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Joint trajectories of task value in multiple subject domains: From both variable- and pattern-centered perspectives

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ABSTRACT

This study used variable- and pattern-centered approaches to better capture the impact of adolescents' joint developmental trajectories of subjective task values (STVs) in three domains (Finnish, math and science, and social subject) from grades 9 to 11 on science, technology, engineering, and mathematics (STEM) aspirations at four years postsecondary school and STEM participation at six years postsecondary school (N = 849 Finnish youth; 52.1% female; 99% native Finnish). Results showed that while adolescents' average STVs in different domains remained stable, three differential joint STV trajectories emerged across domains. Individual changes of STVs in one domain shaped STVs in other domains to form unique *relative* STV hierarchies within subgroups that impacted long-term STEM aspirations and participation. Gender differences in STV trajectory profile distributions partially explained the overall underrepresentation of women in STEM fields. This study is among the first to incorporate multiple domains and explore how STVs fluctuate over time in both homogeneous and heterogeneous fashions. These findings underscore the importance of examining heterogeneity in motivational trajectories across domains.

1. Introduction

Many talented and capable students are opting out of the science, technology, engineering, and mathematics (STEM) pipeline and women remain overall underrepresented in STEM fields (Miller, Eagly, & Linn, 2015; Stoet & Geary, 2018). These two issues represent an international phenomenon that has sparked considerable concern from policy makers and STEM professionals. Since elevated academic motivation in math and science during high school has been positively linked to persistent learning, better knowledge acquisition, and higher aspirations in STEM domains (e.g., Guo, Marsh, Parker, Morin, & Yeung, 2015; Guo, Marsh, Parker, Morin, & Dicke, 2017; Guo, Parker, Marsh, & Morin, 2015), researchers have sought to understand how achievement motivation during adolescence contributes to a sustained trajectory of STEM participation (Wang & Degol, 2013). Although studies have consistently demonstrated a uniform decline in students' academic motivation in math and science throughout adolescence (Wigfield, Tonks, & Klauda, 2016), more recent studies have shown that students are likely to develop differential trajectories in these areas (e.g., Musu-Gillette, Wigfield, Harring, & Eccles, 2015; Wang, Chow, Degol, & Eccles, 2017). For example, some students may experience declines in math and science motivation, whereas others experience a stable or increasing motivational trajectory during adolescence. These divergent trajectories have been differentially associated with academic performance, course selections, and career aspirations (e.g., Wang et al., 2017).

More importantly, the development of motivation in one subject domain seems to influence one's valuing of activities in other academic domains (Wang & Degol, 2016). For instance, by evaluating one's academic strengths and weaknesses across different domains, a student can distinguish subjects in which they excel, which likely prompts an in-depth exploration of interests related to that academic domain. Simultaneously, this student would lower their interests in subject domains in which they hold a relatively low expectancy for success. The student's joint motivational trajectories across domains would form a *relative* intraindividual (i.e., cross-domain) hierarchy of motivation. Because choices of college major and career trajectory occur while adolescents are constructing this hierarchy, individual differences in the development of a relative motivation hierarchy are critical to

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understanding why youth select one career path over another.

Despite the call for examining relative motivation hierarchies across multiple academic domains, extant studies have yet to incorporate multiple subject domains, investigate individual differences in joint developmental changes, and link these variables to long-term educational and career pathways. Moreover, scant attention has been given to the difference between assuming heterogeneity based on a single study sample and identifying and recognizing between-subgroup heterogeneity, a distinction central to the study of individual and gender differences in career development. The use of both variable- and pattern-centered approaches may provide a more holistic picture of different motivational trajectories' impact on STEM career development while also helping to identify areas where interventions could be fruitful for increasing STEM participation, particularly for women.

In this study, we use an expectancy-value theoretical framework (EVT, Eccles, 2009) to investigate subjective task values (STVs) attached to various subject domains. First, we examine the average joint trajectories of STVs in three domains (i.e., Finnish, math/science, and social subjects) for all individuals from grades 9 to 11 using a variable-centered approach. Next, we shift to a between-subgroup heterogeneous perspective (i.e., pattern-centered approach) in which we hope to identify multiple trajectory groups with distinct joint developmental patterns of STVs across domains. We then link these trajectory patterns to STEM aspirations at four years postsecondary school and STEM participation at six years postsecondary school and explore gendered motivational trajectories and how they contribute to gender differences in STEM fields. Finally, we discuss the divergent predictive patterns between variable- and pattern-centered approaches. It should be noted that although self-concept (i.e., expectancies) trajectory also play an imperative role in differentiating individual's educational and occupational pathways, adding self-concept in multiple domains will be beyond our current statistical approaches and greatly increase the complexity of this study. Thus, we only focus on STVs in three domains in the present study due to complexity of our current statistical approaches.

1.1. Development of subjective task values based on expectancy-value framework

Eccles' EVT (2009), a major theoretical framework for studying achievement motivation, has been widely used when investigating both individual and gender differences in education and career trajectories (see Wang & Degol, 2013, 2016 for reviews). EVT posits that achievement-related choices (e.g., career selection) are linked to intellectual competencies and an array of psychological and socio-cultural factors. Subjective task values (STVs) are one of the major psychological components of EVT. STVs consist of intrinsic value (i.e., the personal enjoyment or liking of a task), utility value (i.e., the perceived usefulness of the task as related to fulfilling personal goals), attainment value (i.e., the perceived relevance of a task to one's sense of self, identity, and core personal values), and cost (i.e., the perceived negative aspects of making a specific choice). In addition, The *relative* STVs associated with subject domains have been found to influence education- and career-related choice behaviors more so than course grades (Eccles, 2009). Indeed, the process of career selection is inherently comparative: All options are assumed to be associated with costs, as one choice often eliminates other options (Eccles, 2009). For example, let us consider a student's decision to major in physics at college. Student is likely to select this major only if they place higher value on physics than they do on other majors. Thus, the student's relative STVs influence their educational and occupational decision-making.

Extant research using latent growth modelling (LGM) has indicated that students' STVs decline in each subject domain following elementary school and although specific trends vary somewhat across studies, these STVs become relatively stable during late adolescence (e.g., Dotterer, McHale, & Crouter, 2009; Fredricks & Eccles, 2002; Gottfried, Marcoulides, Gottfried, Oliver, & Guerin, 2007; Petersen & Hyde, 2017; Watt, 2004). Specifically, researchers in the U.S. found that on average, adolescents' STVs for verbal domains (e.g., language and reading) remained unchanged and those for math and science slightly declined (Fredricks & Eccles, 2002; Gottfried et al., 2007; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Petersen & Hyde, 2017). Watt (2004) looked at changes in an Australian sample and found that STVs in English and math declined to a very small extent during the high school transition. Furthermore, Dotterer et al. (2009) showed that American students' interest in reading, writing, math, language arts, and science declined over time although the decline decelerated during late adolescence.

There are two major explanations for the average declining STV trajectories across domains. Some have attributed these declines primarily to aspects of cognitive development. Children in the early elementary years tend to be quite optimistic about their abilities in different domains and have unrealistic expectations of how interesting these subjects are (Wigfield et al., 2016). As their cognitive skills develop and school environments change, academic performance and social comparison begin to shape the students' STVs (Wang et al., 2017). In an achievement-oriented environment, students are likely to evaluate their abilities through social comparisons. In other words, they liken their self-perceived performance in a subject domain to that of their peers. Such comparisons undermine a student's self-perception of ability in that domain, particularly if the student is experiencing academic difficulties (Archambault, Eccles, & Vida, 2010). To protect their self-esteem and self-worth, students may begin to devalue activities and subjects in which they flounder by concluding that those subjects are not interesting or that they do not fit their personal goals and identities (Fredricks & Eccles, 2002).

Others attributed declining motivational trajectories to the mismatch between an adolescent's developmental needs and their school environment (Eccles et al., 1993). Students expect to have more autonomy and independence in learning during adolescence; however, opportunities to meet adolescents' needs in a school environment are limited because of the isolative structure of many high schools and the demands on teachers to manage large student loads, often resulting in the use of controlling classroom strategies and normative grading (Eccles et al., 1993). This mismatch contributes to many students' declining motivation between elementary and secondary school.

1.2. Development of Academic STVs During High School Transition Using Pattern-Centered Approaches

While a tremendous body of research has used variable-centered approaches to focus on average trends of motivational change, the general decline pattern characterizes most, but not all, students (Archambault et al., 2010, Musu-Gillette et al., 2015; Wang et al., 2017). Recently, researchers have employed pattern-centered approaches (i.e., growth mixture modelling, GMM) to demonstrate that students evidence divergent motivational trajectories, especially during the high school years (e.g., Archambault et al., 2010, Musu-Gillette et al., 2015; Wang et al., 2017). In a longitudinal study, Archambault et al. (2010) tracked the development of literacy STVs across grades 1 through 12. While seven trajectory groups were identified in which children all showed motivational decreases with different rates, three groups experienced some recovery during the high school years. Similarly, later inclining trajectory groups were identified in two other recent studies focusing on math and science STVs (see Musu-Gillette et al., 2015, Wang et al., 2017). In one of these studies, the later inclining trajectory group reported a decrease in science STVs across seventh to ninth grade, which was then followed by an increase during high school transition (Wang et al., 2017).

A developmental perspective may explain why multiple population subgroups with distinct trajectories emerge while also offering a theoretical rationale for the importance of tracking joint motivational trajectories across domains during the high school transition. From