bloom, 1985; Csikszentmihalyi et al., 1993; Feldman, 1986; Gruber, 1986; Plucker & Barab, 2005; Subotnik et al., 2011). Renzulli's (1986) three-ring theory is in essence a process theory (e.g., how task commitment and creativity are contextually and developmentally shaped), but presented as a trait model based on prediction studies (see Renzulli, 1978). To use Sternberg and Davidson's (1986) classification, trait models or theoretical accounts of talent development are “implicit” models, since the developmental processes by which traits influence short-term and long-term outcomes are not explicitly articulated. In this context, ECT takes a distinct developmental process approach, and treats talent development as a special case of individual development, filling in a gap in developmental psychology between universal and nonuniversal development (Feldman, 1994), contributing unique insights into differential development neglected in mainstream developmental psychology (see McCall, 1981; Wachs, 2000). An advantage of ECT is that it recognizes and integrates the trait component in its developmental account of talent and creativity, yet explicates how they function in the talent development context, solving the crucial problem of turning a trait account into a process account (Snow, 1995).

Compared with existing process models of talent development, ECT hinges on characteristic and maximal adaptations as central explanatory concepts, resolving the long-standing nature–nurture, domain–specificity (vs. generality), and developmental continuity–discontinuity issues in a relatively parsimonious manner. Regarding the nature–nurture issue, ECT is not a nativist account of talent development in the sense that talent potential is like a seed which, with proper nurturance, will germinate and grow to be what it is biologically “designed” to be. There is no ghost in the machine driving the developmental process (Dai & Renzulli, 2008; Gottlieb, 1998). ECT is not an environmentalist account either, in the sense that complexity of the organism is shaped unidirectionally by the complexity of the environment in which it finds itself, as Herbert Simon (1969/1996) argued. Rather, ECT is a constructivist account of talent development as a process of adapting to environmental opportunities and challenges, and carving out a personal niche (whether it is intellectual, artistic, or practical in nature, or some combination of these domains) uniquely fit to make contributions to certain aspects of human endeavor.

With respect to the domain–specificity issue, ECT postulates the tenet of increasing differentiation and substantiates it through foundational, professional, and personal domains. As for developmental continuity–discontinuity, by postulating



developmental stages, ECT emphasizes qualitative developmental changes (shifting to a new level of competence or evolving complexity). However, ECT also emphasizes developmental continuity in the sense that CA prepares the person for MA and continues while maximally adapting to the task demands and standards imposed by cultural institutions, leading to unique personal creativity.

### Practical Utilities

A theory can be seen as a tool in practice, as Dewey argued (see Tomlinson, 1997). A distinct advantage of ECT (particularly over trait models) is that by explicating the dynamic interplay of endogenous and exogenous forces interacting in shaping talent trajectories and pathways every step of the way, it can be easily applied in educational and training settings, with interventions designed according to its claims and principles (see Table 1). For example, ECT suggests an identification/intervention system that can be based on broad considerations regarding, domain, person, development, and culture delineated by ECT, and specific considerations regarding developmental stages, changes, and transitions specified by ECT, particularly with respect to CA and MA. Compared with trait models, ECT has a normative dimension; beyond predicting who are more likely to succeed given certain traits, ECT specifies optimal conditions of talent development; for example, what kind of environmental press or "push" is needed to develop competencies, what kind of sociocultural support is entailed to "sustain" the momentum of talent development at particular developmental junctures, and what kind of affective development is essential to endure possible setbacks. For that matter, ECT can also be used to identify where the current education system is falling short, and how we can remedy the situation, or even change the system, for the sake of optimal development of gifted and talented children and adolescents.

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