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Math-Related Career Aspirations and Choices Within Eccles et al.'s Expectancy–Value Theory of Achievement-Related Behaviors

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Which occupation to pursue is one of the more consequential decisions people make and represents a key developmental task. Yet the underlying developmental processes associated with either individual or group differences in occupational choices are still not well understood. This study contributes toward filling this gap, focusing in particular on the math domain. We examined two aspects of Eccles et al.'s (1983) expectancy–value theory of achievement-related behaviors: (a) the reciprocal associations between adolescents' expectancy and subjective task value beliefs and adolescents' career plans and (b) the multiplicative association between expectancies and values in predicting occupational outcomes in the math domain. Our analyses indicate that adolescents' expectancy and subjective task value beliefs about math and their math- or science-related career plans reported at the beginning and end of high school predict each other over time, with the exception of intrinsic interest in math. Furthermore, multiplicative associations between adolescents' expectancy and subjective task value beliefs about math predict math-related career attainment approximately 15 years after graduation from high school. Gender differences emerged regarding career-related beliefs and career attainment, with male students being more likely than female to both pursue and attain math-related careers. These gender differences could not be explained by differences in beliefs about math as an academic subject.

Keywords: expectancy–value theory, career choice, STEM, gender

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Career choice is a key developmental task with long-term implications for job satisfaction, job performance, and psychological well-being (Brown, 2002; Eccles, 2009; Gottfredson, 2002; Super, 1990). Substantial evidence has supported the usefulness of Eccles et al.'s (1983) expectancy–value theory (EVT) for understanding the development of and influences on educational and career choices (e.g., Durik, Vida, & Eccles, 2006; Wang, 2012; Watt et al., 2012). The theory's basic premise is that individuals choose to engage in tasks and activities that have high value to them and at which they expect to succeed. In addition, Eccles and colleagues specified four components of subjective task value (intrinsic interest, utility, attainment value, and cost) and outlined a comprehensive set of their antecedents and consequences. In this article, we use EVT to longitudinally investigate the relations between adolescents' math-related academic expectancy–value beliefs and career aspirations, as well as pathways toward math-related adult career attainment.

EVT has provided the foundation for research on a wide range of topics, including the psychological and social determinants of academic success, the pursuit of advanced educational opportunities, and the pursuit of particular career paths, including research on gendered preferences for careers in science, technology, engineering, and math (STEM; Eccles, 2005, 2009; Wang, 2012; Watt, 2004; Watt et al., 2012). EVT has also inspired intervention research designed to increase adolescents' participation in the STEM domain (e.g., Harackiewicz, Rozek, Hulleman, & Hyde, 2012; Hulleman & Harackiewicz, 2009). Of importance, EVT is suitable for analyses that integrate academic and career-focused beliefs (e.g., analyses of the interrelations between interest in math as an academic subject and interest in pursuing a math-related career; see, e.g., Eccles, 2009; Wang, 2012; Watt et al., 2012) due to its general focus on motivational processes and choices that apply across life domains.

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However, evidence grounded in this theoretical framework has been limited in two ways: First, even though Eccles and her colleagues (1983) proposed reciprocal links between career aspirations and both expectancies and subjective task values, expectancy–value researchers have generally examined unidirectional paths, according to which expectancies and subjective task values in academic domains predict career choices, leaving the potential reciprocal effects of career aspirations on expectancies and values relatively unexplored. Second, even though expectancy–value models have historically included a multiplicative association between academic expectancies and subjective task values in predicting subsequent achievement-related outcomes (Atkinson & Birch, 1970), this interaction has not been regularly tested in expectancy–value research, especially in nonexperimental settings (see Nagengast et al., 2011). Increasingly, researchers have begun to study such interactive Expectancy × Value associations in field research (Guo, Parker, Marsh, & Morin, 2015; Nagengast et al., 2011; Trautwein et al., 2012), but these analyses are mostly cross-sectional (see Guo, Parker, et al., 2015, for a notable exception), and to our knowledge no studies have examined potential Expectancy × Value interactions in relation to career attainment.

We address these limitations using data from the Childhood and Beyond (CAB) study—a longitudinal study of the development of expectancy and subjective task value beliefs (Eccles, Wigfield, Harold, & Blumenfeld, 1993). Using newly collected data, we examined the associations of U.S. adolescents' math-related expectancy and subjective task value beliefs with their adult careers. First, we examined the reciprocal links between adolescents' math-related expectancy–value beliefs and math- or science-related career aspirations during the high school years, as well as the power of these beliefs to predict having a math-related career as an adult. Second, we tested the additive and interactive associations between high school math-related expectancy–value beliefs in predicting actual adult careers, as well as the predictive effects of family background, cognitive abilities, and gender. We focus specifically on the domain of mathematics and math-related careers for three reasons: (a) There are national and international concerns about the insufficient involvement of talented adolescents and young adults in math-intensive fields (e.g., National Science Board, 2014), (b) there is a close connection between a specific high-school-acquired academic skill set (math) and the pathway to STEM occupational entry (Wang & Degol, 2013), and (c) there are persistent gender disparities in math-intensive educational and occupational choices, with female students being substantially less likely than male to pursue careers requiring high levels of math skills (e.g., Watt et al., 2012). Finally, we focus on adolescence as a critical stage in the career choice process because individual career preferences tend to crystallize at that stage. Developmental career choice models suggest that the career choice prior to adolescence is primarily characterized by the elimination of unacceptable career options, whereas with increasing mental maturity adolescents are able to engage in greater self-exploration and identification of the most preferred and accessible options (e.g., Gottfredson, 1981, 2002; Super, 1990). Similar to EVT, such models propose that personal preferences and the perceived accessibility of career options shape subsequent career choices. Less is known, however, about whether and how career choices may, in turn, shape self-perceptions related to one's ability and interests during the critical years for career identity formation and preparation.

Reciprocal Links Between Expectancy–Value and Career Beliefs

Grounded in EVT (Eccles et al., 1983), substantial evidence has supported the predictive power of individuals' academic motivations for subsequent career aspirations related to such academic domains as math (Lauermann, Chow, & Eccles, 2015; Watt et al., 2012), science (Chow, Eccles, & Salmela-Aro, 2012; Nagengast et al., 2011), and literacy (Durik et al., 2006). For the purposes of this research, we focus in particular on the math domain. Evidence has suggested that expectancies for success, operationalized as self-concept of ability and expected future success, and the individual's subjective valuing of math both predict math-related career plans (Wang, 2012; Wang, Eccles, & Kenny, 2013). However, whereas utility/importance value (the perceived usefulness and importance of a given academic domain such as math) has emerged as a critical predictor of adolescents' math-related career plans (Watt et al., 2012), evidence regarding the predictive influence of intrinsic interest on career plans has been more mixed. For instance, Watt and colleagues (2012) found that adolescents' intrinsic interest in math predicted math-related career plans in an Australian sample but not in U.S. or Canadian samples. Accordingly, expectancy for success in and utility beliefs about math positively predict math-related career aspirations, but no specific predictions can be made for intrinsic interest, due to inconsistent prior evidence.

Both EVT (Eccles et al., 1983; Eccles & Wigfield, 2002) and career choice research (Lent, Brown, & Hackett, 2002) also support a predictive link from career aspirations to subsequent academic motivations. For instance, Eccles and colleagues (1983) argued that if math skills are perceived as useful and important for a given career goal, then having this career goal should lead to an increase in perceived math utility, even in the absence of intrinsic valuing and enjoyment of math itself. Thus, career plans could affect subsequent academic motivations because they would impact on the valuing of academic material related to those career plans. Furthermore, interest in math-related occupations should lead to increased valuing of and engagement in math-related activities, which should lead to an increased likelihood of experiencing success in these activities and thus to increases in subsequent ability perceptions and expectations for future success. Guo, Marsh, Morin, Parker, and Kaur (2015) examined reciprocal links between school-related but domain-general expectancy–value beliefs (e.g., self-concept of "school ability" and interest in "most courses") and aspired occupational prestige in a sample of U.S. male students across five time points during their secondary and postsecondary education. These authors found stronger evidence that domain-general expectancy–value beliefs predict aspired occupational prestige than vice versa. However, these analyses are not domain-specific and are limited to only boys, and the available data did not allow for tests of reciprocal links across all time points (e.g., expectancy–value beliefs were available for only three of the five time points). Further investigations of the reciprocal associations between domain-specific academic beliefs and career aspirations are therefore needed. In addition, evidence in the career choice literature has supported positive reciprocal associations between occupational interests and self-evaluated abilities that are relevant for these occupational interests (Nauta, Kahn, Angell, & Cantarelli, 2002; Tracey, 2002), but this work has not explicitly focused on academic motivations. Thus, EVT and career choice frameworks suggest that early math-related career aspirations may predict increases in both math-related expectations for success and subjective task values; however, potential reciprocal links between such domain-specific career beliefs and motivations remain largely unexplored in expectancy–value research. In the present study, we examine such reciprocal links for the math domain.

Multiplicative Associations Between Expectancy and Subjective Task Value Beliefs

Beginning in 2010, some expectancy–value researchers became concerned that the historically predicted interaction between expectancies and values in explaining achievement-related behaviors (e.g., Atkinson & Birch, 1970) was no longer being routinely tested, especially in field research (Nagengast et al., 2011). An interactive association implies, for instance, that if an activity is perceived as doable but not worth doing, or worth doing but not achievable, individuals would be unlikely to engage in that activity. Since 2010, several studies have documented a significant interaction between academic expectancies and values in predicting science-related activities and career plans (Nagengast et al., 2011); math and English achievement (even after controlling for prior achievement and general cognitive ability; Trautwein et al., 2012); and math course selection, university entry, and selection of STEM-related college majors (Guo, Parker, et al., 2015). In keeping with these studies, we examine a potential interaction between expectations for success in math and perceived task values in predicting math-related career attainment.

A consideration of interactive Expectancy × Value associations in this area is particularly important because understanding and acknowledging such interactions may help one to avoid counterintuitive effects of interventions. For example, if the impact of academic values on occupational choice depends on individuals' sense of competence, then a value-focused math intervention might fail to produce desired outcomes for individuals who have little confidence in their math abilities, because it may increase the valuing of an outcome that is not perceived as attainable. Alternatively, if both high math expectancies and high math values are needed for selecting a math-intensive career, then an intervention focused solely on increasing students' confidence in their ability to master math might be insufficient to increase the likelihood of entering math-intensive careers (e.g., in STEM). Accordingly, research and intervention efforts that target only ability-related or only value-related beliefs may produce nonoptimal results (see Durik, Shechter, Noh, Rozek, & Harackiewicz, 2015; Harackiewicz et al., 2012; Rozek, Hyde, Svoboda, Hulleman, & Harackiewicz, 2015). For instance, a laboratory study by Durik et al. (2015) found that the effectiveness of an intervention designed to increase the subjective valuing of a math task was moderated by the participants' expectancy for success. For participants with low expectancy, the treatment not only failed to produce a positive effect but also produced a negative effect on their perceived interest in and performance on a math task. Accordingly, if an outcome is seen as potentially unattainable, interventions that increase the subjective valuing of that outcome can produce undesirable effects.

The Career Choice Process and the Role of Gender in Math-Related Domains

Similar to EVT, developmental career choice models propose that individuals choose occupations that are perceived as both accessible and desirable (Gottfredson, 1981, 2002). In both theoretical frameworks, accessibility is assumed to be influenced by such factors as socioeconomic status and cognitive abilities, whereas desirability is assumed to be influenced by personal preferences and interests. Individual characteristics such as gender also play a critical role: Individuals tend to avoid occupations that are not typical for their own gender, because such atypical choices may violate social norms and may pose a threat to their own gender identity; that is, the perceived cost of pursuing such occupations may be too high (Eccles et al., 1983; Gottfredson, 2002). Consistent with these theoretical assumptions, research across two large-scale longitudinal samples from Germany and England supported a differential effects model, according to which socioeconomic status was a key predictor of university entry (a factor influencing access to more or less prestigious careers), whereas gender was a key predictor of college major selection (a factor associated with individuals' career choice; see Parker et al., 2012). These findings are consistent with the conceptualization of socioeconomic status as a factor influencing educational (and thus also occupational) access and of gender as a factor influencing educational (and thus also occupational) specialization.

There has been mixed evidence regarding whether mathematics represents a male-dominated area. Meta-analyses have indicated no (Lindberg, Hyde, Petersen, & Linn, 2010) or only small (Reilly, Neumann, & Andrews, 2015) differences in math achievement between boys and girls. When achievement differences exist, their effects on gendered educational and occupational choices related to math-intensive fields are typically weak (Ceci & Williams, 2010; Riegle-Crumb, King, Grodsky, & Muller, 2012; Riegle-Crumb, Moore, & Ramos-Wada, 2011). Yet, in the United States and most industrialized countries, women remain underrepresented in some math-intensive STEM fields (e.g., engineering), and even when women hold a STEM-related degree, they are less likely than their male counterparts to work in STEM fields (National Science Foundation, 2013). It is important to note that researchers have documented continuing motivational differences related to math, with girls rating their math abilities, perceived math utility, and intrinsic interest in math somewhat lower and their math anxiety somewhat higher than do boys (Frenzel, Goetz, Pekrun, & Watt, 2010; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Organisation for Economic Co-operation and Development, 2013; Watt, 2004). Furthermore, such motivational differences can be domain- and construct-specific. Research differentiating among 11 facets of German adolescents' valuing of math as an academic subject has suggested that boys are more likely to view math as useful for future job prospects and for future life in general than are girls, whereas no gender differences emerged regarding the perceived usefulness of math for school-related goals (for further discussion of gender-specific differences across value facets, see Gaspard, Dicke, Flunger, Schreier, et al., 2015).

Although exceptions exist (e.g., Watt et al., 2012), the preponderance of available evidence has revealed mainly mean-level gender differences in math-related expectancy–value beliefs and educational and occupational choices, whereas the associations between these motivational beliefs and corresponding educational and occupational outcomes have tended to be similar across gender (Guo, Marsh, Parker, Morin, & Yeung, 2015; Guo, Parker, et al., 2015; Nagengast et al., 2011; Simpkins, Fredricks, & Eccles, 2012; Wang, 2012). For instance, Wang (2012) found no significant gender differences in the associations between math self-concept of ability, task values, and math-related career aspirations. Similarly, Nagengast et al. (2011) used a large international data set from 57 countries and found no systematic gender differences in the interactions between adolescents' self-concept of ability and intrinsic interest in science in predicting science-related career aspirations and engagement in science-related tasks. Accordingly, similar motivational processes seem to shape girls' and boys' educational and occupational choices, even though mean-level differences in motivational beliefs and career aspirations exist. In view of this evidence, in this study we examined gender differences in math-related motivations, career aspirations, and choice, controlling for family background and initial teacher-rated math aptitude.

The Present Research

In sum, we first examine the reciprocal associations between adolescents' math-related expectancy–value beliefs and career plans across the high school years to model the development of academic and career-related beliefs and choices. We then examine the predictive role of these beliefs and plans in explaining math-related career attainment approximately fifteen years after graduation from high school. Finally, we examine potential gender differences in math-related motivations, career plans, and attainment. Specifically, we hypothesize positive reciprocal links between math-related self-concept of ability and career plans (Hypothesis 1a [H1a]), as well as between math utility and math-related career plans (H1b). Analogous positive reciprocal associations between intrinsic interest in math and math-related career plans might exist as well (H1c), but this hypothesis is more exploratory due to inconsistent prior evidence (e.g., Watt et al., 2012). We further hypothesize that math-related academic motivations—namely, math self-concept (H2a), math utility (H2b), and intrinsic interest in math (H2c)—as well as career plans (H2d) will directly or indirectly positively predict math-related adult career attainment. In the context of these analyses, we also examine correlational associations with and potential predictive effects of gender on math-related motivations (H3a), career plans (H3b), and career attainment (H3c); when gender differences in math-related constructs occur, we expected them to favor male students (H3a–H3c). Of particular interest for the present study is whether and to what extent gender might directly or indirectly predict math-related career attainment via its links to adolescents' math-related expectancy–value beliefs and career plans reported in high school (see H3a–H3c).

In a separate set of analyses, we further examine additive and interactive associations between adolescents' math-related expectancy–value beliefs—including both Expectancy × Utility (H4a) and Expectancy × Intrinsic Interest (H4b) interactions—in predicting math-related career attainment in adulthood. More specifically, we hypothesize that the combination of relatively high perceived ability and expected success in math with relatively high valuing of math as an academic subject will positively predict math-related career attainment in adulthood, beyond the independent additive effects of these motivational constructs. We also hypothesize that the combination of high levels of either values or expected success with low levels of the alternative belief will predict the lowest likelihood of entering a math-intensive career. We examine potential gender differences regarding these interactive associations, but pose no specific hypotheses; prior research has not revealed systematic differences in the interactive Expectancy × Value associations by gender (see Nagengast et al., 2011).

Method

Participants and Procedure

Data for this research were part of the Childhood and Beyond (CAB) study (Eccles et al., 1993)—a cross-sequential study following three cohorts of public school students from elementary through secondary school and into adulthood (for a detailed description, see www.rcgd.isr.umich.edu/cab). Data were collected in three primarily White (94% White) middle-class school districts in southeastern Michigan (median parental income between $50,000 and $60,000). The participants were originally recruited in elementary school during the 1987–1988 school year, when they were in first (Cohort 1), second (Cohort 2), and fourth (Cohort 3) grade. The same participants were then followed over time as they were changing their schools, classrooms, and teachers. Data in adulthood were collected in 2013–2014 via a short survey asking about major career and family milestones (the participants indicated a preference for online or paper-and-pencil participation after an initial letter of invitation was sent via mail). Search of personal and professional websites (company websites, LinkedIn, Facebook, and Accurint) was used to obtain additional data about current or most recent occupations.

Table 1 provides an overview of key time points, mean age, grade levels, and school years for each data collection included in the present study. We focused on variables assessed at four time points: Elementary school variables (Time 1) included gender, age cohort, parental level of education; students' cognitive ability; and teacher-rated math aptitude. High school variables (Times 2 and 3) included students' math-related expectancy–value beliefs and math- or science-related career plans assessed at the beginning and end of high school (in Grades 9 and 12, respectively). Adult careers (Time 4) were measured in 2013–2014, approximately fifteen years after graduation from high school, when the participants were in their 30s (see Table 1; age range = 32–37 years). Data from all three cohorts were available for Times 1, 3, and 4, but data from only Cohorts 1 and 2 were available for Time 2 (Grade 9); due to a break in funding, no data were collected for the oldest cohort (Cohort 3) at the beginning of high school (Grade 9), and Grade 12 was the only time point in high school for which data from all three cohorts were available (see Table 1).

The CAB sample initially consisted of 980 participants across the three school districts and all three of the original CAB cohorts. Table 2 shows the number of participants with available data, as well as descriptive information for each variable and time point.

Table 1
Sample Description by Cohort, Grade Level, and Age at Each Time Point of Data Collection

Time and variable	Cohort 1	Cohort 2	Cohort 3
Initial participation in CAB (Time 1)			
Grade level	Grade 1	Grade 2	Grade 4
School year	1987–1988	1987–1988	1987–1988
Mean age in years (*SD*)	6.75 (.38)	7.74 (.39)	9.70 (.37)
Beginning of high school (Time 2)			
Grade level	Grade 9	Grade 9	—
School year	1995–1996	1994–1995	—
Mean age in years (*SD*)	14.74 (.37)	14.69 (.37)	—
End of high school (Time 3)			
Grade level	Grade 12	Grade 12	Grade 12
School year	1998–1999	1997–1998	1995–1996
Mean age in years (*SD*)	17.71 (.36)	17.68 (.36)	17.67 (.33)
Participation in adulthood (Time 4)			
Year of data collection	2013–2014	2013–2014	2013–2014
Mean age in years (SD)	32.70 (.36)	33.69 (.34)	35.66 (.37)

Note. The average age was computed as of January 1 of each year shown (e.g., January 1, 2014). Data collections at Times 1–3 were conducted in the spring of each school year, whereas the data collection at Time 4 started at the beginning of 2013 and was concluded at the end of 2014. Due to a break in funding, no data were collected for the oldest cohort (Cohort 3) at the beginning of high school, in Grade 9 (Time 2). CAB = Childhood and Beyond study.

Incomplete data in subsequent analyses were handled with the full information maximum likelihood algorithm, which uses correlates of missingness to estimate unbiased model parameters (Schafer & Graham, 2002). All available data were used in the present analyses ($n = 980$). The amount of missing data (number of missing observations per case) was significantly correlated with being male ($r = .12$, $p < .001$) and was negatively correlated with parental education ($r = -.16$, $p < .001$), students' cognitive ability ($r = -.25$, $p < .001$), and teacher-rated math aptitude ($r = -.22$, $p < .001$). No significant associations of the amount of missing data emerged with math-related expectancy–value beliefs, career plans, and career attainment (rs $= -.10$ to .03, ps $\geq .100$). Gender, age cohort, parental education, students' cognitive ability, and math aptitude were included as covariates in all analyses. In addition, due to the high percentage of missing data for selected variables and time points (e.g., in Grade 9, for which only two cohorts were available; see Table 1 and Table 2), we tested the robustness of our results (a) using data from only participants who

Table 2
Zero-Order Correlations and Descriptive Statistics

	Time 1							Time 2				Time 3				Time 4
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Male	—															
2. Parental education	−.05	—														
3. Cohort 1	.03	−.04	—													
4. Cohort 2	−.02	−.01	−.42**	—												
5. Cohort 3	−.01	.04	−.53**	−.55**	—											
6. Cognitive ability	.13**	.18**	.14**	.08*	−.20**	—										
7. Teacher-rated math aptitude	.03	.22**	−.02	.03	−.01	.42**	—									
8. Gr. 9 math self-concept	.06	.17**	−.18**	.19**	*a.*	.24**	.33**	—								
9. Gr. 9 math utility	.03	.07	−.15*	.15*	*a.*	.03	.04	.50**	—							
10. Gr. 9 math interest	.01	.05	−.11	.10	*a.*	.01	.10	.65**	.60**	—						
11. Gr. 9 career plans	.23**	.04	−.08	.12	*a.*	.23**	.17**	.44**	.38**	.36**	—					
12. Gr. 12 math self-concept	.11*	.20**	−.07	.04	.03	.28**	.38**	.70**	.41**	.50**	.43**	—				
13. Gr. 12 math utility	.06	.07	−.04	−.02	.05	.07	.15**	.39**	.55**	.47**	.37**	.61**	—			
14. Gr. 12 math interest	.03	.06	−.06	.02	.04	.09	.15**	.58**	.47**	.66**	.30**	.72**	.73**	—		
15. Gr. 12 career plans	.30**	.14*	−.07	−.01	.06	.24**	.26**	.37**	.35**	.28**	.60**	.52**	.45**	.42**	—	
16. Math-related career	.21**	.05	−.11*	.07	.03	.15**	.20**	.27**	.21**	.19*	.36**	.28**	.25**	.21**	.43**	—
M	.49	4.70	.29	.30	.41	115.09	5.07	4.87	4.59	3.62	3.56	4.72	4.29	3.57	3.44	40.59
SD	.50	1.74	.45	.46	.49	15.57	1.13	1.22	1.17	1.56	2.18	1.38	1.36	1.66	2.34	12.88
N	980	687	980	980	980	960	968	282	282	282	248	424	425	425	398	382
Skewness		.16				.26	−.45	−.42	−.38	−.05	.22	−.50	−.17	.02	.35	.18
Kurtosis		−1.05				−.01	−.14	−.20	−.18	−.84	−1.38	−.32	−.69	−1.03	−1.45	−.01
α							.90	.92	.81	.89		.94	.88	.92		.95

Note. Cohort 1 is a dummy variable representing the youngest cohort (1 = youngest cohort, 0 = other cohorts), Cohort 2 represents the middle cohort (1 = middle cohort, 0 = other cohorts), and Cohort 3 represents the oldest cohort (1 = oldest cohort, 0 = other cohorts). Cohort 1 was defined as the reference group in subsequent analyses. No data are available for Cohort 3 (oldest cohort) for Grade 9 (Time 2). Gr. = Grade.
* $p < .05$. ** $p < .01$. (All ps are two-tailed.)

had at least one observation in high school and adulthood (n = 596), (b) using only observed variables so that the ratio of estimated parameters to available data is reduced (n = 596 and n = 980), and (c) using only observed variables and data from only Cohorts 1 and 2 with at least one observation in high school or adulthood (n = 361). Only cross-lagged effects were tested with n = 361 due to insufficient statistical power for testing interactive associations. These analyses corroborate our findings regarding cross-lagged effects, interactive effects, and significant (or marginally significant) predictors of career attainment reported in the Results section (for further details, see Appendix 6 in the online supplemental materials). We focus on only the full sample of 980 participants in the present study.

Measures

Self-report items used in the present study are reported in the online supplemental materials (see Appendix 1); questionnaires for the CAB study are available online (see www.rcgd.isr.umich.edu/cab).

Demographics. At the start of the study, participants' parents provided demographic information, including their children's gender (0 = female, 1 = male) and their own level of education on a scale ranging from 1 (*some high school*) to 8 (*Ph.D. or advanced professional degree*). The educational level of the parent with the highest education was used as an indicator of the child's family educational background (Durik et al., 2006). Approximately half of the sample (51%) were female, and the average level of parental education was M = 4.70 (SD = 1.74; Mdn = 5.00), corresponding to a college graduate (55% of the sample had at least one parent with a college degree or higher). Two dummy variables were used to estimate the predictive effects of the participants' age cohort (the youngest cohort, Cohort 1, was defined as a reference group).

Cognitive ability. All children were given the Slosson Intelligence Test—Revised (SIT–R) as an assessment of general cognitive ability when they joined the CAB study (Slosson, Nicholson, & Hibpshman, 1991). Using the CAB data, Jacobs, Lanza, Osgood, Eccles, & Wigfield (2002) found positive associations between the SIT–R scores and children's self-evaluated competence beliefs in both math and language arts. This variable was included as a covariate in the present analyses as well, so that estimated predictive effects in subsequent analyses are independent of our indicator of general intelligence.

Teacher-evaluated math aptitude in elementary school. Elementary school teachers of participating students evaluated their students' math aptitude in the first four waves of data collection (kindergarten through Grade 6) using two items: "Compared to other children, how much innate ability or talent does this child have in math?" ranging from 1 (*very little*) to 7 (*a lot*), and "How well do you expect this child to do next year in math?" ranging from 1 (*very poorly*) to 7 (*exceptionally well*). The internal consistency of this two-item scale at each wave and within each grade level ranged from α = .84 to α = .89. Each student received up to four teacher ratings, and all but 12 students received at least one rating (81% received two or more ratings). The interrater agreement (intraclass correlation [ICC]) between teachers ranged from .68 to .84 across waves and grade levels and was .84 for participants with four ratings. The average of all available teacher ratings per student was used as an indicator of the students' math aptitude in elementary school (α = .90).

Expectancy and subjective task value beliefs in math. The participants' self-concept of ability and expectancy of success in math were assessed with five items; for example, "How good at math are you?" ranging from 1 (*not very good*) to 7 (*very good*), and "How well do you expect to do in math next year?" ranging from 1 (*not well*) to 7 (*very well*). Similar to prior research in Eccles et al.'s (1983) EVT, we did not distinguish between self-concept of ability and expected future success, because these sets of items are highly correlated (r = .79 in Grade 9 and r = .81 in Grade 12; $ps < .001$). The perceived utility and importance of math were assessed with four items; for example, "How useful is what you learn in math?" ranging from 1 (*not useful*) to 7 (*very useful*), and "For me, being good at math is:" ranging from 1 (*not at all important*) to 7 (*very important*). Intrinsic interest and enjoyment of math were assessed with three items; for example, "How much do you like math?" ranging from 1 (*a little*) to 7 (*a lot*). These measures are widely used and have been validated across several academic domains (e.g., Wigfield & Eccles, 2000). The internal consistencies of all constructs were very good, ranging from α = .81 to α = .93 (see Table 2).

Career plans for math- or science-related occupations. The participants were asked to assess the likelihood of pursuing a career in the field of science or math on a scale ranging from 1 (*very unlikely*) to 7 (*very likely*). "Engineer" and "architect" were provided as examples illustrating the types of jobs that may fall under this category. This was a single-item indicator for career plans.

Math-related career attainment. Adult careers were coded for their degree of math-relatedness using data from the Occupational Information Network (O*Net; U.S. Department of Labor Employment and Training Administration, 1998; see www.onetcenter.org), a database of all occupations recognized by the United States Department of Labor (Version 18.0). The participants' open-ended descriptions of their current or most recent occupation (e.g., "real estate broker"), official job title (e.g., "associate broker"), and important job activities and duties (e.g., "selling real estate, marketing, communication") were matched with corresponding occupational titles from the O*Net 18.0 database (e.g., "Real Estate Brokers"). In addition, the participants were asked to list their educational and occupational history in a table, and this information was used to check the plausibility of assigned occupational titles for the participants' current or most recent occupation. Furthermore, the occupational data of 27 individuals were obtained through a web search of personal and professional websites. The math-relatedness of each occupation was then derived from the O*Net 18.0 database, which rates (a) the importance and (b) the required level of math skills for each occupation on a scale ranging from 0 (*low*) to 100 (*high*). The math importance scores reflect how critical the use of mathematics is for completing the job or how consistently math skills are used on the job. These scores have been used successfully to operationalize career plans in prior research (see Durik et al., 2006, for reading importance and Watt et al., 2012, for math importance). The math level scores reflect the level of proficiency and sophistication of math skills required for each occupation. Because O*Net 18.0 does not provide such ratings for military occupations, the scores of four individuals were inferred from corresponding civil occupations (e.g., the math scores for a sergeant with the military were inferred from the scores provided for police sergeants). In addition, the math scores for 10 individuals who identified themselves as homemakers were inferred from the math scores of housekeepers due to overlap in described tasks (housekeeping and child care). Example occupations and corresponding math importance and math level scores, respectively, in our sample were mechanical engineer (69 and 73), accountant (72 and 54), lawyer (28 and 29), photographer (16 and 13), and massage therapist (0 and 0). As noted previously, the math importance and math level scores indicated the degree of math-relatedness of the participants' occupations (α = .95). The interrater reliability for these assigned math scores, based on the ratings of two coders who coded randomly selected 25% of the data, was good (ICC = .92 for the math scores; κ = .71 for the assigned occupational codes). The mean difference in the math scores (average math importance and level) of male and female participants, respectively ($\Delta M = 5.41$), $t(380) = 4.07$, 95% confidence interval [CI: 2.80, 8.02], $p < .001$, corresponded roughly to the difference in average math scores of a mechanical engineer versus a molecular biologist (71 vs. 66), a school administrator versus a secondary school teacher (53 vs. 46), or a computer network support specialist versus a clinical psychologist (33 vs. 28). Both math importance and math level scores were used as two observed indicators of the degree of math relatedness for a given occupation in subsequent analyses.

Analytical Approach

Bivariate correlations were computed to examine the associations between all variables of interest, and structural equations models (SEMs) were used to examine the hypothesized associations between latent variables, as well as predictive effects. All multi-item constructs were modeled as latent variables (teacher-rated math aptitude, students' math self-concept, value beliefs, and math-related career attainment). Two sets of SEMs were tested to answer our proposed hypotheses (see The Present Research section). First, a set of cross-lagged analyses (Models A1–A4) were conducted to examine the reciprocal associations between math-related expectancy–value beliefs and career plans reported at Times 2 and 3 (Grades 9 and 12, respectively; H1a–H1c) and their relations with math-related adult career attainment at Time 4 (H2a–H2d). Variables assessed at Time 1 (gender, age cohort, parental level of education, students' cognitive ability, and teacher-rated math aptitude) were included as covariates in all analyses. Separate analyses were first conducted for each of the expectancy–value beliefs (self-concept of ability in Model A1, math utility in Model A2, and intrinsic interest in Model A3), and all three constructs were then included in one model to study their combined effects (Model A4). Potential direct and indirect predictive effects of academic motivations (H2a–H2c) and career plans (H2d) on career attainment were also examined in these models. Furthermore, analyses of direct and indirect effects were conducted to examine whether gender may predict career attainment directly or indirectly via its links to adolescents' expectancy–value beliefs and career plans reported in high school (see H3a–H3c).

The second set of analyses (Models B1–B10) focused on the additive and interactive associations between adolescents' expectancy and value beliefs reported at the end of high school (in Grade 12; Time 3) predicting math-related career attainment in adulthood (Time 4; H4a and H4b). As noted previously, Grade 12 was the only time point in high school for which data from all three cohorts were available. Models B1–B10 included the same set of variables as did Models A1–A4, except for variables assessed in Grade 9 (Time 2). Accordingly, data from all three cohorts were available for all time points in Models B1–B10, and the proportion of missing data was reduced. Different sets of variables were successively entered as predictors of math-related adult career attainment across Models B1–B10 to test their incremental predictive validity (see the Results section). The hypothesized interaction effects between adolescents' expectancy and value beliefs (H4a and H4b) were tested with the unconstrained approach described in Marsh, Wen, and Hau (2004) and in Wen, Marsh, and Hau (2010), using bootstrapping with 1,000 iterations and maximum likelihood estimation. All variables in models testing interaction terms were grand-mean-centered prior to the analyses (in Models B5, B6, B9, and B10; see the Results section). Appropriate standardized coefficients were calculated for the latent interaction effects (Wen et al., 2010). Product term indicators were computed for tests of latent interactions, using parcels as a means of matching uneven numbers of items across scales (Marsh, Wen, et al., 2004; Wen et al., 2010); product terms and parcels are reported in Appendix 2 in the online supplemental materials.

Across all tested models, significant paths and indirect effects were evaluated using 95% bias-corrected bootstrapped confidence intervals based on 1,000 iterations (Preacher & Hayes, 2008). An advantage of bootstrapping is that this approach does not rely on normal theory assumptions, which are usually violated in tests of indirect effects. Overall model fit was evaluated based on the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root-mean-square error of approximation (RMSEA), and the standardized root-mean-square residual (SRMR). Excellent fit to the data is indicated by CFI and TLI values of .95 or higher and RMSEA and SRMR values of .06 or less, whereas satisfactory fit is indicated by CFI and TLI values of about .90 or higher and RMSEA and SRMR values of .08 or less (Marsh, Hau, & Grayson, 2005). Although there are no universally accepted rules for model comparisons of measurement invariance across groups and time points, a CFI difference between two models of less than .010 and an RMSEA difference of less than .015 generally indicates negligible change in overall model fit and thus provides support for the more parsimonious of the two models (Chen, 2007; Cheung & Rensvold, 2002). Throughout the Results section, we report two-tailed statistical tests of significance and two-tailed 95% bias-corrected bootstrapped confidence intervals. However, because our hypotheses are directional, we also report results with two-tailed $p < .10$, which would be significant according to a one-tailed test (with $p < .05$). We refer to these findings as marginally significant in the context of our two-tailed analyses but note that they are significant according to one-tailed tests.

Results

The Results section includes an overview of correlational patterns for key variables of interest, as well as a discussion of Models A1–A4, of Models B1–B10, and of gender differences.

Correlational Patterns

Correlation results are displayed in Table 2. All correlational patterns are consistent with our expectations, confirming positive associations among math-related academic motivations, career aspirations, and career attainment (ps $\leq$ .017). As expected, the correlations between male gender and math-related career aspirations and attainment were also positive (ps $<$. 001). However, with only one exception (a positive correlation between math self-concept of ability in Grade 12 and being male, r = .11, p = .025), no significant gender differences in either adolescents' expectancy–value beliefs across Grades 9 and 12 (rs = .01 to .06, ps $\geq$.230) or in teacher-rated math aptitude (r = .03, p = .391) emerged, even though male students had slightly higher scores for cognitive ability than did female (r = .13, p < .001). Further information regarding correlational patterns is shown in Table 2.

Models A1–A4: Reciprocal Associations Between Adolescents' Math-Related Expectancy–Value Beliefs and Career Plans, Direct and Indirect Predictive Effects on Career Attainment, and Potential Gender Differences

Models A1–A4 tested the hypothesized reciprocal associations between adolescents' expectancy–value beliefs and career plans in Grades 9 and 12 (Times 2 and 3; H1a–H1c), the associations of these beliefs with subsequent career attainment (at Time 4; H2a–H2d), and potential gender differences (H3a–H3c). These models are illustrated in Figures 1–4 and had satisfactory fit to the data (see Table 3). The full list of estimated predictive coefficients in these models is reported in Appendix 3 of the online supplemental materials, whereas Figures 1–4 show only coefficients with p < .10 (corresponding to one-tailed p < .05). First, item loadings of corresponding constructs assessed in Grades 9 and 12 (Times 2 and 3) were fixed to be the same to ensure measurement invariance across time; fixing these factor loadings led to negligible change in overall model fit relative to a model with freely estimated factor loadings (ΔCFIs $\leq$ .001, ΔRMSEAs $\leq$ .001; see Table 3). Second, error variances of corresponding items assessed in Grades 9 and 12 were allowed to covary, which accounts for item-specific shared variance across time points. Third, the error variance for one of the two indicators of math-related career attainment—the required level of math skill for each occupation—was estimated to be very close to zero and had negative values in some of our models. This error variance was therefore fixed at zero in all models, whereas the error variance of the second indicator—the importance of math skills for each occupation—was freely estimated. These two indicators were highly correlated (r = .91, p < .001), which might explain the low amount of estimated unique residual variance. Fourth, we allowed the error variances between two items assessing math utility to be correlated (the items had similar wording referencing the usefulness of math). All of our findings were replicated with and without estimating these residual covariances, but estimating them led to improved model fit in Models A2 and A4. Finally, the predictive effects of Cohort 3 on Grade 9 variables (Time 2) were fixed at zero, because no data were available for Cohort 3 at that time point, but we replicated our findings with and without this constraint. Overall, these models explained between 58%–59% of the variance in Grade 12 math self-concept of ability, 36%–40% of the variance in Grade 12 math utility, 54%–56% of the variance in Grade 12 math interest, 42%–44% of the variance in Grade 12 math- or science-related career plans, and 22%–24% of the variance in math-related career attainment (see Figures 1–4, Models A1–A4).

Reciprocal associations between adolescents' expectancy–value beliefs and career plans in Grades 9 and 12 (Times 2 and 3). Autoregressive paths estimated in Models A1–A3 (see Figures 1–3) indicated moderate to high stability for math self-concept of ability (β = .60, b = .69, 95% bootstrapped CI [.52, .83], p < .001 in Model A1), math utility (β = .48, b = .60, [.39, .82], p < .001 in Model A2), intrinsic interest in math (β = .68, b = .70, [.58, .82], p < .001 in Model A3), and math- or science-related career plans (βs = .47 to .49, ps < .001 in Models A1–A3). The performed cross-lagged analyses supported the hypothesized reciprocal predictive effects between adolescents' math-related expectancy–value beliefs and career plans reported in

Model A1.

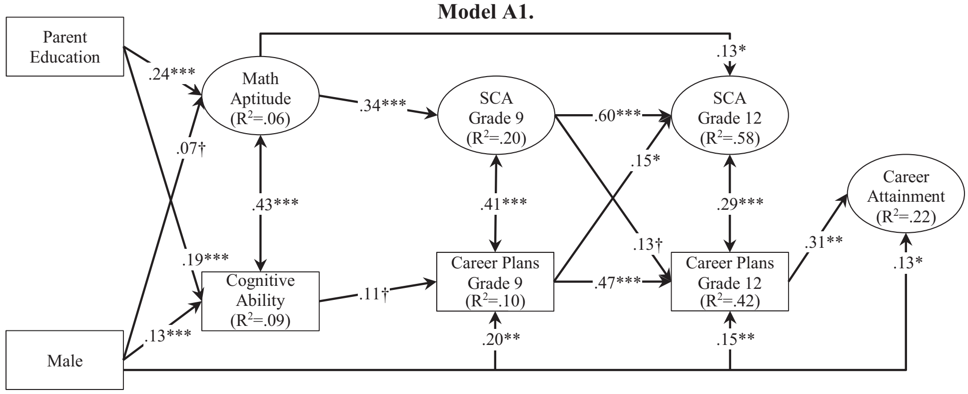

Figure 1. Reciprocal relations between math-related self-concept of ability (SCA) and career plans and long-term predictive effects on math-related career attainment. Cohort was also included as a control variable, but for the sake of clarity, it is not shown; only paths with $p < .10$ are shown. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. $^{\dagger}p < .10$. (All ps are two-tailed.)

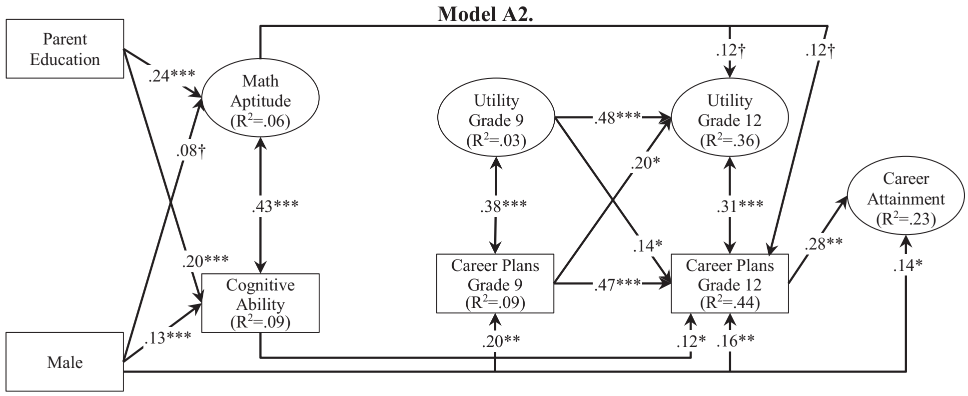

Figure 2. Reciprocal relations between perceived math utility and math-related career plans and long-term predictive effects on math-related career attainment. Cohort was also included as a control variable, but for the sake of clarity, it is not shown; only paths with $p < .10$ are shown. * $p < .05$. ** $p < .01$. *** $p < .001$. † $p < .10$. (All *p*s are two-tailed.)

Grades 9 and 12 for math self-concept of ability (H1a; see Figure 1, Model A1) and for math utility (H1b; see Figure 2, Model A2) but failed to support them for intrinsic interest in math (H1c; see Figure 3, Model A3). According to Model A1 analyses (see Figure 1), adolescents' self-concept of math ability at the beginning of high school had a marginally significant (according to the two-tailed level and significant according to the one-tailed level) positive cross-lagged effect on the perceived likelihood of pursuing a math- or science-related career at the end of high school (see the cross-lagged effect of Grade 9 self-concept on Grade 12 career plans in Figure 1, Model A1: $\beta = .13$, $b = .23$, [.00, .49], $p = .066$). In addition, as expected, the perceived likelihood of pursuing a math- or science-related career at the beginning of high school predicted significant positive change in adolescents' views about their math abilities at the end of high school (see the cross-lagged effect of Grade 9 career plans on Grade 12 self-concept in Figure 1, Model A1: $\beta = .15$, $b = .10$, [.01, .20], $p = .042$). These findings are consistent with H1a (see Figure 1, Model A1).

Our findings for math utility were analogous (H1b). According to Model A2 (see Figure 2), math utility at the beginning of high school predicted positive change in the perceived likelihood of pursuing a math- or science-related career at the end of high school (see the cross-lagged effect of Grade 9 utility on Grade 12 career plans in Figure 2, Model A2: $\beta = .14$, $b = .35$, 95% bootstrapped CI [.03,0.66], $p = .027$). In addition, as expected, the perceived likelihood of pursuing a math- or science-related career at the beginning of high school predicted positive change in adolescents' perceived usefulness and importance of math at the end of high school (see the cross-lagged effect of Grade 9 career plans on Grade 12 math utility in Figure 2, Model A2: $\beta = .20$, $b = .11$, [.03, .19], $p = .014$). These findings are consistent with H1b.

However, neither the cross-lagged predictive effect of Grade 9 math interest on Grade 12 math- or science-related career plans ($\beta = .10$, $b = .16$, 95% bootstrapped CI [−.02, .14], $p = .127$) nor the cross-lagged predictive effect of Grade 9 math- or science-related career plans on Grade 12 math interest reached significance in Model A3 ($\beta = .09$, $b = .06$, [−.04, .36], $p = .154$, see Figure

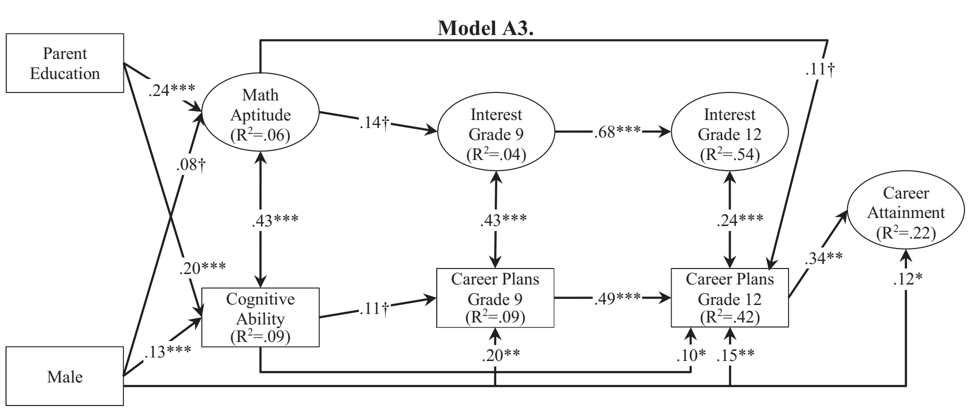

Figure 3. Reciprocal relations between intrinsic interest in math and math-related career plans and long-term predictive effects on math-related career attainment. Cohort was also included as a control variable, but for the sake of clarity, it is not shown; only paths with $p < .10$ are shown. * $p < .05$. ** $p < .01$. *** $p < .001$. † $p < .10$. (All *p*s are two-tailed.)

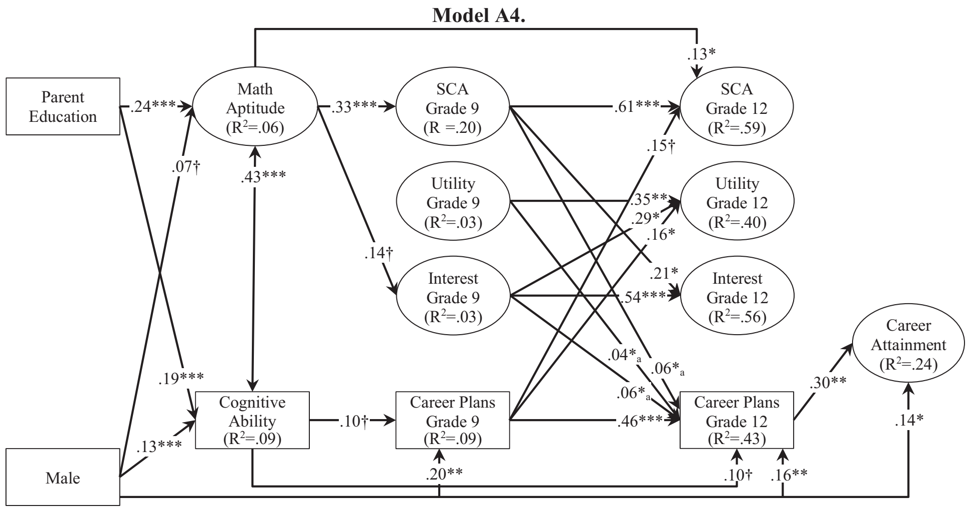

Figure 4. Reciprocal relations between math-related self-concept of ability (SCA), utility, intrinsic interest, and career plans and long-term predictive effects on math-related career attainment. Correlations between constructs assessed in Grade 9 (Time 2) and correlations between constructs assessed in Grade 12 (Time 3) were estimated but are not shown (these correlations were positive and significant [ρs = .30 to .78; *p*s ≤ .001]). The unstandardized path coefficients for Grade 9 (Time 2) math self-concept, math utility, and intrinsic interest predicting Grade 12 (Time 3) career plans were fixed to be the same. Cohort was also included as a control variable, but for the sake of clarity, it is not shown; only paths with $p < .10$ are shown. * $p < .05$. ** $p < .01$. *** $p < .001$. † $p < .10$. (All *p*s are two-tailed.)

3), failing to support H1c. Thus, initial intrinsic interest in math was not a unique significant predictor of change in career plans across the high school years, and planning to pursue a career requiring math skills at the beginning of high school was not a unique significant predictor of change in the intrinsic interest and enjoyment of math across the high school years. Nonetheless, it is worth noting that the estimated effect sizes for all three cross-lagged effects of Grade 9 expectancy–value beliefs on Grade 12 career plans across Models A1–A3 were comparable (βs = .10–.14), and that similar amounts of variance in Grade 12 career plans were explained across all three models (ranging from 42% in Models A1 and A3 to 44% in Model A2; see Figures 1–3).

When all three expectancy–value constructs were included in the same analysis in Model A4 (see Figure 4), the unique cross-lagged predictive effects of Grade 9 math- or science-related career plans on Grade 12 math self-concept of ability became marginally significant at the two-tailed level (β = .15, *b* = .10, 95% bootstrapped CI [.00, .20], *p* = .053), the cross-lagged predictive effect of Grade 9 math- or science-related career plans on Grade 12 math utility remained significant (β = .16, *b* = .09,

Table 3
Overall Fit for Models A1–A4 and Tests of Measurement Invariance for Latent Constructs Assessed in Both Grades 9 (Time 2) and 12 (Time 3)

Estimated models	χ^2	*df*	CFI	TLI	RMSEA	SRMR	ΔCFI	ΔRMSEA
Model A1								
Freely estimated parameters[a]	374.28	139	.960	.940	.042	.062		
Fixed factor loadings	380.07	143	.960	.941	.041	.063	.000	.001
Model A2								
Freely estimated parameters[a]	257.51	101	.964	.939	.040	.067		
Fixed factor loadings	260.33	104	.964	.941	.039	.068	.000	.001
Model A3								
Freely estimated parameters[a]	170.95	71	.977	.956	.038	.086		
Fixed factor loadings	177.08	73	.976	.956	.038	.086	.000	.000
Model A4								
Freely estimated parameters[a]	1,115.79	453	.936	.916	.039	.077		
Fixed factor loadings	1,129.99	462	.936	.917	.038	.078	.000	.001
Fixed factor loadings and equality constraints for Grade 9 expectancy–value predictors of Grade 12 career plans	1,130.61	464	.936	.918	.038	.078	.000	.001

Note. Fixed factor loadings refers to the factor loadings for latent constructs assessed in both Grades 9 (Time 2) and 12 (Time 3). One factor loading per latent construct was fixed at 1.0 for model identification purposes. CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual.

[.01, .17], $p = .043$), and the cross-lagged predictive effect of Grade 9 math- or science-related career plans on Grade 12 math interest remained nonsignificant ($\beta = .05$, $b = .03$, [−.06, .12], $p = .489$; see Figure 4). None of the cross-lagged effects of adolescents' expectancy–value beliefs reported in Grade 9 on their career plans reported in Grade 12 was statistically significant in Model A4 when these effects were freely estimated ($ps \geq .292$). Accordingly, none of the Grade 9 expectancy–value beliefs had significant predictive power in Model A4 when the other Grade 9 expectancy–value beliefs were also included as predictors. This finding is not surprising, considering that the estimated latent unique correlations between these three Grade 9 expectancy–value constructs in Model A4 ranged from .59 to .71 in Grade 9 (Time 2) and from .68 to .78 in Grade 12 (Time 3). Following recommendations by Marsh, Dowson, Pietsch, and Walker (2004) for dealing with multicollinearity in the presence of highly interrelated predictors, we fixed the predictive cross-lagged effects of the three Grade 9 expectancy–value constructs on Grade 12 career plans to be the same (see Figure 4). This equality constraint led to negligible change in model fit (ΔCFI < .001 and ΔRMSEA < .001; see Table 3) and indicated that the set of Grade 9 expectancy–value beliefs had a small but significant positive cross-lagged predictive effect on Grade 12 career plans (βs = .04 to .06, $b = .10$, [.02, .19], $p = .031$; see Figure 4, Model A4). Compared to a model in which these three model parameters were freely estimated, a model in which they were fixed to be the same produced more precise confidence intervals (between 78% and 83% reduction in the width of the bootstrapped 95% CI for these three path coefficients) at the expense of about .6% reduction in the amount of explained variance in Grade 12 career plans (44% vs. 43% explained variance Figure 4, Model A4). A model in which these paths are freely estimated is shown in Appendix 4 of the online supplemental materials. In sum, H1a and H1b regarding the reciprocal links between math self-concept and career plans and math utility and career plans were supported across Models A1–A4, whereas H1c regarding such reciprocal links between intrinsic interest and career plans was not.

We note that in addition to our stated hypotheses, two additional cross-lagged effects emerged in the Model A4 analyses (see Figure 4). Specifically, adolescents' initial self-concept of math ability reported in Grade 9 predicted subsequent change in adolescents' intrinsic interest in math reported in Grade 12 ($\beta = .21$, $b = .23$, 95% bootstrapped CI [.01, .47], $p = .038$), and initial intrinsic interest in math reported in Grade 9 predicted subsequent change in the perceived usefulness and importance of math reported in Grade 12 ($\beta = .29$, $b = .24$, [.04, .48], $p = .024$; see Figure 4). These associations suggest that adolescents' perceived math ability can positively affect subsequent interest in and enjoyment of math and that intrinsic interest in math could be one of the reasons why adolescents perceive math as useful and important.

Links between adolescents' math-related expectancy–value beliefs and career plans and subsequent career attainment in Models A1–A4. All three of the expectancy–value constructs assessed at the beginning and at the end of high school (Times 2 and 3) were significantly correlated with math-related career attainment (Time 4; $rs = .19$ to .28; $ps \leq .017$, Table 2), consistent with H2a–H2c, but did not have significant direct predictive effects when career plans at the end of high school were also included as a predictor (see Figures 1–4, Models A1–A4). Across all tested models, Models A1–A4 in Figures 1–4, math-related career attainment in adulthood was significantly predicted only by career plans in Grade 12 (in support of H2d) and by gender (direct effect of Grade 12 career plans on career attainment in Figure 4, Model A4: $\beta = .30$, $b = 1.63$, 95% bootstrapped CI [.50, 2.84], $p = .007$, and of gender on career attainment: $\beta = .14$, $b = 3.45$, [.20, 6.31], $p = .026$; see also Figures 1–3 for Models A1–A3), and none of the Grade 9 constructs had a significant direct predictive effect on math-related career attainment ($ps \geq .246$ in Figures 1–4, Models A1–A4).

However, our analyses supported significant indirect effects of Grade 9 (Time 2) constructs on math-related career attainment (Time 4), which we present in Table 4. As shown in Table 4, our analyses revealed a significant positive indirect effect of Grade 9 career plans on math-related career attainment, via its positive association with Grade 12 career plans (βs = .13 to .16; bs = .78 to .95; lower bounds of 95% bootstrapped CI ≥ .23 across Models A1–A4; see Table 4). In addition, the analyses indicate that math self-concept, math utility, and career plans reported at the beginning of high school (Grade 9; Time 2) indirectly positively predicted having a math-related occupation as an adult via their positive associations with math- or science-related career plans at the end of high school (Grade 12; Time 3), although these indirect effects were very small when we controlled for Time 1 covariates and for Grade 9 (Time 2) career plans (βs = .02 to .04; bs = .16 to .53; lower bounds of 95% bootstrapped CI ≥ .02 across Models A1–A4; see Table 4). In sum, although math-related career attainment was positively correlated with students' math-related expectancy–value beliefs in Grades 9 and 12 (supporting H2a–H2c) and with career plans in Grades 9 and 12 (supporting H2d), Grade 12 career plans and gender emerged as the strongest predictors of career attainment in our analyses, whereas adolescents' expectancy–value beliefs had only small indirect predictive effects (Models A1–A4).

Gender differences in Models A1–A4. Gender differences in students' math-related motivations (H3a), career plans (H3b), and adult career attainment (H3c) were examined via bivariate correlations and in the context of our Models A1–A4. As noted previously, analyses of bivariate correlations indicated a weak positive association between gender and Grade 12 self-concept of ability favoring male students but no other significant correlations with academic motivations emerged (see Table 2). Accordingly, with the exception of Grade 12 self-concept, we found little evidence in support of H3a. In contrast, H3b and H3c, regarding the positive associations between being male and aspirations toward as well as attainment of math-related careers, were supported across all of our analyses (see the correlational patterns in Table 2, as well as Figures 1–4, Models A1–A4).

Focusing on our final model, Model A4 (see Figure 4), we further examined the direct and indirect associations between gender and math-related career attainment (see H3c). Two-group analyses provided no evidence of gender-specific differences in Models A1–A4 when we compared the overall model fit of models in which all factor loadings and predictive paths were fixed to be the same across gender with models in which these parameters were freely estimated (ΔCFIs ≤ .002, ΔRMSEAs < .001; see Appendix 5 in the online supplemental materials). However, we had insufficient statistical power to adequately examine our mod-

Table 4
Specific Indirect Predictive Effects in Models A1–A4 on Math-Related Career Attainment (Time 4)

Model and effect	β	*b*	95% bias-corrected bootstrapped CI Lower 2.5%	95% bias-corrected bootstrapped CI Upper 2.5%	90% bias-corrected bootstrapped CI Lower 5%	90% bias-corrected bootstrapped CI Upper 5%
Model A1						
Career plans in Gr. 9 → Career plans in Gr.12 → Career attainment	.15*	.85	.36	1.68	.44	1.55
Self-concept in Gr. 9 → Career plans in Gr.12 → Career attainment	.04*	.39	.02	1.10	.07	.96
Male → Career plans in Gr.12 → Career attainment	.05*	1.20	.39	2.51	.52	2.37
Male → Career plans in Gr. 9 → Career plans in Gr.12 → Career attainment	.03*	.73	.24	1.85	.31	1.59
Male → Self-Concept in Gr. 9 → Career plans in Gr.12 → Career attainment	.00	.04	−.03	.30	−.01	.27
Model A2						
Career plans in Gr. 9 → Career plans in Gr.12 → Career attainment	.13*	.78	.23	1.52	.31	1.39
Utility in Gr. 9 → Career plans in Gr.12 → Career attainment	.04*	.53	.08	1.43	.15	1.25
Male → Career plans in Gr.12 → Career attainment	.05*	1.13	.33	2.58	.45	2.30
Male → Career plans in Gr. 9 → Career plans in Gr.12 → Career attainment	.03*	.69	.18	1.71	.27	1.53
Male → Utility in Gr. 9 → Career plans in Gr.12 → Career attainment	.00	−.02	−.25	.09	−.19	.07
Model A3						
Career plans in Gr. 9 → Career plans in Gr.12 → Career attainment	.16*	.95	.42	1.80	.50	1.63
Interest in Gr. 9 → Career plans in Gr.12 → Career attainment	.03†	.29	−.03	.83	.01	.74
Male → Career plans in Gr.12 → Career attainment	.05*	1.27	.38	2.72	.53	2.48
Male → Career plans in Gr. 9 → Career plans in Gr.12 → Career attainment	.03*	.82	.27	1.94	.37	1.78
Male → Interest in Gr. 9 → Career plans in Gr.12 → Career attainment	.00	.01	−.08	.16	−.05	.13
Model A4						
Career plans in Gr. 9 → Career plans in Gr.12 → Career attainment	.14*	.81	.28	1.67	.38	1.49
Self-Concept in Gr. 9 → Career plans in Gr.12 → Career attainment	.02*	.16[a]	.02	.42	.04	.37
Utility in Gr. 9 → Career plans in Gr.12 → Career attainment	.01*	.16[a]	.02	.42	.04	.37
Interest in Gr. 9 → Career plans in Gr.12 → Career attainment	.02*	.16[a]	.02	.42	.04	.37
Male → Career plans in Gr.12 → Career attainment	.05*	1.18	.37	2.67	.48	2.47
Male → Career plans in Gr. 9 → Career plans in Gr.12 → Career attainment	.03*	.71	.22	1.92	.29	1.60
Male → Self-Concept in Gr. 9 → Career plans in Gr.12 → Career attainment	.00	.02	−.02	.11	−.01	.09
Male → Utility in Gr. 9 → Career plans in Gr.12 → Career attainment	.00	.00	−.08	.03	−.06	.02
Male → Interest in Gr. 9 → Career plans in Gr.12 → Career attainment	.00	.01	−.04	.09	−.03	.07

Note. All remaining indirect effects not shown in this table had $\beta < .01$ and/or both 95% CIs and 90% CIs that included 0. CI = confidence interval; Gr. = grade. Unstandardized coefficients were fixed to be the same.
† Lower bound of 90% bootstrapped CI > 0, corresponding to a one-tailed $p < .05$. * 95% bootstrapped CI did not include 0, corresponding to a two-tailed $p < .05$.

els within each subgroup (e.g., the ratio of male participants who had data in Grade 9 to the number of freely estimated parameters in Models A1–A4 ranged from .64 to 1.31, which is clearly insufficient for group-specific analyses). Accordingly, we limit the present discussion to the direct and indirect predictive effects of gender.

Analyses of indirect effects presented in Table 4 suggested that, in addition to the significant positive direct effect of being male on math-related career attainment (Figure 4, Model A4: $\beta = .14$, $b = 3.45$, 95% bootstrapped CI [.20, 6.31], $p = .026$), gender also had significant indirect effects mediated via adolescents' math- or science-related career plans. Male participants were more likely to consider pursuing a math- or science-related career during adolescence and subsequently also more likely to actually have such careers as adults (the indirect predictive effect of gender on math-related career attainment mediated via Grade 12 career plans was $\beta = .05$, $b = 1.18$, and the indirect predictive effect of gender on math-related career attainment mediated via Grade 9 and Grade 12 career plans was $\beta = .03$, $b = .71$, lower bounds of 95% bootstrapped CI $b \geq .22$; see Table 4). By contrast, the estimated indirect effects of gender via any of the Grade 9 or Grade 12 expectancy–value constructs approximated zero and were not significant, with both the 95% CI and the 90% CI including zero. Gender differences in adolescents' math- or science-related career plans and math-related career attainment persisted even in the absence of differences in math-related motivations reported in high school. As expected, male participants were more likely to pursue and to attain math-related occupations than were female (in support of H3b and H3c, respectively), but we found little evidence of systematic motivational differences regarding math as an academic subject (contrary to H3a).

Models B1–B10: Additive and Multiplicative Predictive Effects of Grade 12 Expectancy–Value Beliefs (Time 3) on Math-Related Career Attainment (Time 4)

Models B1–B10 examined both additive and multiplicative associations between adolescents' expectancy–value beliefs about math (reported in Grade 12; Time 3) in predicting math-related career attainment (reported in adulthood; Time 4) and thus focus on H4a and H4b. These analyses excluded Grade 9 data (Time 2) in order to reduce the ratio of missing data and to avoid potential problems with multicollinearity due to the high correlations between corresponding Grade 9 and Grade 12 constructs but include all other variables from Models A1–A4. As shown in Table 5, all models had satisfactory fit to the data. Model constraints and specifications were analogous to those in Models A1–A4.

Table 5
Standardized Path Coefficients for Predictors of Math-Related Career Attainment in Models B1–B10

Predictor	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
Male	.21***	.20***	.21***	.21***	.20***	.12*	.21***	.21***	.20***	.12*
Parent education	.02	.00	.02	.02	.01	.00	.02	.01	.00	−.01
Cohort 2	.11†	.08	.10†	.09	.09	.09	.09	.08	.09	.10
Cohort 3	.14*	.12†	.13*	.12†	.12†	.08	.12†	.11†	.10	.08
Cognitive ability	.08	.05	.08	.07	.05	.02	.07	.05	.02	−.01
Math aptitude	.14†	.08	.10	.09	.08	.07	.12	.09	.07	.06
Gr. 12 self-concept		.19**		.06	.13	.01		.15	.31*	.14
Gr. 12 utility			.21**	.17†	.12	.05				
Gr. 12 Self-Concept × Utility					.13†	.12†				
Gr. 12 interest							.15**	.05	−.08	−.10
Gr. 12 Self-Concept × Interest									.19*	.17*
Gr. 12 career plans						.34***				.35***
R^2	.10	.13	.14	.14	.15	.23	.12	.13	.16	.23
$\chi^2(df)$	59.02 (12)	232.85 (55)	132.17 (42)	402.64 (104)	530.56 (169)	549.20 (181)	128.80 (32)	417.68 (89)	551.28 (131)	564.16 (141)
CFI/TLI	.981/.942	.960/.934	.974/.952	.948/.923	.943/.923	.944/.922	.972/.942	.944/.914	.935/.906	.937/.906
RMSEA	.063	.057	.047	.054	.047	.046	.056	.061	.057	.055
SRMR	.019	.030	.031	.037	.038	.037	.027	.036	.037	.036

Note. The outcome measure is math-related adult career attainment (Time 4). Standardized coefficients for interaction terms are computed based on appropriate standardization procedures, as described in Wen et al. (2010). Gr. 12 = Grade 12 in high school (Time 3); CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual.
† $p < .10$. (All *p*s are two-sided.) * $p < .05$. ** $p < .01$.

When all Time 1 covariates were included in Model B1 (see Table 5), the following variables emerged as significant or marginally significant predictors of math-related career attainment: being male (β = .21, *b* = 5.26, 95% bootstrapped CI [2.67, 7.89], *p* < .001), age cohort (the two older cohorts, Cohort 2 and Cohort 3, had slightly higher values than did the younger Cohort 1: β = .11, *b* = 3.06, [−.40, 5.90], *p* = .057, for Cohort 2, and β = .14, *b* = 3.66, [.50, 6.81], *p* = .028, for Cohort 3), and teacher-rated math aptitude (β = .14, *b* = 1.55, [.08, 3.45], *p* = .072). Collectively, these covariates explained about 10% of the variance in math-related careers and were included in all subsequent analyses. Models B2, B3, and B7 (see Table 5) suggested that, controlling for the Time 1 covariates, the individual predictive effects of math self-concept of ability (Model B2: β = .19, *b* = 1.57, [.50, 2.66], *p* = .007), math utility (Model B3: β = .21, *b* = 2.56, [.97, 3.82], *p* = .002), and math interest (Model B7: β = .15, *b* = 1.25, [.34, 2.18], *p* = .009) on math-related career attainment were positive and significant. Analyses of the additive effects of math self-concept and perceived utility (Model B4) and math self-concept and intrinsic interest (Model B8) revealed that neither of these constructs was a significant predictor of math-related careers when accounting for the other. Given the high correlations among these constructs, it is worth noting that the effect of math utility, when controlling for math self-concept, was significant at the one-tailed level in Model B4 (β = .17, *b* = 1.86, [−.20, 4.03], *p* = .080).

Furthermore, models including interaction effects revealed a marginally significant interaction between math self-concept and perceived math utility in predicting math-related careers (Self-Concept × Perceived Math Utility interaction in Model B5: β = .13, *b* = .79, 95% bootstrapped CI [−.05, 1.70], *p* = .067) and a significant interaction between math self-concept and intrinsic interest in math (Self-Concept × Interest interaction in Model B9: β = .19, *b* = .90, [.19, 1.61], *p* = .011). These interaction effects remained significant (and marginally significant for utility) even after controlling for Grade 12 career plans (Math Self-Concept × Perceived Math Utility interaction in Model B6: β = .12, *b* = .72, [−.09, 1.55], *p* = .090, and Math Self-Concept × Math Interest interaction in Model B10: β = .17, *b* = .79, [.11, 1.46], *p* = .023). These analyses support H4a (marginally significant Math Self-Concept × Perceived Math Utility interaction) and H4b (significant Math Self-Concept × Intrinsic Interest interaction).

The significant interaction between math self-concept and math interest is illustrated in Figure 5. As hypothesized, the predictive power of each construct was dependent on the other. Math self-concept was a significant predictor of math-related careers at average and high levels (1 *SD* above the mean) of intrinsic interest in math but not at low levels of interest (1 *SD* below the mean). Simple slope analyses with latent variables indicated that the corresponding path coefficients for the main effect of math self-concept on math-related career attainment at low, average, and high levels of intrinsic interest were β = .12, *b* = .96, 95% bootstrapped CI [−.95, 3.00], *p* = .329, at low interest; β = .31, *b* = 2.56, [.15, 5.04], *p* = .037, at average interest; and β = .50, *b* = 4.15, [.69, 7.42], *p* = .014, at high interest (see Figure 5, Model B9). Math self-concept did not predict going into a math-related career at low levels of intrinsic interest in math itself.

The unique associations of math-related career attainment with math interest were generally weaker than its unique associations with math self-concept of ability. Math interest was a significant positive predictor of career attainment only at very high levels of math self-concept of ability (e.g., main effect of math interest when math self-concept is centered at 2 *SD* above the mean in Model B9: β = .31, *b* = 2.18, 95% bootstrapped CI [.04, 4.03], *p* = .028) but not at lower levels (e.g., main effect of math interest when math self-concept is centered at 1 *SD* above the mean in Model B9: β = .12, *b* = .82, [−.69, 2.19], *p* = .264, and the main effect of math interest at average levels of math self-concept in Model B9: β = −.08, *b* = −.54, [−2.25, 1.06], *p* = .506). Furthermore, at low levels of math self-concept, interest in math was actually inversely related to the probability of going into a math-related career, although this effect reached significance only at very low levels of math self-concept (e.g., main effect

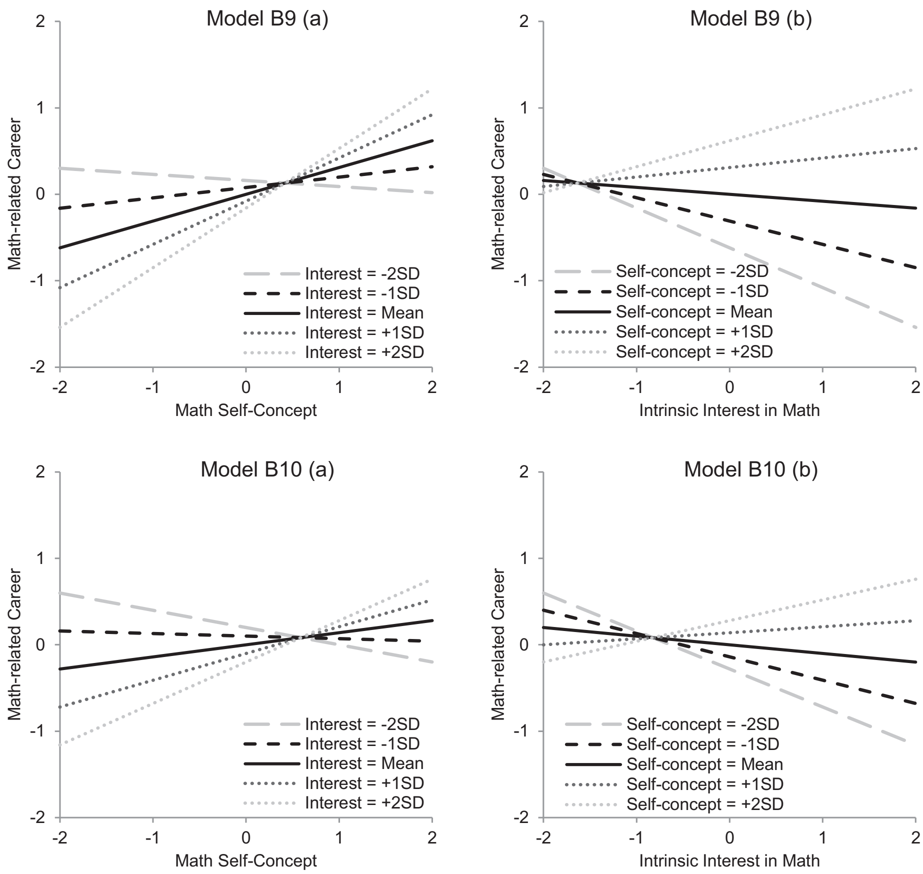

Figure 5. Interaction effects between math ability self-concept and math interest predicting having a math-related career as an adult in Models B9 and B10. Model B10 included career plans as a predictor of math-related career attainment, whereas Model B9 did not. The predictive effects of math self-concept on math-related career attainment at different levels of intrinsic interest (Panels a) and of intrinsic interest on math-related career attainment at different levels of math self-concept (Panels b) are shown. All variables are standardized.

of math interest when math self-concept is centered at 2 *SD* below the mean in Model B9: $\beta = -.46$, $b = -3.27$, $[-6.43, -.05]$, $p = .045$).

The interaction effect between math self-concept and math interest remained significant, even when math- or science-related career plans were included as a predictor of math-related career attainment in Model B10 ($\beta = .17$, $b = .79$, 95% bootstrapped CI [.11, 1.46], $p = .023$; see Table 5), but the predictive power of math self-concept of ability at different levels of intrinsic interest was substantially reduced. Specifically, the main effect of math self-concept on math-related career attainment became marginally significant even at very high levels of math interest (the main effect of math self-concept when math interest is centered at 2 *SD* above the mean in Model B10 was $\beta = .47$, $b = 3.93$, $[-.67, 8.65]$, $p = .087$; see Figure 5). The identified predictive effects of intrinsic interest on career attainment at very high and very low levels of math self-concept in Model B9 also became marginally significant in Model B10 (main effect of intrinsic interest on math-related career attainment when self-concept is centered at 2 *SD* above the mean was $\beta = .24$, $b = 1.67$, $[-.25, 3.43]$, $p = .079$, and main effect of intrinsic interest on math-related career attainment when self-concept is centered at 2 *SD* below the mean was $\beta = -.43$, $b = -3.04$, $[-6.52, .33]$, $p = .068$).

Expectancy and subjective task value beliefs about math each explained between 2% and 4% additional variance in math-related career attainment, beyond the effects of gender, cohort, parental education, teacher-rated math aptitude, and students' cognitive ability assessed in elementary school. The Expectancy × Value interaction term explained about 3% additional variance, and career plans another 7%. Overall, these predictors explained about 23% of the total variance in math-related career attainment.

We examined the potential moderating role of gender for our most complex models, Models B5–B6 and Models B9–B10, in two-group analyses. All variables were group-mean-centered prior to the analyses (for male and female participants). Across all four models, fixing all factor loadings and predictive paths to be the same across gender led to negligible change in overall model fit compared to models in which these parameters were freely estimated, although caveats about insufficient sample size for such multigroup analyses apply (ΔCFI $< .002$, ΔRMSEA $< .004$; see Appendix 5 in the online supplemental materials). The direct predictive effect of gender on math-related career attainment remained significant across all analyses in Models B1–B10 but was substantially reduced when math- or science-related career plans were included as a predictor in Models B6 and B10 (see Table 5). Controlling for all Time 1 covariates and for math-related expectancy–value beliefs reported in high school (Time 3), our analyses suggest that male participants were significantly more likely than female participants to pursue math- or science-related careers in adolescence (Time 3) and to have math-related careers in adulthood (Time 4).

Supplemental analyses. A set of additional analyses was conducted to test the robustness of our results reported in the previous sections. First, as noted previously, we replicated our main results regarding cross-lagged effects, interaction effects, and significant or marginally significant predictors of career attainment with subsets of our full sample, for which we had smaller proportions of missing data (see Appendix 6 of the online supplemental materials). Second, of particular relevance for our analyses is the fact that high school achievement data are available in CAB, but due to the amount of missing information for these variables, they could not be included in our main analyses. Nevertheless, we describe and report these data in the online supplemental materials (see Appendix 7).

Discussion

The present study focused on the ontogeny and underlying developmental processes of math-related career aspirations and choices within Eccles et al.'s (1983) expectancy–value theory and examined two aspects of this theoretical framework in a longitudinal sample of predominantly White middle class midwestern Americans: (a) the reciprocal links between adolescents' math-related expectancy–value beliefs and career plans and (b) the multiplicative associations between expectancy and subjective task value beliefs in predicting occupational outcomes in the math domain. Possible gender differences in beliefs about math as an academic subject, in preferences for math- or science-related careers during adolescence, and in math-related career attainment approximately fifteen years after graduation from high school were also examined.

First, with the exception of intrinsic interest in math, our analyses confirmed the predicted reciprocal links between adolescents' expectancy–value beliefs about math, and their math- or science-related career plans reported at the beginning and end of high school. Thus, our data suggest that math- or science-related career plans should not be conceptualized only as a consequence of expectancy and subjective task value beliefs but also as a potential antecedent. Whether the same degree of reciprocity is true for other careers is not known. Given the importance of career choices and trajectories for all aspects of human development, understanding these reciprocal developmental pathways is an important task for developmental psychologists for the foreseeable future.

Second, our data confirmed multiplicative associations between adolescents' expectancy and subjective task value beliefs in predicting actual adult careers related to math. Accordingly, it is important to consider both of these academic beliefs in analyses of adolescents' career choices as well as in the design of interventions, because the effects of each of these constructs on subsequent career attainment depend on the other.

In addition, on a more general level, our findings document the predictive power of ninth-grade math-related career plans on the ontogeny of White middle-class Americans' math-related career development and trajectories. The strongest predictor in our models of adult math-related career attainment is 12th grade math- or science-related career plans, which, in turn, is most strongly predicted by ninth-grade math- or science-related career plans. Other research focusing on the longitudinal links between adolescents' motivations, career aspirations, and career attainment has been limited to analyses of the predictors of the prestige of individuals' occupational aspirations and choices and has not focused on specific occupations (e.g., Guo, Marsh, Morin, et al., 2015; Schoon & Polek, 2011) or has examined the links between STEM-related motivations and career attainment but not the predictive effects of career aspirations (e.g., Ing & Nylund-Gibson, 2013). In addition, few prospective longitudinal studies linking specific career aspirations with career attainment exist to date (e.g., Schoon, 2001). Understanding the interrelations between domain-specific academic motivations, career aspirations, and career outcomes is critical for understanding the ontogeny of career pathways in American culture. Our findings suggest that early career aspirations in STEM-related fields are key predictors of subsequent math-related motivational beliefs, career aspirations, and occupational choices.

Finally, consistent with prior evidence, we confirmed systematic gender differences in adolescents' preferences for math- or science-related careers and subsequent math-related career attainment that could not be explained entirely by differences in adolescents' motivations about math as an academic subject or by early differences in math aptitude. Thus, converging evidence indicates that understanding gendered educational and occupational choices related to math requires analyses not only of adolescents' expected success in and subjective valuing of math as an academic subject but also of their expected success in and the subjective valuing of math-related occupations compared to other occupational options. In addition, given the predictive power of gender in explaining actual math-related career participation in adulthood, even when we controlled for such factors as students' cognitive ability, math aptitude, and math-related expectancy–value beliefs, our results suggest that more work is needed to fully understand the major influences on both individual and group differences in math-related career trajectories. We discuss our main findings in greater detail in the following sections.

Reciprocal Associations Between Math-Related Expectancy–Value Beliefs and Career Plans, and Implications for Math-Related Career Attainment

Our analyses confirmed the predicted positive reciprocal influences between math- or science-related career plans and math ability self-concept, as well as between math- or science-related career plans and perceived math utility during adolescence. These results point to the importance of studying the early developmental processes associated with the ontogeny of adolescents' and young adults' career choices. In addition, if a societal goal is to increase the number of adolescents who seek out math-intensive careers, our results point to the importance of early interventions aimed at changing both fundamental motivational beliefs such as domain-specific ability self-concepts and values and early career aspirations. Evidence that one can influence mid to late adolescents' perceptions of the utility value of taking math and science courses has been accumulating. For example, as Hulleman, Harackiewicz, and their colleagues have shown, interventions designed to increase the perceived utility value of STEM-related content in high school can produce increases in performance and involvement in STEM courses (Harackiewicz et al., 2012; Hulleman, Godes, Hendricks, & Harackiewicz, 2010). How early such interventions might be effective is unknown and should be investigated.

Our findings also suggest that early interventions designed to increase the attractiveness and knowledge about potential math-related careers might increase early adolescents' math ability self-concepts and the subjective task value they attach to doing well in this domain, both of which, in turn, can further increase students' aspirations to enter math-related careers. Evidence that this is possible has been emerging. For example, Harackiewicz and colleagues (2012) have shown the effectiveness of an intervention aimed at increasing parents' knowledge about potential STEM careers so that they can better guide their children's high school course choices and thus contribute toward increasing the number of STEM courses taken by their children. This alternative route from career aspirations to subsequent motivations is important to consider, given the emphasis in career counseling on (a) identifying occupational options that match presumably traitlike characteristics of the individual, such as identified abilities and interests, or (b) increasing individual self-efficacy beliefs so that they match identified occupational interests (for a review, see Brown, 2002). Our results suggest that it is equally sensible to (a) increase the range of careers middle childhood and early adolescent students know about and consider as they generate their career aspirations and (b) point out the utility value of math and science for this wider range of potential careers.

In contrast, we did not find evidence of significant reciprocal links between math- or science-related career plans and adolescents' intrinsic interest in math. These results are consistent with the theoretical assumptions of EVT (Eccles et al., 1983), according to which aspirations for particular math-related careers are assumed to increase the perceived utility of math but not necessarily intrinsic interest in math itself. Accordingly, a focus on the relevance of math for future career prospects may be insufficient for increasing intrinsic interest in and enjoyment of math as an academic subject or may produce only small effects (see, however, Gaspard, Dicke, Flunger, Brisson, et al., 2015, for an intervention that successfully increased intrinsic interest in math, in addition to utility value).

Multiplicative Associations Between Expectancy and Subjective Task Value Beliefs in Predicting Math-Related Career Attainment

Our analyses of multiplicative associations provide a more nuanced perspective on the importance of intrinsic interest in math, showing that intrinsic interest moderates the links between perceived math ability and math-related career attainment and vice versa. Our findings for the moderating role of math utility were analogous but less strong. This interactive association indicates a noncompensatory relationship between self-concept and interest, such that perceived ability in math cannot compensate for lack of intrinsic interest in predicting career choices. Indeed, the associations between math self-concept of ability and math-related career attainment were not significant at low levels of intrinsic interest in math.

The associations between math interest and math-related career attainment were more complex in that interest significantly predicted career attainment only at very high levels of math ability self-concept, and there was a negative association at very low levels of math self-concept. Accordingly, the coupling of very low perceived ability with at least some valuing of mathematics could trigger avoidance behaviors and may further reduce the likelihood of pursuing a career for which math skills are important. This finding is consistent with experimental research according to which the combination of high value but low expected success in achievement-related tasks was associated with decreased performance and motivation (Durik et al., 2015). Similarly, a field study by Rozek et al. (2015) found that an intervention designed to increase adolescents' subjective valuing of math and science failed to produce the hypothesized positive effects on involvement in STEM for low-achieving girls (with a tendency toward a negative effect), despite its positive effects for low-achieving boys and high-achieving girls (no significant effect was found for high-achieving boys, likely due to ceiling effects). The authors proposed that self-concept of ability and expected success in STEM could contribute to the observed gender differences. Low-achieving girls might be less likely than low-achieving boys to be optimistic about their competence in STEM and their potential to learn, so that the implemented utility value intervention could have increased the subjective desirability of an outcome that they perceive as potentially unattainable. A field study by Gaspard, Dicke, Flunger, Brisson, et al. (2015) that not only included a manipulation of the subjective valuing of mathematics but also focused on students' expected success in mathematics demonstrated positive effects on the subjective valuing of mathematics as an academic domain for both boys and girls, with somewhat stronger effects for girls. Although the treatment designs in Rozek et al.'s and Gaspard et al.'s research are not directly comparable, their findings clearly indicate a need to consider both the value and the expectancy components of the expectancy–value framework in future intervention research. Collectively, these studies highlight the conceptual and practical significance of the expectancy–value interaction. The present study further suggests that the significance of this interaction extends beyond a focus on high school outcomes and career preferences and has the potential to impact long-term career outcomes in the math domain.

Gender Differences in Math-Related Career Attainment

Consistent with earlier evidence (Eccles, 2005; National Science Foundation, 2013; Watt et al., 2012), analyses in the present study revealed systematic gender differences in preferences for and attainment of math-intensive careers. These differences existed despite the fact that female and male participants in our sample rated their math abilities similarly and valued math to the same degree. Previous analyses of the CAB data have suggested that even though a gender gap in math-related self-perceptions of ability existed in elementary school, this gap closed by the end of high school (Jacobs et al., 2002). Yet, a gap in math-related career preferences persisted throughout adolescence (e.g., Lauermann et al., 2015; Watt et al., 2012) and into adulthood. Much more needs to be known about the other factors mediating the continued gender difference in these individuals' selection of math-intensive STEM fields. Overall, our findings, together with those of prior research, suggest that intervention efforts focusing solely on women's (or men's) perceptions of their math abilities may not be the most effective way to increase women's (or men's) participation in math-intensive fields. Given their reciprocal ties, a combined focus on expectancies and values not only about math but also about math-related careers would likely be a more fruitful approach toward supporting individuals' career choice than would be a focus on solely academic *or* career-related beliefs.

Limitations and Directions for Future Research

The present study suggests several important questions for future research. First, our research is limited to one region of the world and a limited number of cohorts, which included individuals who were primarily White and from middle-class backgrounds. Thus, we do not know whether these findings will generalize to other countries, other ethnic groups, or other historical periods. Conceptual and empirical work focusing on adolescents' STEM-related choices suggests that the predictive influence of the expectancy–value constructs may indeed vary as a function of students' ethnic backgrounds (Anderson & Ward, 2014; Eccles, 2005, 2009). More international, cross-ethnic, and cross-cohort work is therefore needed.

Second, our analyses were limited to the domain of mathematics and math-intensive careers. The perceived and actual competence in mathematics predict such desirable outcomes as future income (Paglin & Rufolo, 1990), university entry (Parker et al., 2012), and access to STEM-oriented careers (Wang et al., 2013), so that understanding the motivational underpinnings of adolescents' involvement in this domain is important. Nonetheless, our focus on a single domain represents a limitation because we do not have information about the generalizability of our findings to other subject areas and careers. Earlier research focusing on the additive and interactive predictive effects of adolescents' expectancy–value beliefs on career aspirations and career-related outcomes (e.g., college majors) has also been limited to the STEM domain (Guo, Parker, et al., 2015; Nagengast et al., 2011). It is possible that the associations of beliefs about specific academic subjects with career choices is stronger in math-related fields because the math that is being learned in school is quite directly linked to the types of math needed in these occupations. Such a direct link of what is being learned in specific school courses might be less clear for other professional careers that draw on more general knowledge and cognitive abilities (e.g., health and human services occupations).

Third, further research is needed for detailed analyses of the mechanisms through which career preferences may impact subsequent academic motivations. Some associations are fairly straightforward. For instance, choosing a career that requires math skills directly implies that math will be seen as useful and important for future career goals (Eccles et al., 1983), but this effect likely also depends on adolescents' awareness of the ways in which math knowledge may contribute to their future career success. Adolescents' interest in pursuing a math-related career without an awareness of the relevance of math for their career choice may not produce similar results (note that our assessment of career plans explicitly referenced the likelihood of pursuing a career in the field of math or science, such as engineering or architecture, so that the relevance of math skills was evident). Indeed, making adolescents aware of the relevance of math and science for various occupational goals is an important element of intervention research (e.g., Harackiewicz et al., 2012). In addition, we hypothesized that to the extent that interest in math-related careers contributes to increased involvement in math and thus to greater likelihood of experiencing success in that domain, it also likely leads to increases in subsequent math self-concept of ability (Eccles et al., 1983; Lent et al., 2002). However, although we found a positive cross-lagged link between career plans and math self-concept of ability, we were unable to directly test these hypothesized associations in the context of the present study.

Fourth, our primary focus was on the associations between math-related career plans and expectancy–value beliefs during adolescence. Analyses that extend beyond this developmental period are needed to examine at what point career preferences may become particularly important for subsequent motivations. For instance, both Wigfield and Eccles (2002) and Lent et al. (2002) proposed that efficacy-enhancing interventions might be particularly valuable during early adolescence or even earlier because occupational aspirations become established during that time. Outside of adolescence, however, it might be more difficult to pinpoint analogous sensitive periods for career aspirations and their potential to influence academic motivations, because their effects might vary as a function of different factors. These factors likely include individuals' more or less realistic ideas about the nature and required skills for particular career paths (such ideas tend to become more realistic during adolescence; Gottfredson, 2002) and potential misconceptions (e.g., whether math is necessary and useful for such fields as psychology or whether the field of engineering is compatible with such values as the desire to work with people and to help others; Eccles, 2009). Nonetheless, children develop career aspirations at young ages (e.g., Eccles, 2009; Gottfredson, 1981, 2002), and addressing these informational needs could potentially influence both subsequent career choices and academic motivations even prior to adolescence.

Finally, our operationalization of math-related career attainment provides only an indirect indicator of the amount of mathematical skills that individuals use on their job. Arguably, even when individuals have the same occupational title, specific job tasks, skills, and knowledge can vary substantially, and individuals may differ in their propensity to actively seek or avoid math-related tasks. Further research is necessary to examine the ways in which individuals may seek or avoid math-related tasks in their work contexts, independent of their specific occupational titles.

Conclusions

The present research focused on (a) the reciprocal links between academic expectancy–value beliefs and career plans and (b) the multiplicative associations between expectancies and values in predicting math-related career attainment. Our findings suggest that career aspirations could function as an antecedent of academic motivations and should not be conceptualized as only a consequence of such motivations. In addition, our results corroborate available evidence of a multiplicative relationship between adolescents' expectancies and values in that the effects of each construct depend upon the presence of the other (Nagengast et al., 2011) and demonstrate that these interactive associations can predict such distal outcomes as career attainment. The analyses also contribute to a growing body of evidence indicating that a focus on gender differences in beliefs about math as an academic domain cannot explain gendered preferences for math-intensive fields (e.g., Ceci & Williams, 2010). To address disparities in the participation of women and men in these domains, researchers should turn their attention to characteristics of these occupations and their desirability from the perspective of female and male adolescents.

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