The Effects of Context and Experience on the Scientific Career Choices of Canadian Adolescents

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Abstract

This study explored the differential utility of contextual and experiential factors in the prediction of scientific career aspirations. Specific propositions based on the Lent et al. (1994) social-cognitive model of career choice were also examined. Data were obtained from a Canadian national subgroup (n=3,306) of adolescents (13-19 years) who participated in the National Youth and Science Fair Project Study (NYSPS). Multivariate logistic regression analyses indicated that family background, scientific learning experiences, science self-efficacy measures, outcome expectancies, and scientific interests contributed significant unique variance to the prediction of scientific career choice. Results of a final model revealed that students aspiring for a career in the sciences were more likely than their peers to be male, senior students, have higher grades in science, more interest in science, and expect their science courses to be useful to their future career. Scientific self-efficacy and outcome expectancies were found to have direct effects on choice goals. Outcome expectancies also had an indirect effect on choice goals through scientific interests. Scientific interests had a significant direct effect on choice goals. Implications for career development/choice theory and practice are discussed.

Introduction

Advances in theory and a growing body of empirical literature have characterized vocational-counseling psychology in recent years (Lent, 2001). Career process explanations have evolved through the development of new theoretical approaches (e.g., Gottfredson, 1996) and the refinement/expansion of foundational works (e.g., Dawis, 1996; Super, Savickas, & Super, 1996). Investigators have cited the utility of consolidating the various perspectives guiding career development research and practice (e.g., Walsh, 2001). Paralleling this trend has been an increase in cross-domain inquiry both within and beyond the field (Lent, 2001). Research has sought to understand commonalities across the many domains that affect career-related behaviour by incorporating constructs from other areas of social science (e.g., cognitive psychology, sociology). A particularly fruitful trend has been the application of Bandura's (1986) social-cognitive theory to career behaviour. An example is the social-cognitive career development framework proposed by Lent, Brown, and Hackett (1994).

The Lent et al. (1994) framework is one of the most recent and comprehensive career development theories. This model integrates person, background / context and experiential factors as antecedent influences on career-related choice behaviour. It emphasizes one of the most influential periods in terms of career choice and commitment – adolescence and young adulthood – by highlighting mechanisms that may help shape career-related interests and selections. However, occupational choice is a life-long process that starts long before school-leaving age and continues long afterwards (Schoon, 2001). The socio-cognitive processes emphasized as important to career entry are hypothesized to influence subsequent career choices (Lent et al., 1994). Relationships may also be bidirectional at points. A basic version of the social-cognitive career choice model proposed by Lent et al. (1994) is presented in Figure 1.

The Lent et al. (1994) model seeks to explain central, dynamic mechanisms through which young people forge academic and career choices. Person-input variables and background/ context influence the learning experiences of an individual. Person-inputs are comprised of personal characteristics (e.g., gender). Parent and family influences are important contextual features in the model (Lent et al., 1994). The experiential learning sources, such as objective performance and role-modeling experiences, shape and inform career-related self-efficacy (e.g., perceived task competence) and outcome expectancies (e.g., anticipation of certain outcomes, such as self-satisfaction, financial reward). The self-cognition constructs – self-efficacy and outcome expectancies – figure prominently in the formation of interests. Self-cognitions and career-relevant interests, in turn, affect career choice. Choices and performance accomplishments result in subsequent self-efficacy and outcome appraisals, and thus feed back into the model (not shown).

This study applied multivariate logistic regression analyses to a partial

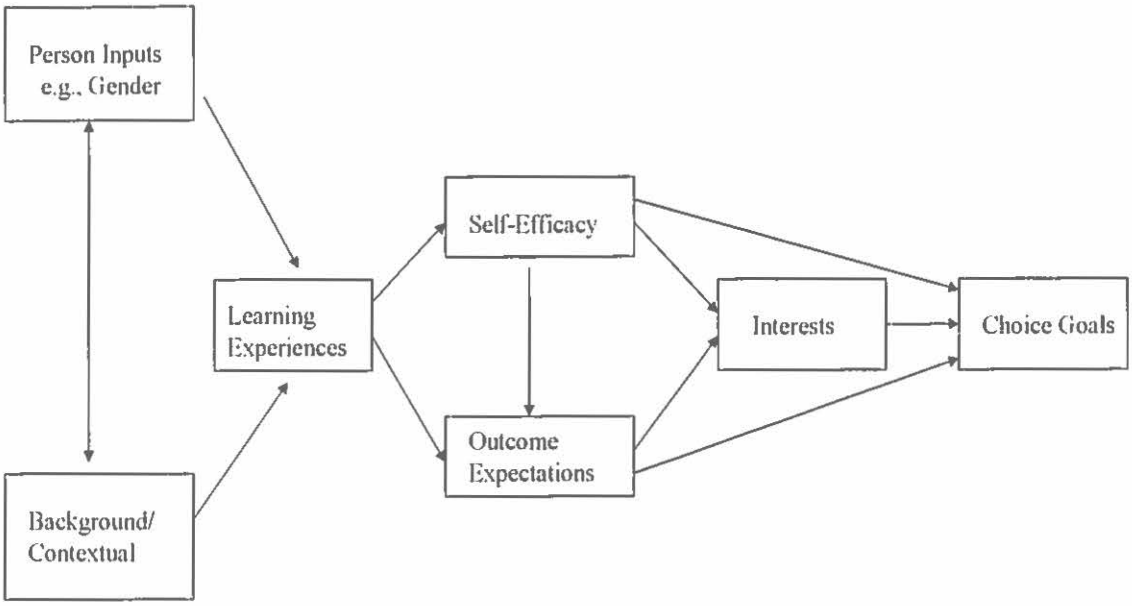

Figure 1. *Partial version of the Lent et al. (1994) social-cognitive model of career development*

version of the Lent et al. (1994) model (Figure 1). The differential utility of model constructs in accounting for career choice was analyzed. Examination of the relations between separate constructs and career choice is needed. Prior investigations on social-cognitive theory have tended to focus on self-efficacy beliefs in isolation from other constructs (Lopez, Lent, Brown, & Gore, 1997). There has been relatively less inquiry on the role of the other socio-cognitive mechanisms (e.g., outcome expectations) in the study of educational and career behaviours. Lent and colleagues (1994) have suggested that assessment of their model focus upon content-specific variables. Few studies have examined the theoretical constructs in their model from a domain-specific perspective (Ferry, Fouad, & Smith, 2000) and with samples other than college students. Research on the relations between science education factors and preadolescent/adolescent career aspirations has been limited (Fouad & Smith, 1996; Lopez et al., 1997; Plucker, 1998; Wang & Staver, 1999). The present study builds upon past research by exploring the science domain for a sample of Canadian adolescents.

The primary goal was to examine the added influence of context and experience in the prediction of scientific career choice (yes/no), beyond the personal characteristics of adolescents. Person-inputs in the present study included gender, grade-level, and primary language (English or French). Contextual factors included socio-economic status (SES – parent occupations), family cohesiveness, family social/scientific communication, family career encouragement, and parent scientific expectations/encouragement. Family cohesion has been found to play a role in the development of academic and career cognitions (e.g., academic self-concept) and choice (Glasgow, Dornbusch, Troyer, Steinberg, & Ritter, 1997; Juang & Vondracek, 2001; Wall, Covell, & MacIntyre, 1999). The remaining measures were domain-related. Students identify parents as the largest influence on career decisions (Blecker & Jacobs, 2004) especially when choosing careers in science and engineering (Dick & Rallis, 1991). Parent SES was also considered a relevant domain factor. Children's educational and career aspirations are found to be related to parental SES (as measured by parents' income, education, and occupation) (Schoon, 2001; Trice & Knapp, 1992; Wahl & Blackhurst, 2000). Occupations requiring science and math skills also tend to be higher in status (Ferry et al., 2000).

Learning experiences included science/math grades, perceptions of science/math teachers, and friends interested in science. These factors reflect the documented influence of objective scientific performance and the school environment on academic and career processes (e.g., Burkham, Lee, & Smerdon, 1997; Plucker, 1998; Schoon, 2001; Wall et al., 1999). The academic competencies of adolescents play an important role in capability beliefs, which contribute to career decision-making (Bleeker & Jacobs, 2004; Ferry et al., 2000; Hackett, 1995; Juang & Vondracek, 2001; Lapan, Shaughnessy, & Boggs, 1996; Lee, 1998; Lent, Lopez, & Bieschke, 1991; Lent, Lopez, & Bieschke, 1993; Nauta & Epperson, 2003). Perceptions of the school environment, peers, and teachers' beliefs may affect a child's self-efficacy and attitudes towards math and science (Burkham et al., 1997; Plucker, 1998; Schoon, 2001; Wang & Staver, 2001). Teachers act as role models by providing students with scientific learning opportunities and encouragement (Burkham et al., 1997). Likewise, it is possible that adolescents who have peers interested in the sciences may engage in scientific activities themselves, and have similar future aspirations. The remaining experiential constructs were self-efficacy, outcome expectations, and interests. Self-efficacy reflected adolescent perceptions of scientific ability. Outcome expectancies included whether one felt science would be useful to one's future career, and expectations for a scientific occupation. Interests were comprised of interest in scientific concepts, and engagement in extracurricular science activities.

Specific propositions based on the Lent et al. (1994) model were also examined in this study. These included: Self-efficacy beliefs will affect career choice goals both directly, and indirectly through interests (Lent et al.'s Propositions 3A and 3C); Outcome expectations will affect career choice directly and indirectly through interests (Propositions 4A and 4C); and there will be a direct effect of interests on choice goals (Proposition 5A). Research has indicated direct relationships between these experiential constructs with choice goals in the science/math domain (e.g., Ferry et al., 2000; Fouad & Smith, 1996). There is also evidence that the influences of self-efficacy and outcome expectations on choice goals are mediated by interests (Borget & Gilroy, 1994; Ferry et al., 2000; Fouad & Smith, 1996; Lent et al., 1991; Lent et al., 1993; Nauta & Epperson, 2003; Post, Stewart, & Smith, 1991). Investigations of social-cognitive theory have largely focused on the role of self-efficacy (Fouad & Smith, 1996). There has been relatively less examination of the role of scientific outcome expectancies. The current study explores the relations of these three experiential influences – self-efficacy, outcome expectancies, and interests – with scientific career goals.

Method

Sample

Participants were obtained from the National Youth and Science Fair Project Study (NYSPS). The original study sample consisted of 4,034 Canadian students (13-19 years). Eighteen percent (728) of participants were Canada-Wide Science Fair (CWSF) competitors (56% male, 44% female) and 82.0% (3,306), a comparable national sample of students (50% male, 50% female). The present study is based on the comparison subgroup of adolescents.

The science fair participants are a homogeneous sample of high-performing science students. The control sample may be a more typical group of students, or provide better representation in terms of generalizability. Eighty-four percent of these students were Caucasian, 7.0% Native American, 6.4% Asian, and 2.2% represented other racial/ethnic groups (2,430 valid cases). Thirty-two percent were junior-level students, 35.7% intermediate, and 33.2% were seniors (3,185 valid cases). Approximately 76% of the students had English as their first language, and 24%, French (3,079 valid cases).

Procedure

Data collection involved a two-phase, convenience sampling design. In the first phase, the CWSF competitors were invited to participate in the study by completing the National Youth and Science Fair Project (NYSP) survey while in attendance at the fair. The nature of the study was explained to the students by a member of the research team, and participation was voluntary. The second phase involved the administration of the NYSP to the comparison sample of students (attending the same schools as CWSF students) by their teachers during regular classroom sessions.

The NYSP is a self-report instrument comprised of items assessing general demographic information, achievement/schoolwork, perceptions of education and schooling, parental background, and family information. Items were adapted from the work of Krahn (1988) (Three City Study of the School to Work Transition), Breakwell, Fife-Shaw and Devereaux (1988) (Youth, Science, and Technology), and items developed as part of a study conducted on Canadian high school students in the context of science career choices (Hein & Lewko, 1994). Participants completed the survey based on language of instruction (English or French), with language appropriate forms distributed to all students. Instrument administration required an average of 50-60 minutes.

Measures

Career Choice/Goals. Participants indicated the occupation they expected to attain. An overall structure for classifying occupation according to type of work performed was based on the Standard Occupational Codes Index (Statistics Canada, 1991). Scientific career choice in the present study was reflected in a dichotomous career goal score as: 1 (science career, e.g., natural sciences, mathematics, health sciences); and 0 (non-science). This measure was used as the dependent variable.

Person Input. *Gender*; *Language* – Language first learned to speak, and still spoken (English or French); and *Grade Level* – Junior (grade 8-9), Intermediate (grades 10-11), and Senior (grade 12+).

Background/Contextual. *Socio-economic Status (SES)* – Paternal and maternal occupation was coded using the SES index developed by Blishen, Carroll, and Moore (1987). A measure of parental occupational status was developed based on the higher index score of either parent; *Family Communication on Social / Scientific Issues* – Ten statements measured the extent to which family members discuss current social and scientific issues (e.g., politics, science). A sample item includes: "How often do you talk to your mother or father about issues involving science or technology?" Responses were rated on five-point scales ("Never" to "Often") and averaged to obtain a single score. The internal consistency reliability (Cronbach alpha) for the scale was .89; *Family Cohesiveness* – Consisted of four items rated on five-point scales ("Very untrue to "Very true") and assessed feelings of "togetherness" and support provided by family members. The reliability for the scale was .78.

Family Career Encouragement measured adolescent perceptions of family encouragement for first choice of career. Students responded to four statements, rated on five-point scales ("None" to "A lot"). Higher scores indicated higher levels of family career encouragement. The reliability was .78; and *Parent Science / Math Expectations and Encouragement* – Perceptions of parental encouragement for, and expectations to excel in science/math were assessed through responses to four, five-point scales ("Never" to "Always"). Items were completed separately for mother and father. Internal consistency coefficients were .91 and

.92, respectively. Responses for both parents were averaged to obtain a single score.

Learning Experiences. *Science/Math Grades* – Students were asked to indicate on an eight-point scale ("Mostly below D" to "Mostly A") their grades within the subject areas of: English, mathematics, science, and social studies. The average of math and science grades was used in all analyses; *Perceptions of Science/Math Teachers* – Students rated each of 11 items (three-point scales) according to perceived science/math teacher encouragement, and expectations for scientific performance and homework. An item includes: "My science teacher expects me to work hard on science." Higher scores indicated higher levels of teacher encouragement/expectations. The items were completed separately for science and math teachers (alpha reliabilities of .74 and .80), and averaged to obtain a total score; and *Friends Interested in Science / Math* – Students were required to rate how many of their friends were interested in science and math. The scale contained five statements (five-point scales – "None" to "All") and the reliability was .84.

Self-Efficacy. *Science/Math Self-Efficacy* – Consisted of a four-item scale assessing perceived general science and math ability. A sample item is: "I am good at math." Responses were rated on five-point scales ("Strongly disagree" to "Strongly agree"). Reliability of the scale was .81; and *Science Knowledge Confidence* – Assessed confidence in completing a science knowledge test. The items were: "How well do you think you did on this test?" and "How difficult was this test for you?" Five-point response scales indicated increasing confidence in one's science knowledge. Reliability was .77.

Outcome Expectations. *Scientific Career Expectancies* – Nineteen statements on three-point scales measured students' perceptions of a scientific career. Higher scores indicated increasingly positive expectations for having a science-related career. Reliability of the scale was .84; and *Science Course Expectations* – Students rated their science courses in terms of the extent to which they expected them to be useful to their future career. Higher scores on six-point scales indicated higher expected course usefulness. Science course ratings were averaged.

Interest in Science and Math. *Scientific Interest* – Students rated three statements on five-point scales ("Strongly disagree" to "Strongly agree") according to their level of scientific interest. A sample statement is: "I like to find out how machinery works." Cronbach's alpha was .86; and *Extracurricular Scientific Interest* – Responses to nine (five-point scale) statements ("Never" to "Always") assessed the frequency with which students engaged in extracurricular scientific activities. Responses were averaged and the reliability for the scale was .83.

Results

Descriptive statistics for the measures comprising the five theoretically-based constructs (person input, background/context, learning experiences, self-efficacy, outcome expectations, interests) by science career choice (yes/no) are presented in Table 1. Preliminary analyses were undertaken to assess the univariate properties of the study measures, impact of missing data, and to verify constructs/scales. There were several significant relations among the predictor variables. However, the magnitude of the correlations (.001-459) was not sufficiently high as to pose problems with multicollinearity in further analyses.

Logistic regression analysis was performed to explore the contribution of contextual and experiential factors to the prediction of career choice. Adolescent person-input variables were entered into the model first to determine the unique predictive variance of the separate sets of measures in subsequent models. Table 2 shows the multivariate odds ratios (OR) and 95% confidence intervals for the series of regression models.

Results of the model comprised of person input variables (Model 1) indicated that gender, senior grade-level, and English as a first language were positively associated with the likelihood of a scientific career. Being male increased the probability of a scientific career choice by 23% as compared to females. Senior-level, and English students had an approximate 50% increased likelihood of choosing a career in the sciences than junior and French students, respectively. Intermediate grade-level was not significantly different from the junior student reference. The overall model was significant ($p < .001$), with a McFadden's (pseudo) R^2 of 0.01 (Table 2).

The addition of the background / contextual set of measures (Model 2) uniquely contributed to the prediction of career choice (block $\chi^2 = 43.58$, df $= 5$, $p < .001$, $R^2 = 0.03$) beyond that accounted for by the person-input factors. Students were more likely to want a scientific career with increasing family communication on social/scientific issues, and parental encouragement/expectations to do well in science. The independent effects of gender and grade on career choice held upon adjustment for the contextual influences. Parent SES, family cohesiveness, and family career encouragement had no significant effect on career choice.

A similar pattern for the person input and contextual factors emerged when scientific learning experiences were added to the model (Model 3). Results also showed that students with higher science/math grades and more friends interested in science, were more likely to have preference for a scientific career. Learning experiences significantly added to the prediction of career choice (block $\chi^2 = 44.85$, df $= 3$, $p < .001$, $R^2 = 0.05$). The models with scientific self-efficacy (Model 4) (block $\chi^2 = 13.55$, df $= 2$, $p < .01$, $R^2 = 0.06$), outcome expectations (Model 5) (block $\chi^2 = 122.56$, df $= 2$, $p < .001$, $R^2 = 0.11$), and interest in science/math (Model 6) (block $\chi^2 = 10.88$, df $= 2$, $p < .01$, $R^2 = 0.12$) indicated that these separate sets of measures differentially added to the prediction of career choice over prior models.

The individual effects of self-efficacy, outcome expectancy, and interest measures (Models 4-6) mainly supported the model propositions (Lent et al., 1994) with respect to their influences on career choice. Proposition 3 states that self-efficacy will have a direct, positive relation to choice goals (3A). Self-efficacy will also have an indirect positive effect on career choice, through

Table 1

Descriptive statistics for person input factors, background factors, scientific learning experiences, science/math self-efficacy, outcome expectations, and scientific interests by science career (yes/no) (National Youth and Science Project (NYSP), N=3,306).

	Science Career				
	Yes	n[1]	No	n	Total
Person Input	%		%		N
Gender					
Male	42.8	565	57.2	756	1,321
Female	37.1	428	62.9	726	1,154
Grade					
Senior (12+)	45.8	370	54.2	438	808
Intermediate (10-11)	39.0	339	61.0	530	869
Junior (8-9)	35.9	264	64.1	472	736
Language					
English	37.3	684	62.7	1,152	1,836
French	47.9	281	52.1	306	587
Background / Contextual	**(Mean(sd))[2]**		**(Mean(sd))**		
Parent Socio-economic Status (SES)	46.25(12.71)	913	44.42(12.74)	1,344	2,257
Family Cohesiveness	3.59(0.91)	918	3.47(0.92)	1,340	2,258
Communication – Social / Scientific Issues	2.43(0.99)	928	2.24(0.97)	1,360	2,288
Family Career Encouragement	3.02(1.09)	988	3.10(1.14)	1,477	2,465
Parent Science / Math Encourage / Expect's	4.18(0.86)	871	3.90(0.96)	1,256	2,127
Learning Experiences					
Science / Math Grades	6.56(1.64)	986	5.79(1.88)	1,452	2,438
Perceptions of Science / Math Teachers	2.21(0.22)	993	2.20(0.24)	1,478	2,471
Friends Interested in Science / Math	2.78(0.69)	910	2.61(0.73)	1,326	2,236
Self-Efficacy					
Science / Math Self-Efficacy	3.88(0.74)	999	3.54(0.78)	1,484	2,483
Science Knowledge Confidence	3.59(0.85)	963	3.43(0.93)	1,410	2,373
Outcome Expectations					
Science Course Expectations	5.30(1.30)	972	4.29(1.86)	1,408	2,380
Scientific Career Expectancies	2.03(0.26)	967	2.05(0.31)	1,411	2,378
Interests					
Scientific Interests	3.94(0.86)	955	3.68(0.95)	1,386	2,341
Extracurricular Scientific Interests	2.08(0.74)	891	1.87(0.71)	1,300	2,191

[1] All n based on valid cases for analyses.
[2] sd=standard deviation; figures for experiential factors are also means and standard deviations.

interests (3C). Proposition 3C specifically suggests that the relation of self-efficacy to choice goals will be reduced, but not eliminated when the influence of interests is controlled. Proposition 4 makes the same predictions regarding the relation of outcome expectations to choice goals. Interests will also directly influence career choice (Proposition 5).

Results of Model 4 indicated that science/math self-efficacy had a significant, direct effect on career goals after controlling for person input, contextual factors, and scientific learning experiences. Scientific outcome expectancies also had a direct relation to scientific career choice upon addition to the model (Model 5). Students with scientific career goals were more likely to have confidence in their scientific ability, and to expect their courses to be useful to their future career as compared to those with non-science goals. The latter relationship was attenuated but held after adjusting for scientific interests in the final model.

The relation between scientific self-efficacy and career choice (Model 4) was no longer significant after controlling for outcome expectancies, and scientific interests in subsequent models (Models 5 and 6). The effect of the second self-efficacy measure – science knowledge confidence – was marginally significant across Models 4 and 5. Scientific career expectancies did not have a significant impact on career choice. The full model (Model 6) indicated a significant, direct effect of both scientific interest measures: Students who wanted a science career were more likely to be interested in scientific concepts and activities. Model 6 supported continued individual effects of gender, grade-level, parent science encouragement/expectations (marginally significant), and objective scientific ability on career goals. The probability of choos-

Table 2

Descriptive statistics for person input factors, background factors, scientific learning experiences, science/math self-efficacy, outcome expectations and scientific interests by science career (yes/no) (National Youth and Science Project (NYSP), N=3,306).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Person Input						
Gender						
Male	**1.23 (1.01-1.49)**	**1.26 (1.03-1.53)**	**1.24 (1.01-1.52)**	**1.38 (1.11-1.71)**	**1.36 (1.09-1.69)**	**1.45 (1.16-1.83)**
Female	ref.	ref.	ref.	ref.	ref.	ref.
Grade						
Senior (12+)	**1.44 (1.12-1.84)**	**1.49 (1.14-1.93)**	**1.66 (1.28-2.17)**	**1.54 (1.17-2.02)**	**1.88 (1.42-2.50)**	**1.91 (1.43-2.54)**
Intermediate (10-11)	1.11 (0.87-1.41)	1.09 (0.86-1.41)	1.19 (0.92-1.54)	1.14 (0.88-1.47)	1.11 (0.85-1.45)	1.16 (0.89-1.52)
Junior (8-9)	ref.	ref.	ref.	ref.	ref.	ref.
Language						
English	**1.48 (1.18-1.86)**	1.21 (0.92-1.59)	1.11 (0.84-1.47)	1.13 (0.86-1.50)	1.25 (0.93-1.68)	1.27 (0.94-1.71)
French	ref.	ref.	ref.	ref.	ref.	ref.
Background / Context						
Parent SES		1.00 (0.99-1.02)	1.00 (0.99-1.01)	1.00 (0.99-1.01)	1.00 (0.99-1.01)	1.00 (0.99-1.01)
Family Cohesiveness		0.96 (0.84-1.09)	0.94 (0.83-1.07)	0.94 (0.82-1.07)	0.94 (0.82-1.08)	0.94 (0.82-1.08)
Family Communication		**1.16 (1.04-1.29)**	1.12 (0.99-1.26)	1.09 (0.97-1.23)	1.06 (0.94-1.20)	1.00 (0.88-1.14)
Family Career Encouragement		0.92 (0.83-1.02)	0.93 (0.84-1.04)	0.93 (0.84-1.04)	0.94 (0.84-1.05)	0.92 (0.82-1.03)
Science Encourage/Expectations		**1.39 (1.22-1.58)**	**1.26 (1.10-1.43)**	**1.22 (1.07-1.40)**	**1.15 (1.01-1.33)**	1.14 (0.99-1.31)
Learning Experiences						
Science/Math Grades			**1.20 (1.13-1.28)**	**1.12 (1.04-1.21)**	**1.12 (1.04-1.21)**	**1.13 (1.04-1.22)**
Percept. Of Science/Math Teachers			0.96 (0.61-1.52)	0.92 (0.58-1.47)	1.00 (0.62-1.63)	0.97 (0.60-1.57)
Friends Interested in Science/Math			**1.22 (1.04-1.43)**	**1.18 (1.01-1.39)**	1.11 (0.94-1.31)	1.06 (0.89-1.25)
Self-Efficacy						
Science/Math Self-Efficacy				**1.30 (1.09-1.55)**	1.11 (0.92-1.34)	1.09 (0.90-1.31)
Science Knowledge Confidence				1.12 (0.99-1.27)	1.13 (0.99-1.28)	1.10 (0.97-1.25)

Table 2 cont'd.

Multivariate odds ratios (OR's) and 95% CI's, continued. [1,2]

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Outcome Expectations						
Science Course Expectations					**1.56 (1.42-1.70)**	**1.52 (1.39-1.66)**
Scientific Career Expectancies					0.72 (0.47-1.08)	0.75 (0.50-1.14)
Interests						
Scientific Interests						**1.16 (1.02-1.32)**
Extracurricular Scientific Interests						**1.22 (1.03-1.45)**
Constant	-0.67	-2.09	-3.00	-3.63	-4.49	-4.88
-2 Log Likelihood	2253.54	2209.96	2165.11	2151.55	2029.0	2018.12
Model Chi-Square [df]	25.61[4]**	69.19[9]**	114.04[12]**	127.59[14]*	250.15[16]**	261.03[18]*
Block Chi-Square [df]		43.58[5]**	44.85[3]**	13.55[2]*	122.56[2]**	10.88[2]*
McFadden's (Pseudo) R^2	0.01	0.03	0.05	0.06	0.11	0.12

[1] 95% confidence intervals (CI) in parentheses; significant terms are in bold.
[2] Variable significance was tested by Wald distributed chi-square statistics with 1 degree of freedom (the exception was grade-level, with 2df).
Note: *p < .01; **p < .001.

ing a science career was about 50% higher for males than females in the final model. Senior students were just about twice as likely to have scientific career aspirations than juniors.

DISCUSSION

This study examined the impact of person input, family, and self-cognitions on the scientific career aspirations of Canadian adolescents. The primary goal was to explore the differential utility of the Lent et al. (1994) theoretical constructs in explaining career choice after adjustment for personal characteristics. Results indicated that family background, scientific learning experiences, self-efficacy measures, outcome expectancies, and scientific interests contributed unique variance to the prediction of scientific career choice. These findings are consistent with the career choice model (Lent et al., 1994) and other work in the area of scientific educational / vocational outcomes (e.g., Borget & Gilroy, 1994; Ferry et al., 2000; Fouad & Smith, 1996; Lee, 1998; Lent et al., 1993; Nauta & Epperson, 2003; Post et al., 1991; Wang & Staver, 2001;). A number of constructs (e.g., context, self-cognitions) were integrated and examined within one theoretical framework. Important, is the generality of the theoretical presuppositions to domain-related areas – namely the science domain in this study.

Findings from the addition of person-input factors to the logistic regression analyses demonstrated the impact of gender, grade-level, and students' primary language on career aspirations. Adolescents wanting a career in the sciences were more likely male, senior-level students, and those with English as their first language. The gender and grade effects held, even after the addition of contextual and experiential influences. These results accord with prior findings (e.g., Fouad & Smith, 1996; Ferry, et al., 2000; Schoon, 2001). Males have traditionally been socialized, or encouraged more than females to pursue science-related majors and occupations (Haines & Wallace, 2002; Gadalla, 2001). Lent et al. (1994) refer to this as one component of the "structure of opportunity" that may drive sex differences in career-related behaviour. The under-representation of females in high status math and science fields has consistently been identified, and is particularly evident in the physical sciences (Bleeker & Jacobs, 2004; Gadalla, 2001; Jacobs, Finken, Griffin, & Wright, 1998). Multiple causes have been explored, including differences in science course enrollment, science efficacy-beliefs, abilities, and interests (Bleeker & Jacobs, 2004; Nauta & Epperson, 2003). However, there is likely no single reason for the gender gap. A variety of psychological, sociological, institutional, and economic factors may deter females from education and careers within scientific areas (Gadalla, 2002).

The most influential period in terms of career commitment is during adolescence and young adulthood, when important decisions about the future need to be made (Schoon, 2001). Senior high-school students are closer proximally in time to actual career entry and may need to commit to their choice. Here, choice is more immediate for older than for younger adolescents, and can be driven by need (e.g., college, employment). Conventional wisdom suggests that older adolescents have more realistic views of career choices and options (Wahl & Blackhurst, 2000). Despite this suggestion, the career aspirations of adolescents are assumed to be unstable, and to change many times before adulthood (Schoon, 2001). There is also evidence that career development starts well before adolescence (Trice, Hughes, Odom, Woods, & McClellan, 1995). However, choice for the younger students might be more remote and best described as intentions.

Research needs to further explore the nature of the gender and grade-level effects. Examination may reveal additional theoretical mechanisms that could be generating the differences. The development of separate models for males/females, and younger/older students may provide further insight into the measures tested in the current study and elsewhere (e.g., encouragement, interests, science-task efficacy) (Bleeker & Jacobs, 2004; Lopez et al., 1997; Nauta & Epperson, 2003). Fouad and Smith (1996), for example, found a significant negative relationship between age and math/science interests in their study of middle-school students. This indicated less interest in math and science for their sample of younger children. They suggested the increasing challenge of the math and science curriculum in the middle-school years, and a wider scope of academic content as possible reasons for the decline. These findings highlight the critical role individual difference variables assume within the Lent et al. (1994) model. Career mechanisms may be different for children at particular developmental junctures. Such processes are also likely to depend on gender and other demographic variables such as race-ethnicity (Fouad & Smith, 1996).

Examination of the independent effects of the context measures indicated that family social/scientific communication and parent science encouragement/expectations had significant effects on career choice. Students were more likely to want a scientific career with increasing family discussion and encouragement by parents to do well in science. The findings for these scientific-specific measures coincide with previous research that has documented the strong influence of family and parental "push" on a child's choice of career (e.g., Wang & Staver, 2001). These contextual characteristics have been found to operate through self-capability beliefs, which in turn contribute to career choice (Bleeker & Jacobs, 2004; Ferry et al., 2000; Hackett, 1995; Juang & Vondracek, 2001; Lopez et al., 1997; Wall et al., 1999). The relationship with choice for the family discussion measure was not significant upon addition of further theoretically derived sets of measures. However, the relation for parental encouragement held upon adjustment for personal factors, learning experiences, self-efficacy, and outcome expectations. It also attained marginal significance in the final model (Model 6). The results of this study seem to confirm both direct and indirect relations of encouragement with scientific career choice.

The remaining family context measures did not perform quite as expected. In particular, family cohesiveness and career encouragement were not predictive of scientific career choice at any stage of adjustment for other measures. These variables also had coefficients/likelihood estimates in a direction that was contraindicative of theoretical expectations. Parent SES was marginally significant across models, but the odds ratios were at baseline. This is somewhat surprising, as those families that are supportive and encouraging tend to promote adolescent decision-making with respect to career choice (Bleeker & Jacobs, 2004; Dick & Rallis, 1991; Glasgow et al., 1997; Lopez et al., 1997; Juang & Vondracek, 2001; Wall et al., 1999). Likewise, children's career aspirations are likely to correspond to their parents' occupational attainment or social status (Trice & Knapp, 1992; Wahl & Blackhurst, 2000). Social background has shown to be a good indicator of the types of learning experiences encountered and interests encouraged in the child, as well as educational achievement and future occupational attainment (Schoon, 2001). Careers requiring expertise in science and math also tend to be higher in status and prestige (Ferry et al., 2000).

The findings for family cohesiveness, career encouragement, and parent SES could indicate more complex relationships between predictors, and/or the effects of these factors on scientific choice may be operating through alternative constructs. They could also be due to the non-scientific nature of the measures. In other words, these variables may influence adolescent career aspirations regardless of whether first choice of career is scientific or non-scientific. Scientific factors may have a stronger role in influencing choice of a career in the sciences. For example, even after adjustment for SES, parent scientific encouragement predicted choice of a career in the sciences. It would be interesting to include specific parent occupations in future studies of the effects of SES and scientific-related factors on adolescent career choice.

Results for the experiential variables showed that students aspiring to a career in the sciences were more likely than their peers to have higher grades in science, more confidence in their scientific ability, more friends interested in science, to expect their science courses to be useful in future, and a larger interest in science themselves. Average science/math grades, expected science course usefulness, and scientific interests remained significant in the final model (Model 6). These results are consistent with prior research (e.g., Ferry et al., 2000; Lapan et al., 1996; Lent et al., 1993; Nauta & Epperson, 2003; Schoon, 2001; Wang & Staver, 2001), and may offer a path-like explanation for the effects of the experiential factors on scientific career choice. It is possible that the grade effect (learning experiences) on career choice is mediated through self-efficacy. This is reflected in the reduced risk estimate for grades upon addition of efficacy beliefs. But the further addition of scientific outcome expectancies and interests did not appreciably affect the estimate. The final model results may thus suggest a significant direct effect of grades on career choice, and an indirect effect largely mediated through self-efficacy.

The relations between experiential constructs and choice outlined here generally coincide with evidence based on the Lent (1994) model (Borget & Gilroy, 1994; Ferry et al., 2000; Fouad & Smith, 1996; Lent et al., 1991; Lent et al., 1993; Nauta & Epperson, 2003; Post et al., 1991). Ferry and colleagues (2000) found that the effect of grades on science/math goals was mediated through both self-efficacy and outcome expectations. Self-efficacy and outcome beliefs were in turn directly associated with choice goals, with indirect effects on goals also mediated through interests. Results for the model propositions in the current study tended to correspond with the Ferry et al. (2000) results. Findings for Model 4 provided support for Proposition 3 – there was a significant direct relationship between efficacy and scientific career choice (3A). Scientific outcome expectancies also had a direct relation to scientific career choice upon addition to the model (Model 5) (4A). The latter relationship was reduced but not eliminated after adjusting for scientific interests in the final model – this offers support for an indirect effect of outcome expectancies on choice (4C). Evidence for an indirect effect of efficacy on choice through interests according to Proposition 3C was not found. This may suggest that efficacy effects are largely mediated through outcome expectancies. These findings are consistent with studies that have used younger children (Fouad & Smith, 1996).

Limitations

The present study has several limitations. The findings represent associations between each construct/measure and scientific career choice. The cross-sectional nature of the research did not permit for tests of causality. There was also the inability to track changes in scientific career development processes with time. Longitudinal work is necessary in order to confirm or clarify the attempts at effect explanation and test the predictive validity of the current results. Multiple assessments of the constructs in an order (e.g., temporal) that is strictly consonant with the Lent et al. (1994) model is needed in order to answer questions about the presumed causal sequence of the social-cognitive factors over time (Nauta & Epperson, 2003).

Data collection involved a convenience sampling design. This alone presents some question as to the representativeness of the sample and generality of the findings. These issues need to be kept in mind with respect to the self-report nature of the instrument upon which the data are based. There is the possibility of subjective bias in the information obtained – the self-report of data may be subject to inflation or underreport. The specificity of data to particular schools should also be considered. The results are specific to school-attending adolescents 13-19 years, and characteristics of the finite number of schools involved may act as ecological (group-level) confounders that cannot be addressed or adjusted for here. Therefore, caution is needed in generalizing the current findings to other groups of adolescents (e.g., home-schooled).

The findings, for the most part, followed the expected pattern and coincided with previous research concerning key theoretical relations (e.g., Ferry et al., 2000). However, future research should use alternative measures to more fully capture specific aspects of the constructs. A replication of our findings with established measures that are based on the social-cognitive career model (see Fouad & Smith, 1996) would be ideal. The degree of domain specificity of the measures and criterion should also be considered in further tests. This may involve using more homogeneous predictors (e.g., separate math and science scales) and various groupings of scientific career (Bleeker & Jacobs, 2004; Lopez et al., 1997).

Implications

This study has theoretical and practical implications for career development and practice. The social-cognitive framework is a comprehensive conceptualization of career and academic developmental processes. The usefulness of the model has been demonstrated for a sample of Canadian adolescents in the context of science career choice. The findings confirm and add empirical validity to several theoretical propositions (Lent et al., 1994). The results are also consistent with prior model testing within the science field (Ferry et al., 2000). This may point towards the robustness of the model in explaining career choice across domains of inquiry. Examining the model relations for selected measures and science career choice facilitates knowledge on the types of variables that may or may not be appropriate to use for the science domain. Further empirical comparisons may promote refinement of existing constructs by the addition of alternative measures. This is important by virtue of the multi-dimensional and complex nature of the career choice process.

The present findings highlight several key variables that could be targets for intervention. Science grades may be one such measure. Counselors and educators can design, implement, and evaluate interventions that promote successful scientific performance, and encourage students to participate in science activities (Burkham et al., 1997; Ferry et al., 2000). Such efforts would, in turn, enhance self-efficacy percepts. This may be particularly useful for those groups that have traditionally been under-represented in scientific fields (e.g., females) (Gadalla, 2001). The current research also demonstrates the important influence of parent science encouragement on adolescent career choice. Schools and communities should develop programs that emphasize the education of parents about the important role they may play in their child's choice of career (Whiston & Sexton, 1998; Wahl & Blackhurst, 2000). Effective training may provide parents with the information they need to foster their children's success in science.

Social-cognitive theory (Bandura, 1986; Lent et al., 1994) suggests that performance accomplishments and family experiences serve as sources of self-efficacy. To the extent that outcome expectancies depend on self-efficacy, interventions that enhance self-efficacy may be appropriate for targeting outcome expectations (Lopez et al., 1997). Other interventions that target outcome beliefs can focus on providing students with scientific role models and information on the positive rewards of a career in the sciences. These methods could further have an impact on the development or maintenance of scientific interests. Early intervention and support of efforts to encourage children in the sciences may facilitate entry into scientific careers.

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