Journal of Vocational Behavior 73 (2008) 328–335

Contents lists available at ScienceDirect

Journal of Vocational Behavior

journal homepage: www.elsevier.com/locate/jvb

Longitudinal relations of self-efficacy to outcome expectations, interests, and major choice goals in engineering students ☆

Robert W. Lent [a,*], Hung-Bin Sheu [b], Daniel Singley [c], Janet A. Schmidt [a], Linda C. Schmidt [d], Clay S. Gloster [e]

[a] Department of Counseling and Personnel Services, University of Maryland, College Park, MD 20742, USA
[b] Division of Psychology in Education, Arizona State University, Tempe, AZ, USA
[c] Counseling Center, University of California, San Diego, CA, USA
[d] Department of Mechanical Engineering, University of Maryland, College Park, MD, USA
[e] Department of Electrical Engineering, Howard University, Washington, DC, USA

ARTICLE INFO

Article history:
Received 1 April 2008
Available online 22 July 2008

Keywords:
Social cognitive career theory
Self-efficacy
Outcome expectations
Interests
Choice goals
Engineering

ABSTRACT

We examined the nature of the temporal relations among the core person variables in the social cognitive model of academic and career choice [Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance [Monograph]. *Journal of Vocational Behavior, 45*, 79–122.]. Participants were 209 students taking beginning level engineering courses at either a predominantly White or a historically Black university. They completed measures of self-efficacy, outcome expectations, interests, and goals near the end of two consecutive semesters. Path analyses indicated support for a model in which self-efficacy served as a temporal precursor of outcome expectations, interests, and goals. There was less support for a model in which the latter variables produced reciprocal paths to self-efficacy. Implications for future longitudinal research on SCCT's (social cognitive career theory's) choice hypotheses are discussed.

1. Introduction

Social cognitive career theory (SCCT; Lent, Brown, & Hackett, 1994, 2000) has become a frequently used framework for studying academic and career development in recent years (Betz, 2008; Lent, 2005). The theory initially consisted of three interrelated models of interest development, choice-making, and performance (Lent et al., 1994). A fourth SCCT model, aimed at explaining educational and work-related satisfaction, was recently proposed (Lent & Brown, 2006). The four models incorporate an overlapping set of person (e.g., self-efficacy), environmental (e.g., social support), and behavioral (e.g., goal implementation) variables that are assumed to help direct the flow of academic and career development.

One major stream of research on SCCT has focused on the pursuit (or avoidance) of science, technology, engineering, and mathematics (STEM) related coursework and academic majors. Findings indicate that individual SCCT variables (e.g., self-efficacy) are good predictors of science and math-intensive interests, goals, persistence, and performance (e.g., Betz & Hackett, 1983; Fouad & Smith, 1996; Gainor & Lent, 1998; Hackett, Betz, Casas, & Rocha-Singh, 1992; Lapan, Boggs, & Morrill, 1989; Lent, Brown, & Larkin, 1984, 1986; Lent, Lopez, & Bieschke, 1991, 1993; Schaefers, Epperson, & Nauta, 1997). Given the underrepresentation of women and students of color in many STEM fields, it is noteworthy that a number of these studies have specifically focused on SCCT's utility within samples of women and minority group members.

☆ This study is based on work supported by the National Science Foundation under Grant No. DUE-0089079. An earlier version of this article was presented at the 115th Annual Convention of the American Psychological Association, San Francisco, August, 2007.

* Corresponding author. Fax: +1 301 405 9995.
E-mail address: boblent@umd.edu (R.W. Lent).

0001-8791/$ - see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.jvb.2008.07.005

In recent years, research has extended beyond the predictive utility of individual social cognitive variables and begun testing fuller versions of SCCT's interest and choice models. Model tests have, for example, included self-efficacy (beliefs about one's ability to successfully perform particular behaviors or courses of action), outcome expectations (beliefs about the consequences of given actions), interests (activity liking), choice goals (intent to choose or persist at a particular course of action), and contextual supports and barriers related to one's goal pursuit. These fuller model tests have generally found good support for SCCT's basic interest and choice hypotheses both in general samples of college students (Lent et al., 2001) and in samples of STEM (engineering: Lent et al., 2003, 2005; Schaefers et al., 1997; computing: Lent, Lopez, Lopez, & Sheu, 2008) students. Some of these studies have examined the fit of SCCT's choice model across student gender, class year, and university type (predominantly White and historically Black universities) (Lent et al., 2005, 2008).

Although their findings suggest that SCCT is a useful explanatory framework with a fairly wide range of generalizability, most of the studies that have thus far tested aspects of SCCT's interest and choice models have been limited by their cross-sectional nature. That is, the typical study has assessed both predictors and criterion variables at a single point in time and used correlational or regression analyses to examine relations among the variables as specified by the theory. Such a design can establish that obtained relations are consistent with SCCT's hypotheses, but it cannot demonstrate that the predictors are causally related to students' interest in and choice of particular fields.

Fortunately, several studies have used experimental or longitudinal designs to test SCCT hypotheses. By manipulating an independent variable and observing its effect on a dependent variable under controlled conditions, experimental designs offer the most compelling evidence that the independent variable leads to, rather than merely predicts or covaries with, the dependent variable. Longitudinal designs are also useful in the search for causal relations, though they are less able to rule out competing hypotheses than are experimental designs. In particular, longitudinal designs allow one to test a key logical requirement of causal interpretations, namely, that the presumed cause precedes the effect in time (this is not possible in cross-sectional designs wherein putative causes and effects are measured at the same point in time). They also offer a viable way to examine the temporal ordering of variables under naturalistic conditions and where experimental manipulation may not be feasible. However, because unmeasured variables, other than the independent variable under investigation, can be responsible for change in the dependent variable, longitudinal designs do have their limitations. They can test the plausibility of a causal interpretation but cannot establish it conclusively.

In one relevant experiment, Silvia (2003) manipulated level of self-efficacy at a simple physical task, finding support for the hypothesized effects of self-efficacy on task interest. Focusing on math and science-relevant activities, Luzzo, Hasper, Albert, Bibby, and Martinelli (1999) found that interventions involving exposure to two of the hypothesized sources of efficacy information (personal performance accomplishments, vicarious learning) produced significant increases in math/science interests between pre- and post-treatment. Participants in the performance accomplishments condition also reported enhanced math/science interests and choice behavior at a 4-week follow-up. Using longitudinal designs, Lapan, Shaughnessy, and Boggs (1996) and Lent et al. (2003) found that, as hypothesized by SCCT, choice goals were predictive of later choice actions or persistence in STEM-related college majors.

A few longitudinal studies have provided relatively sophisticated tests of temporal predominance and bidirectional relations among certain SCCT variables. For example, Nauta, Kahn, Angell, and Cantarelli (2002) used a cross-lagged panel design in which self-efficacy and interests were both measured at the same point in time and then again later, at 3-, 4-, and 7-month lags. By controlling for autoregressive paths (e.g., the relation of interest at time 1 with interest at time 2) and exploring paths from time 1 (T1) self-efficacy to time 2 (T2) interest as well as from T1 interest to T2 self-efficacy, they were able to examine whether either variable was temporally predominant in predicting the other. Their findings were generally consistent with a bidirectional, or reciprocal, relationship between self-efficacy and interests over time (i.e., self-efficacy predicted changes in interest and vice versa). A few other studies using a similar design have also found reciprocal relations between competency beliefs (which are conceptually related to but somewhat different than self-efficacy) and interests over time (e.g., Lent, Tracey, Brown, Soresi, & Nota, 2006; Tracey, 2002).

The present study was aimed at extending the longitudinal study of SCCT's interest and choice hypotheses in several ways. In particular, we examined four of the variables in SCCT's choice model (self-efficacy, outcome expectations, interests, and goals), rather than only self-efficacy and interests, at two points in time, 5 months apart. This allowed us to test longitudinally a greater portion of the model, potentially adding to the current understanding of how the four variables relate to one another over time. Second, we included a sample of engineering students, most of whom were in their first semester of studies. By examining the precursors of choice stability in engineering students, we might shed light on variables responsible for persistence in (or attrition from) STEM fields, which is seen as a prominent societal issue in the US at present (e.g., Committee on Science & Public Policy, 2006). Third, we included students from predominantly White and historically Black universities, potentially adding to the generalizability of our findings.

According to SCCT's interest and choice models, self-efficacy helps determine outcome expectations; self-efficacy and outcome expectations are both precursors of interests; and interests, self-efficacy, and outcome expectations jointly lead to choice goals (Lent et al., 1994). Translating these basic causal predictions into the framework of the longitudinal study, we posited, as shown in Fig. 1, that (a) T1 self-efficacy would predict T2 outcome expectations; (b) T1 self-efficacy and outcome expectations would each predict T2 interests; and (c) T1 self-efficacy, outcome expectations, and interests would each predict T2 goals. In each case, we expected that the T1 predictors would explain unique variance in the T2 criterion variables after controlling for autoregressive paths (i.e., the relation of each variable with itself between times 1 and 2) as well as covariances among T1 variables and those among T2 variables. This sort of design allows for examination of the extent to

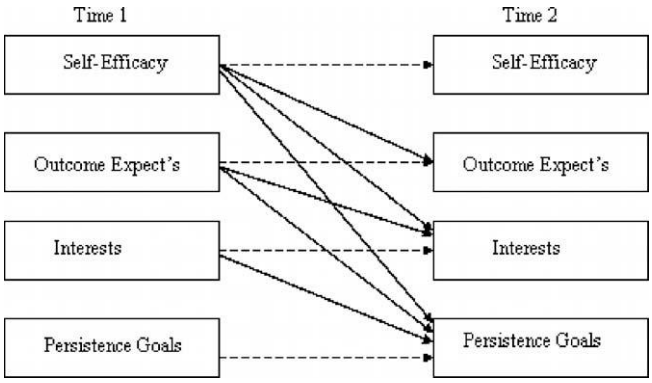

Fig. 1. Longitudinal model depicting self-efficacy as an antecedent of outcome expectations, interests, and choice goals. Dotted lines represent autoregressive paths. Covariances among variables at Time 1 and Time 2 are omitted to avoid visual clutter.

which a T1 predictor accounts for change in a T2 criterion variable over time. It also represents a particularly challenging hurdle for the predictors if, as expected based on past research (Nauta et al., 2002), the criterion variables tend to be relatively stable between T1 and T2.

The above predictions reflect SCCT's assumptions about the predominant temporal ordering of self-efficacy, outcome expectations, interests, and goals. However, it has also been suggested that certain SCCT variables should yield bidirectional relations to one another over time. For instance, Lent, Larkin, and Brown (1989) suggested that, by motivating task practice, interests provide the opportunity for additional personal and vicarious learning experiences, which can yield subsequent changes in task-related self-efficacy. It is also possible that increases or decreases in outcome expectations associated with a particular task affect one's interest in the task which, in turn, affect task practice and self-efficacy. Moreover, it has been hypothesized that progress (or lack thereof) in pursuing one's goals (one way to index personal performance accomplishments) can raise (or lower) self-efficacy (Lent & Brown, 2006).

As noted above, some support has been found for the self-efficacy–interest bidirectional relation hypothesis, but there has been less study of the other potential bidirectional relations. We, therefore, compared models in which self-efficacy was conceived as (a) an antecedent of outcome expectations, interests, and goals (Fig. 1), (b) a consequent of these other variables (Fig. 2), or (c) both an antecedent and a consequent (i.e., self-efficacy and the other variables relate to one another reciprocally, or bidirectionally). Study of such model variations may further understanding of SCCT's utility both as an explanatory framework and as a basis for educational interventions designed to enhance participation and persistence in particular fields, such as STEM.

2. Method

2.1. Participants

Participants were 209 students (166 men, 37 women, 6 sex-unidentified) in introductory engineering classes at either a predominantly White state university (164 students) or at a historically Black private university (45 students) in the mid-Atlantic region of the US. They were nearly all first-year (92%) or second-year (7%) students. In terms of race/ethnicity,

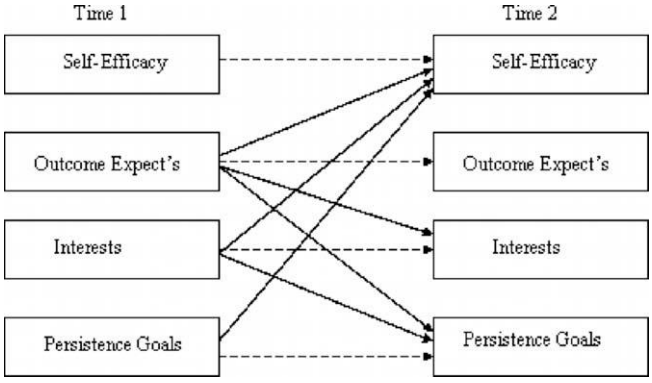

Fig. 2. Longitudinal model depicting self-efficacy as a consequent of outcome expectations, interests, and choice goals. Dotted lines represent autoregressive paths. Covariances among variables at Time 1 and Time 2 are omitted to avoid visual clutter.

22% self-identified as Black or African American, 63% as White or European American, 2% as Hispanic American, 11% as Asian American, and 2% reported other (e.g., multiracial) racial/ethnic identifications. Their mean math SAT score was 690.35, *SD* = 68.02. The most frequently reported intended majors were mechanical (26%), aerospace (22%), and electrical (18%) engineering.

2.2. Procedure and instruments

Participants completed a battery of demographic, academic status, and social cognitive measures related to the pursuit of engineering coursework. The battery was completed twice, during the final 2 weeks of a Fall semester (the first semester for most students) and then again during the final 2 weeks of the succeeding Spring semester, a roughly 5-month lag between assessments. The point of initial data gathering was intended to ensure that students' survey responses would be informed by at least some college-level experience.

Participants completed the measures within introductory engineering classes. A total of 374 students participated in the T1 assessment, with 209 (56%) of them taking part in the T2 assessment. The social cognitive measures included academic milestone self-efficacy, barrier-coping self-efficacy, outcome expectations, interests, and major choice goals (i.e., intention to remain in engineering over subsequent semesters). We used the same versions of these measures as were employed by Lent et al. (2005). For each measure, scale scores were calculated by dividing the summed item responses by the number of items.

2.2.1. Self-efficacy

Self-efficacy was assessed with an 11-item instrument that included four items adapted from Lent et al.'s (1986) self-efficacy for academic milestones scale and a 7-item coping efficacy measure (Lent et al., 2001, 2003). The academic milestone self-efficacy items asked students to indicate their confidence in their ability to complete academic requirements in engineering majors (e.g., "how much confidence do you have in your ability to *excel* in your engineering major over the next semester"). On the coping efficacy items, participants rated their confidence in their ability to cope with a variety of barriers that engineering students might experience (e.g., "cope with a lack of support from professors or your advisor"). All self-efficacy ratings were obtained on a 10-point scale, from *no confidence* (0) to *complete confidence* (9). Lent et al. (2005) found that this scale yielded a coefficient alpha estimate of .91 and correlated in expected ways with measures of outcome expectations, interests, goals, and social supports and barriers relative to pursuit of engineering majors. The coefficient alpha value of the self-efficacy scale in the present study was .89 and .90 at T1 and T2, respectively.

2.2.2. Outcome expectations

Participants responded by indicating how strongly they agreed that an engineering degree would likely lead to each of 10 positive outcomes, such as "earn an attractive salary". Ratings were made along a 10-point scale, from *strongly disagree* (0) to *strongly agree* (9). Previous studies employing this measure have found that it yields adequate internal consistency reliability estimates (coefficient alpha of .89–.91) and relates, as expected, to measures of task and coping efficacy, interests, and major choice goals (Lent et al., 2003, 2005). The coefficient alpha value for the outcome expectations measure in our sample was .90 at both T1 and T2.

2.2.3. Interests

Interests were measured by having participants indicate their degree of interest (from *very low interest* = 1 to *very high interest* = 5) in seven engineering-related activities, such as "solving complicated technical problems". This measure has been found to yield adequate coefficient alpha estimates in past research (.83 in Lent et al., 2003; .80 in Lent et al., 2005) and to correlate with measures of self-efficacy, outcome expectations, and major choice goals in theory-consistent ways. Coefficient alpha values in the current sample were .66 and .75, respectively, at T1 and T2.

2.2.4. Goals

On the measure of major choice goals, participants rated their level of agreement (from *strongly disagree* = 1 to *strongly agree* = 5) with four statements about their academic plans. A sample item was, "I intend to major in an engineering field". Prior uses of this measure have yielded satisfactory estimates of internal consistency reliability (coefficient alphas of .93–.95) and findings of theory-consistent relations with measures of self-efficacy, outcome expectations, and interests (Lent et al., 2003, 2005). In addition, Lent et al. (2003) found this measure to be useful in predicting actual future persistence in engineering majors. Coefficient alpha estimates in the present sample were .87 and .95, respectively, at T1 and T2.

3. Results

The means, standard deviations, internal consistency reliability estimates, and correlations among the social cognitive measures at T1 and T2 are presented in Table 1. We observed in preliminary analyses that two of the four variables, outcome expectations and goals, exhibited considerable skew and kurtosis at both time points. Because such conditions can distort predictor-criterion relations, we used rank order transformations to yield more normally distributed scores for both variables. These rank order scores were used in the subsequent analyses.

Table 1
Means, standard deviations, internal consistency estimates, and correlations among predictor and criterion variables at Time 1 (T1) and Time 2 (T2)

Variable	1	2	3	4	5	6	7	*M*	*SD*	α
1. T1 Self-efficacy	—							6.69	1.10	.89
2. T1 Outcome exp.	.35[a]	—						7.06	1.08	.90
3. T1 Interests	.39	.22	—					3.65	.53	.66
4. T1 Goals	.39	.19	.24	—				4.70	.48	.87
5. T2 Self-efficacy	.64	.14	.31	.31	—			6.54	1.32	.90
6. T2 Outcome exp.	.33	.46	.16	.25	.46	—		7.21	1.09	.90
7. T2 Interests	.34	.08	.63	.26	.44	.34	—	3.62	.61	.75
8. T2 Goals	.32	.04	.23	.53	.43	.27	.35	4.62	.76	.95

Note. $N = 209$. Exp. = expectations.
[a] Correlations $\geqslant |14|$ are significant at $p < .05$.

To explore potential mean differences in the variables as a function of university, gender, and time period, we conducted a set of 2 (university site) × 2 (gender) × 2 (time) mixed factorial design with time as the repeated measure on the theoretical variables. The main effects of gender and time and the interaction effects were all non-significant. We did, however, find significant main effects for university type on two of the variables, with students at the historically Black university reporting higher self-efficacy (F [1, 199] = 6.99, $p < .01$, $\eta^2 = .03$) and outcome expectations (F [1, 199] = 14.04, $p < .001$, $\eta^2 = .07$) than those at the predominantly White university across time periods. Given the absence of significant interactions, we collapsed the variables over university type and gender in the correlation and model testing analyses. Because of the university differences in self-efficacy and outcome expectations, however, we also ran a set of path analyses in which university site was included as a predictor of the T2 variables.

To test SCCT's interest and choice hypotheses longitudinally, we examined the fit to the data of four model variations. First, consistent with procedures used in prior longitudinal analyses (e.g., Nauta et al., 2002), we created a Base model containing (a) covariances among all of the T1 variables, (b) covariances among the errors of the T2 variables, and (c) only autoregressive paths, indexing the relation of each T1 variable to the same variable at T2. (Note that, for visual simplicity, the covariances at T1 and T2 are not shown in the figures). The Base model estimates the stability of each variable over a roughly 5-month period.

The second model, designated *Self-efficacy as Antecedent* (SE-Antecedent), shown in Fig. 1, includes the Base model but adds the theoretically posited lagged paths from (a) T1 self-efficacy to T2 outcome expectations; (b) T1 self-efficacy and outcome expectations to interests at T2; and (c) T1 self-efficacy, outcome expectations, and interests to persistence goals at T2. This model reflects SCCT's assumption that self-efficacy leads to outcome expectations, interests, and goals.

The third model, termed *SE as Consequent* (SE-Consequent), is illustrated in Fig. 2. Like the second model, this model includes the Base model and the lagged paths from T1 outcome expectations to T2 interests, and from T1 outcome expectations and interests to T2 goals. However, unlike the second model, the third model contains paths from T1 outcome expectations, interests, and goals to T2 self-efficacy–instead of the paths from T1 self-efficacy to each of the other variables at T2. This model tests the possibility that the other variables are sources of self-efficacy, whereas the second model tests the reverse assumption (i.e., that self-efficacy is a source of the other variables).

A fourth, *Bidirectional*, model includes the Base model and all of the paths in the second and third models. This model tests the possibility that the relations among self-efficacy and each of the other variables are fully reciprocal in nature (e.g., self-efficacy is both an antecedent and a consequent of the other variables).

All models were tested using the path analysis procedures of EQS 6.1 (Bentler & Wu, 2005), the covariance matrices of the measured variables, and maximum likelihood estimation. The value of Mardia's normalized estimate was small, suggesting that the score distributions did not depart substantially from multivariate normality. Three primary fit indices were employed: the comparative fit index (CFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). Hu and Bentler (1999) have recommended that CFI values close to .95, SRMR close to .08, and RMSEA values close to .06 may be taken as indicators of good model fit.

As shown in Table 2, the Base model yielded adequate fit across most indices, $\chi^2(12) = 23.93$, $p < .05$, CFI = .98, SRMR = .08, RMSEA = .07, and the autoregressive paths were all significant. All variables showed moderate to strong stability between T1

Table 2
Fit indices for the path analyses

Model	χ^2	*df*	CFI	SRMR	RMSEA
1. Base	23.93*	12	.98	.08	.07
2. SE-Antecedent	9.99[a]	6	.99	.04	.06
3. SE-Consequent	16.70*	6	.98	.07	.09
4. Bidirectional	4.52[a,b]	3	1.00	.03	.05

[a] Significantly different from Base model, $p < .05$.
[b] Significantly different from SE-Consequent model, $p < .05$.
* $p < .05$.

and T2 (the stability coefficients for self-efficacy, outcome expectations, interests, and goals were, respectively, .59, .49, .60, and .49).

The SE-Antecedent model fit the data well across all indices, $\chi^2(6) = 9.99$, $p > .05$, CFI = .99, SRMR = .04, RMSEA = .06. In a direct contrast of this model to the Base model using the χ^2 difference test, we found that the SE-Antecedent model yielded improved fit over the Base model, $\Delta\chi^2(6) = 13.94$, $p < .05$. In addition to the significant autoregressive paths, the SE-Antecedent model revealed small but significant lagged paths ($p < .05$) from T1 self-efficacy to T2 outcome expectations (.17), interests (.13), and goals (.15). All other T1 to T2 lagged paths were non-significant.

The SE-Consequent model also produced acceptable fit on most of the primary fit indicators, $\chi^2(6) = 16.70$, $p < .05$, CFI = .98, SRMR = .07, RMSEA = .09. It did not, however, improve over the fit of the Base model, $\Delta\chi^2(6) = 7.23$, $p > .05$. Moreover, the paths from T1 outcome expectations (−.08), interests (.09), and goals (.02) to T2 self-efficacy were all non-significant.

The Bidirectional model, incorporating reciprocal paths between self-efficacy and each of the other variables, produced strong indications of fit, $\chi^2(3) = 4.52$, $p > .05$, CFI = 1.00, SRMR = .03, RMSEA = .05. It also demonstrated improved fit relative to both the Base ($\Delta\chi^2(9) = 19.41$, $p < .05$) and SE-Consequent models ($\Delta\chi^2(3) = 12.18$, $p < .05$). It did not, however, differ in fit from the SE-Antecedent model, $\Delta\chi^2(3) = 5.47$, $p > .05$. As in the latter model, all paths from T1 self-efficacy to T2 outcome expectations (.19), interests (.14), and goals (.15) were small but significant; the return paths from these variables to self-efficacy were all non-significant. It was not possible to directly contrast the SE-Antecedent and SE-Consequent models with the $\Delta\chi^2$ test because they are non-nested models. However, the preponderance of the model comparison findings suggest that the SE-Antecedent model is the more tenable of the two and is more parsimonious than the Bidirectional model (i.e., it achieves comparable fit with fewer paths).

Finally, because we observed differences in some of the variables as a function of university site, we replicated the above path analyses with the inclusion of university site (as a dummy coded T1 variable). In these analyses, we allowed university site to covary with each of the other T1 variables, and we added paths from university site to each of the T2 dependent variables. The fit indices for the new Base, SE-Antecedent, SE-Consequent, and Bidirectional models were found to be similar to those of the models without university site. In addition, the contrasts among the models yielded the same pattern of findings, with the SE-Antecedent model not differing in fit from the Bidirectional model, and both of these models yielding stronger fit than the Base model. University site did, however, add small, significant unique paths to T2 self-efficacy, outcome expectations, and interests (−.12, −.23, −.14, respectively, in the SE-Antecedent model), indicating that students at the historically Black university reported somewhat stronger perceptions of self-efficacy, anticipated outcomes, and interests than did their counterparts at the predominantly White university at T2.

4. Discussion

This study explored the nature of the temporal relations among the four core person variables in the SCCT choice model. In testing the SE-Antecedent and Bidirectional models, it was found that T1 self-efficacy yielded significant lagged paths to T2 outcome expectations, interests, and persistence goals. On the other hand, T1 outcome expectations did not yield significant lagged paths to T2 interests or goals; neither was the path from T1 interests to T2 goals significant. These findings indicate that self-efficacy accounted for change in each of the other variables, which is consistent with the hypothesized role of self-efficacy as a precursor of outcome expectations, interests, and goals. The findings do not, however, support SCCT's hypotheses about the unique role of outcome expectations in fostering interests and goals, or about interest as a unique antecedent of goals.

We also observed that the SE-Consequent model did not improve upon the fit of the Base model and that the lagged paths from T1 outcome expectations, interests, and goals to T2 self-efficacy were all non-significant. The Bidirectional model produced excellent fit to the data, exceeding the fit of the Base and SE-Consequent models. It did not, however, differ significantly from the fit of the SE-Antecedent model. On balance, the pattern of results suggests that the SE-Antecedent model offers a sufficient and parsimonious explanation of the relations among the theoretical variables. That is, the predominant temporal flow appeared to be from self-efficacy to the other variables rather than vice versa.

Past research relevant to the directionality of the relations among the social cognitive variables has suggested that self-efficacy is a precursor of interests (Silvia, 2003). For instance, providing personal success experiences (an hypothesized source of self-efficacy) at a math task has been found to enhance interest in math-related career options (Luzzo et al., 1999). Our findings regarding the temporal path from self-efficacy to interests is consistent with these earlier results. However, several prior studies, employing thought-listing (Lent, Brown, Gover, & Nijjer, 1996) and cross-lagged panel analysis (Nauta et al., 2002), have also found that there may be reciprocal relations among self-efficacy and interests, with interests serving as a source of self-efficacy. In this reciprocal view, pursuing one's interests allows opportunities for building self-efficacy (Lent et al., 1989).

Our findings offered better support for a unidirectional flow from self-efficacy to interests than for bidirectional relations between these two variables. Extending the study of temporal predominance to the other variables, we also found better support for a model containing lagged paths from self-efficacy to outcome expectations and goals than for a model in which outcome expectations and goals were depicted as precursors of self-efficacy. Although our findings suggest that the predominant temporal path is from self-efficacy to the other variables, it should be noted that our findings may have been affected

by the characteristics of our sample. Whereas other studies of the directionality of self-efficacy and interest relations have typically employed general samples of college students, our participants were mostly first-year students taking engineering coursework. They may, therefore, have been more crystallized in their interests and major plans than is the case in more heterogeneous student samples.

It is possible that the directional relationship of self-efficacy to interest (and the other social cognitive variables) is partly a function of such developmental considerations as major choice status. For example, bidirectionality may be more likely before interests and choices stabilize, and unidirectional paths from self-efficacy to the other variables may be more likely afterwards when, for example, interest maintenance and goal persistence require robust self-efficacy at negotiating increasingly challenging academic conditions. This speculation suggests that the issue of temporal predominance be studied in different developmental contexts and age levels, including at earlier, formative stages of skill development when interests, self-efficacy, outcome expectations, and goals are all likely to be more fluid.

It is noteworthy that the paths from self-efficacy to the other variables, though significant, were modest in magnitude. Similar effect sizes were obtained in other cross-lagged studies of self-efficacy–interest (Nauta et al., 2002) and competency belief–interest (e.g., Tracey, 2002) relations. Unlike the larger effect sizes indexing relations among the variables that are typically found in cross-sectional studies (e.g., Lent et al., 2005), our parameter estimates were obtained via more conservative analyses (e.g., after controlling for autoregressive effects and cross-sectional covariances).

As others have noted (e.g., Nauta et al., 2002; Sher, Wood, Wood, & Raskin, 1996), it is difficult to account for large portions of variance in a dependent variable within a longitudinal design when there is a great deal of stability in that variable over the predictive interval (as reflected by the autoregressive path). In other words, there may simply be relatively little unique variance in the T2 dependent variables left to explain once autoregressive paths (as well as covariances among the T2 variables) are taken into account (we observed autoregressive coefficients of .49 to .60 for the variables in our study).

It is possible that there is more fluidity in the predictors and dependent variables over different measurement intervals and, as suggested above, at earlier stages of skill development. Since the measurement interval and the developmental trajectory of the variables in question can have important effects on longitudinal findings (e.g., Cole & Maxwell, 2003; Sher et al., 1996), these issues deserve exploration within future research on SCCT's interest and choice hypotheses. Cole and Maxwell have suggested that there may be optimal time lags within which to study particular longitudinal relationships. Given the relatively nascent stage of longitudinal research on SCCT, it would be useful to explore the moderating role of measurement interval on predictor-criterion relations. Another useful direction for longitudinal research on SCCT's choice model would be to include at least three measurement points (cf. Cole & Maxwell), which would be necessary to adequately test hypothesized mediator relationships (e.g., interest as a partial mediator of the relations of self-efficacy and outcome expectations to goals). In addition, it would be valuable to examine fuller versions of the choice model (e.g., including contextual supports and barriers) in future longitudinal research.

Our findings regarding university type were also noteworthy. In particular, we observed that, when included in the path analyses, university site explained a small amount of additional variance in three of the T2 variables (self-efficacy, outcome expectations, and interests). In each case, students in the historically Black university reported more favorable percepts than did those at the predominantly White university. Prior research has also found mean level differences in certain social cognitive variables between these two types of universities (Lent et al., 2005). It is not clear whether this contribution of university site to predictions in the current study is due to environmental differences between the two universities, pre-existing differences among the students who select each type of university, or other factors. But these findings do suggest the value of future research exploring the utility of the SCCT choice model in both types of university and the reasons for any differences in model fit among them. Among other things, such research may shed light on factors that can be used to modify social cognitive percepts.

The findings should be interpreted in the context of the attrition in the sample between T1 and T2. Although much of the attrition was attributable to T1-only students' either not being enrolled in or present at the particular classes at which the T2 assessment was administered, some of it may also have been due to departures from the engineering curriculum. Unfortunately, the design of this study did not allow us to track the academic status of students who did not complete the T2 assessment. It is possible that attrition at T2 may have accentuated the homogeneity of the T1–T2 sample and, thereby, reduced the predictive utility of the model. It would be useful for future longitudinal research on the SCCT choice model to retain more participants at all assessments, try to ascertain reasons for attrition when it does occur, and examine the status of students who change academic directions.

Assuming that the current findings are shown to replicate in future research, they would support the utility of efficacy-based interventions to assist interest development and major/career choice consideration (e.g., Luzzo et al., 1999). Although longitudinal designs are useful in exploring temporal relations among the SCCT variables under naturalistic conditions, it would also be valuable to employ experimental designs to a greater degree in future SCCT research. Such research could, for example, examine hypothesized causal relations among the variables while testing the clinical utility of particular theoretical elements (e.g., does an intervention designed to promote STEM-related self-efficacy in high school students also yield changes in relevant interest and choice consideration criteria?).

In sum, this study provides a fairly rigorous test of temporal predominance because (a) the independent variables were measured prior to (rather than concurrently with) the dependent variables; and (b) the design controlled for autoregressive paths (i.e., change or stability in the dependent variables over time) and the presence of other SCCT variables in the model (i.e., covariances among variables at T1 and T2). Though these findings are consistent with a causal role for self-efficacy, they

cannot conclusively prove such a role. Nevertheless, the longitudinal aspect of this study does increase confidence in the utility of SCCT as an explanatory framework and adds to accumulated cross-sectional findings on the role of self-efficacy relative to interest and choice processes.

References

Bentler, P. M., & Wu, E. J. C. (2005). *EQS 6.1 for Windows user's guide*. Encino, CA: Multivariate Software.

Betz, N. E. (2008). Advances in vocational theories. In S. D. Brown & R. W. Lent (Eds.), *Handbook of counseling psychology* (4th ed., pp. 357–374). New York: Wiley.

Betz, N. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23*, 329–345.

Cole, D. A., & Maxwell, S. E. (2003). Testing mediational models with longitudinal data: Questions and tips in the use of structural equation modeling. *Journal of Abnormal Psychology, 112*, 558–577.

Committee on Science, Engineering, and Public Policy (2006). Rising above the gathering storm: energizing and employing America for a brighter economic future. Washington, DC: National Academy of Sciences.

Fouad, N. A., & Smith, P. L. (1996). A test of a social cognitive model for middle school students: Math and science. *Journal of Counseling Psychology, 43*, 338–346.

Gainor, K. A., & Lent, R. W. (1998). Social cognitive expectations and racial identity attitudes in predicting the math choice intentions of Black college students. *Journal of Counseling Psychology, 45*, 403–413.

Hackett, G., Betz, N. E., Casas, J. M., & Rocha-Singh, I. A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology, 39*, 527–538.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1–55.

Lapan, R. T., Boggs, K. R., & Morrill, W. H. (1989). Self-efficacy as a mediator of Investigative and Realistic General Occupational Themes on the Strong-Campbell Interest Inventory. *Journal of Counseling Psychology, 36*, 176–182.

Lapan, R. T., Shaughnessy, P., & Boggs, K. (1996). Efficacy expectations and vocational interests as mediators between sex and choice of math/science college majors: A longitudinal study. *Journal of Vocational Behavior, 49*, 277–291.

Lent, R. W. (2005). A social cognitive view of career development and counseling. In S. D. Brown & R. W. Lent (Eds.), *Career development and counseling: Putting theory and research to work* (pp. 101–127). New York: Wiley.

Lent, R. W., & Brown, S. D. (2006). Integrating person and situation perspectives on work satisfaction: A social-cognitive view. *Journal of Vocational Behavior, 69*, 236–247.

Lent, R. W., Brown, S. D., Brenner, B., Chopra, S. B., Davis, T., Talleyrand, R., et al (2001). The role of contextual supports and barriers in the choice of math/science educational options: A test of social cognitive hypotheses. *Journal of Counseling Psychology, 48*, 474–483.

Lent, R. W., Brown, S. D., Gover, M. R., & Nijjer, S. K. (1996). Cognitive assessment of the sources of mathematics self-efficacy: A thought-listing analysis. *Journal of Career Assessment, 4*, 33–46.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance [Monograph]. *Journal of Vocational Behavior, 45*, 79–122.

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology, 47*, 36–49.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. *Journal of Counseling Psychology, 31*, 356–362.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1986). Self-efficacy in the prediction of academic performance and perceived career options. *Journal of Counseling Psychology, 33*, 265–269.

Lent, R. W., Brown, S. D., Schmidt, J., Brenner, B., Lyons, H., & Treistman, D. (2003). Relation of contextual supports and barriers to choice behavior in engineering majors: Test of alternative social cognitive models. *Journal of Counseling Psychology, 50*, 458–465.

Lent, R. W., Brown, S. D., Sheu, H., Schmidt, J., Brenner, B. R., Gloster, C. S., et al (2005). Social cognitive predictors of academic interests and goals in engineering: Utility for women and students at historically Black universities. *Journal of Counseling Psychology, 52*, 84–92.

Lent, R. W., Larkin, K. C., & Brown, S. D. (1989). Relation of self-efficacy to inventoried vocational interests. *Journal of Vocational Behavior, 34*, 279–288.

Lent, R. W., Lopez, A. M., Lopez, F. ., & Sheu, H. (2008). Social cognitive career theory and the prediction of interests and choice goals in the computing disciplines. *Journal of Vocational Behavior, 73*, 52–62.

Lent, R. W., Lopez, F. G., & Bieschke, K. J. (1991). Mathematics self-efficacy: Sources and relation to science-based career choice. *Journal of Counseling Psychology, 38*, 424–430.

Lent, R. W., Lopez, F. G., & Bieschke, K. J. (1993). Predicting mathematics-related choice and success behaviors: Test of an expanded social cognitive model. *Journal of Vocational Behavior, 42*, 223–236.

Lent, R. W., Tracey, T. J. G., Brown, S. D., Soresi, S., & Nota, L. (2006). Development of interests and competency beliefs in Italian adolescents: An exploration of circumplex structure and bidirectional relationships. *Journal of Counseling Psychology, 53*, 181–191.

Luzzo, D. A., Hasper, P., Albert, K. A., Bibby, M. A., & Martinelli, E. A. (1999). Effects of self-efficacy-enhancing interventions on the math/science self-efficacy and career interests, goals, and actions of career undecided college students. *Journal of Counseling Psychology, 46*, 233–243.

Nauta, M. M., Kahn, J. H., Angell, J. W., & Cantarelli, E. A. (2002). Identifying the antecedent in the relation between career interests and self-efficacy: Is it one, the other, or both? *Journal of Counseling Psychology, 49*, 290–301.

Schaefers, K. G., Epperson, D. L., & Nauta, M. M. (1997). Women's career development: Can theoretically derived variables predict persistence in engineering majors? *Journal of Counseling Psychology, 44*, 173–183.

Sher, K. J., Wood, M. D., Wood, P. K., & Raskin, G. (1996). Alcohol outcome expectancies and alcohol use: A latent variable cross-lagged panel study. *Journal of Abnormal Psychology, 105*, 561–574.

Silvia, P. J. (2003). Self-efficacy and interest: Experimental studies of optimal incompetence. *Journal of Vocational Behavior, 62*, 237–249.

Tracey, T. J. G. (2002). Development of interests and competency beliefs: A one-year longitudinal study of fifth to eighth grade students using the ICA-R and structural equation modeling. *Journal of Counseling Psychology, 49*, 148–163.