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A Multilevel Approach to Motivational Climate in Physical Education and Sport Settings: An Individual or a Group Level Construct?

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Motivational climate is inherently a group-level construct so that longitudinal, multilevel designs are needed to evaluate its effects on subsequent outcomes. Based on a large sample of physical education classes (2,786 students, 200 classes, 67 teachers), we evaluated the effects of classroom motivational climate (task-involving and ego-involving) and individual goal orientations (task and ego) on individual students' outcomes (intrinsic motivation, attitudes, physical self-concept, and exercise intentions) collected early (T1) and late (T2) in the school year. Using a multilevel approach, we found significant class-average differences in motivational climate at T1 that had positive effects on T2 outcomes after controlling T1 outcomes. Although there was no support for a "compatibility hypothesis" (e.g., that task oriented students were more benefited by task-involving motivation climates), the stability of goal orientations was undermined by incompatible climates.

Key Words: multilevel hierarchical modeling, motivational goal orientation, variance components, person-environment fit, teacher effects

Our intent is to introduce important advances in the application of multilevel modeling (also referred to as hierarchical linear modeling) to sport and exercise psychology. In sport and exercise research—and the social sciences more generally—data typically have a multilevel structure in which individuals (e.g., athletes, students, or other members of a group) are clustered into groups (teams, classes, gyms) that might be clustered into higher level administrative units (schools, states, countries, federations). In most studies, individual characteristics and those associated with groups are confounded because groups are typically not established according to random assignment. Individuals in the same group are typically more similar to others in the same group than they are to persons in other groups. Even when individuals are initially assigned at random, they tend to become more similar to each other over time. Multilevel modeling is designed to

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resolve the confounding of these two effects at different levels by decomposing an observed relationship among variables into separate within-group and between-group components (see Goldstein, 1995; Raudenbush & Bryk, 2002). The multilevel modeling approach has important statistical, methodological, and substantive implications for sport and exercise researchers.

Multilevel modeling should always be the statistical technique of choice whenever the data have a multilevel structure. It is generally inappropriate to pool responses of individuals without regard to groups as in single-level analyses, unless it can be shown that there are no group differences or effects. A fundamental assumption of single-level analyses is that measures collected for each individual are independent of those for other individuals. This assumption is violated whenever individuals in the same group are more similar to each other on average than they are to persons in other groups. If for example there are systematic differences between groups, then the typical single-level analyses that ignore this clustering of individuals into groups are likely to be invalid by violating statistical assumptions in a way that increases the likelihood of a Type I error.

It is important to emphasize that if the data have a multilevel structure, then the statistically appropriate analysis of the data requires multilevel analyses—whether or not the multilevel effects are a methodological, substantive, or theoretical focus of the study. This assumption of independence is almost always violated when the data have a multilevel structure (even when assumption is not violated, some sort of multilevel analysis is required to evaluate this assumption). Hence the onus is on the researcher to demonstrate why multilevel analyses are not required when the data have a multilevel structure. The evaluation of this assumption will become increasingly prevalent as researchers, editors, and readers become more familiar with multilevel approaches. Therefore, since nearly all data collected in sport psychology, exercise, and physical education settings have a multilevel structure, this approach is likely to become increasingly popular (for further discussion, see Bryk & Raudenbush, 1992; Goldstein, 1995; Goldstein, Rasbash, Plewis, et al., 1998; Raudenbush & Bryk, 2002).

Methodologically, a multilevel focus opens up critically important new perspectives about constructs operating at the individual level, the group level, or both. However, it also provides new challenges for theory, research, measurement, and practice. Apparently the same construct measured at the level of the individual and group may be fundamentally different. For example, Marsh and Craven (2001) demonstrated that individual student achievement has a positive effect on academic self-concept (the brighter I am, the higher my academic self-concept) whereas class-average achievement has a negative effect (the brighter the other students in my class, the lower my academic self-concept).

Class-average achievement has a significant effect above and beyond the effect of achievement at the individual student level. Furthermore, measures that have good psychometric properties at the individual level may not be satisfactory at the group level. For example, Marsh, Rowe, and Martin (2002) demonstrated that individual student ratings of the quality of the PhD research supervision had good psychometric properties at the individual level but were completely unreliable at the level of the university; i.e., there were no significant differences between universities for university-average measures of the quality of supervision. Hence, measures found to be effective at one level must also be evaluated at other levels using a traditional construct validity approach. In addition, there may be substantively important questions of practical significance that involve interactions between individual- and group-level variables. For example, a "matching hypothesis" might posit that individuals with certain characteristics are more likely to be successful when grouped together with other individuals of similar characteristics than when grouped with individuals of dissimilar characteristics.

From a practical perspective, a multilevel approach allows researchers to pursue new questions about how effects vary from group to group and the characteristics of groups associated with this variation. This is particularly important in studies such as the present investigation in which critical variables are associated with both the individual level (individual motivation goal orientation) and group level (group motivational climate) constructs and their cross-level interactions. Hence the multilevel approach provides a richer and more appropriate methodological approach to evaluating motivational climate than would be possible with traditional single-level approaches that ignore the clustering of individuals in groups.

Theoretically and substantively, the purpose of the present study was to introduce a new approach to the evaluation of motivational climate in sports, exercise, and physical educational settings. Particularly when the focus of the research is on an inherently group-level variable such as "climate," it makes no sense to ignore the group level in the analysis. Traditionally, sport psychology researchers have distinguished between the motivational goal orientations of individual participants (athlete, player, or student) and the perceptions of the individual members in the group (classroom or team) climate. Although the goal orientations of individual participants are clearly designed to be an individual-level variable, the appropriate level of analysis for classroom or team climate is not as straightforward. In contrast to most previous research operationalizations, we argue that it is essential that climate research consider indicators of the climate at the level of the group—typically the classroom or team level in sport and exercise research.

When such climate measures are based on responses about the overall group climate by a single person for each group (e.g., teacher, coach, external observer of the group setting), then it is clear that the level of analysis is the group, not individuals within each group—although there are statistical complexities about how to bring together data representing different levels of analysis into an overarching analytic framework. When each member of a group evaluates the perceptions of the group climate, it is possible to consider responses at both the individual and the group level. Even here, however, we argue that the most appropriate measure of the group climate is an aggregate of the perceptions of the individual group members. Thus, for example, the mean of climate perceptions by each member of a group provides one reasonable index of the climate. Alternatively, aggregated climate measures could also be constructed to represent the variation in perceptions of individual members and the difference in climate perceptions by key subgroups (most and least able, males and females, senior and junior participants).

The existence of multiple indicators of the inferred climate based on responses by different group members also provides an important test for the validity of the climate construct. If there is no reasonable agreement about group climate among members in the same group, then support for the construct validity of the perceived climate ratings is dubious (in the same way as lack of agreement among items designed to measure the same construct undermines support for the construct validity of the construct). This is not to say, of course, that the perceptions of each group member and how these individual perceptions differ from the aggregated perceptions are not also important. However, measures of climate at the group level are essential in the pursuit of climate research. Fortunately, recent advances in the application of multilevel modeling provide new opportunities to combine appropriate measures from multiple levels of measurement. Hence the issue is not whether research should be done at the level of the individual participant or the group level, but how best to combine measures from multiple levels of measurement.

Individual Motivational Goal Orientations and Motivational Climates

Individual-Level Motivation Constructs

The starting point for our study is achievement goal theory, motivational research stemming largely from work by Nicholls and colleagues (Duda, 2001; Duda & Nicholls, 1992; Nicholls, 1984; Roberts, 2001; also see Marsh, 1994; Marsh, Craven, Hinkley, & Debus, in press; Papaioannou & Theodorakis, 1996; Roberts, Treasure, & Kavussanu, 1997) as well as the work of Dweck (1975, 1986), Harackiewicz, Barron, Carter, Lehto, and Elliot (1997), Maehr and Braskamp (1986), Murphy and Alexander (2000), Urdan (1997), and others on two contrasting dispositional goal orientations. Central to a task orientation is attention to the processes of successfully completing or mastering tasks: development of increased competency and knowledge, endorsement of the intrinsic value of learning as an end in itself, and the belief that appropriate effort will result in better performance. Central to an ego orientation is a focus on social comparison processes in which the individual “beats” other students or attains success based on little effort. It includes a desire to gain positive judgments and avoid negative judgments of one’s competence, external evaluations of self, endorsement of the extrinsic value of performance as a means to a desired goal, and beliefs that ability is a relatively fixed attribute that cannot be altered by effort.

As this research is well covered in extensive reviews (e.g., Duda, 2001; Roberts, 2001; also see Pintrich, 2000), we only highlight a few features particularly relevant for the present investigation. In her review of goal orientation research in physical education and sport settings, Duda (2001) reiterated many issues examined in more general educational settings. She emphasized that task and ego goal orientations are dispositional (individual difference) variables that are reasonably orthogonal—not bipolar—when measured with the most widely used instruments in sport and physical educational settings. Because these scales are independent, she suggested the usefulness of measuring goal profiles with particular emphasis on individuals who are high in both task and ego orientations or who are low in both orientations. Implicit is the assumption that the interaction between these goal orientations provides useful information beyond what can be explained, when each scale is considered separately (i.e., their “main” effects in the language of analysis of variance).

Motivational Climate

Achievement goal theorists (Ames, 1984, 1992; Duda, 2001; Nicholls, 1989; Roberts, 2001; Treasure, 2001) have emphasized that dispositional goal orientations of the individual (e.g., task and ego goal orientations) are distinct from perceptions of the motivational climate. Thus, for example, individual students can have task and ego goal orientations, and the climate may place more emphasis on learning and task involvement or on social comparison, performance, and ego involvement. In distinguishing between individual goal orientations and classroom motivational climates, Ames (1992) suggested that learning goals are reinforced when tasks are diverse, interesting, personally meaningful, challenging, and give students a sense of control.

There is widespread acceptance of the fact that motivational goal orientations and motivational climate are likely to interact, and that motivational climates created by parents, teachers, coaches, as well as other characteristics that influence climate, can influence individual motivation and motivational goal orientations. Ames (1992), for example, emphasized how motivational climate—the structure of the environment—can reinforce specific behaviors associated with a particular goal. Dweck and Leggett (1988; also see Roberts et al., 1997) suggested an interactionist approach in which goal orientation is an individual-level variable that influences the likelihood of pursuing a particular pattern of behavior whereas situational factors such as motivational climate are seen to influence this likelihood.

Individual Motivation Constructs and Motivational Climate

Duda (2001) emphasized the need to evaluate the combined effects and interactions of individual goal orientations and perceived motivational climate on a variety of outcome measures. She lamented, however, that this is rarely pursued in motivational research. Adapting an interactionist perspective, Duda indicated that particularly strong climates might override the effects of goal orientations, whereas individuals with particularly strong goal orientations are likely to be less affected by motivational climate. Noting that the individual task and ego goal orientations are robust and reasonably stable over time, Duda reviewed research suggesting that a task-involving climate may reinforce task goal orientations whereas an ego-involving climate may reinforce ego goal orientations.

Similarly, Whitehead, Andree, and Lee (1997) reported that a high mastery climate at Time 1 in their study had a negative effect on individual ego orientation at Time 2. Ntoumanis and Biddle (1998) evaluated relationships between motivational goal orientations and motivational climate; they found that individual perceptions of an ego-involving climate were related to ego goal orientations while individual perceptions of a task-involving climate were related to task goal orientations. They interpreted this as support for a “matching hypothesis.” Duda indicated, however, that such a matching (or person-environment fit) hypothesis requires comparisons of individuals with goal orientations that differ systematically in compatibility with the motivational climates in order to test interactions between goal orientations and motivational climates.

Duda (2001) also addressed the complex issue of the causal ordering of goal orientations and motivational climates, specifically asking whether individual goal orientations change over time as a function of motivational climate. She emphasized that researchers need to consider longitudinal designs in which goal orientations and perceptions of motivational climate are measured on at least two occasions over a long enough period of time for meaningful changes to occur.

In studies of perceived motivational climate, research has focused primarily on the responses of individual group members rather than aggregated ones based on responses by members of a group. Duda (2001; also see Duda, Newton, & Yin, 1999, as cited in Duda, 2001) addressed some aspects of this issue by evaluating the within-group variability in perceived motivation climate. She proposed that a complete lack of within-group agreement would mean there was no group-level effect on perceived motivational climate. Duda et al. examined this issue using intraclass correlations (variance components) to evaluate the extent of within-group agreement and reported a significant group-level effect for both ego-involving and task-involving dimensions of the group-level climate. Duda (2001, p. 149) emphasized,

> These results have important implications for the types of analyses we employ when determining antecedents or potential consequences of differences in perceived motivational climate in sport. In particular, it appears to be incorrect to analyze the athletes in our samples (who are members of different sport teams) only as one large group, which is what we have done to date. That is, we need to separate individual and group effects in the analyses (and need large samples of athletes, as well as intact teams, in our studies!).

This observation is critically important for the present investigation, as it provides a crucial link between previous research in this area and new directions that are the focus of our study.

The Present Investigation: The Big Picture

The central variables in the present investigation are *perceived classroom climate* (Task-involving and Ego-involving) and *individual goal orientations* (Task and Ego) that we have already discussed and that are reviewed extensively in other research (Duda, 2001; Roberts, 2001; Treasure, 2001; Marsh et al., in press). In order to evaluate the effects of these motivational variables, we consider a diverse set of individual student outcomes that are logically related to our goal orientation and climate constructs, including measures of intrinsic motivation (enjoyment and effort), attitudes, physical self-concept, and indicators of physical activity (exercise intentions, perceived control, and actual exercise behavior) as well as student demographic variables (age and gender).

Research reviewed by Marsh et al. (in press) has consistently demonstrated the positive effects of task orientations and task-involving environments. However, the pattern was not as clear for ego orientations and ego-involving climates that were sometimes positively related to desirable outcomes suggesting that ego effects may interact with characteristics of the particular setting or of individuals. Thus, for example, Duda (2001) concluded that task orientation was associated positively with intrinsic motivation, perceptions of control, self-determined forms of motivation, exercise intentions, engagement in physical activity, and physical self-concept whereas ego orientation was associated with low levels of self-determined behaviors. Similarly, Biddle (2001) reported that task orientation was related to intrinsic motivation (effort and enjoyment), positive affect and attitudes, and physical activity behaviors. Roberts (2001) stressed that for individuals with an ego orientation, self-perceived physical ability and physical self-concept are harder to maintain because any sense of competence these individuals have is dependent on doing better than others, whereas individuals with a task orientation are primarily concerned with task mastery and thus are more likely to develop a positive self-concept over time. Roberts suggested, however, that the effects of ego orientation were likely to interact with task orientation. Our approach of evaluating goal orientations and climate in relation to a range of outcome variables is consistent with Duda's (2001) call to evaluate goal orientations and climates in relation to a wider variety of outcome variables.

The design of the present study was explicitly multilevel. It involved a broad selection of physical education teachers (*N* = 67) teaching a total of 200 PE classes at different levels of schooling (primary, middle, and high schools), and the individual students (*N* = 2,786) taught by these teachers. This allows us to use multilevel modeling approaches to distinguish between the effects associated with individual students, teachers, and the different classes taught by the same teacher. The design is also explicitly longitudinal in that parallel measures were collected early in the school year and again near the end of the school year. This allows us to examine the effects of T1 class climate on T2 outcomes, controlling for the parallel measures of T1 outcomes. Although a longitudinal, multilevel research design like that considered here was recommended by Duda (2001), we are unaware of any previous research that has systematically evaluated the effects of motivational climate using an appropriate multilevel framework and longitudinal data. Hence there is not a good basis for generating a priori hypotheses. Instead we outline the research questions that we wish to pursue and offer some speculations about expected outcomes based on our earlier review as an advanced organizer for the analyses we pursued.

1. Variance Components

Initially we examine the extent to which there are teacher-level effects in the variables we consider, particularly student ratings of classroom climate. These effects are indexed by variance components—the extent of agreement among students within the same class relative to differences between classes. Because each teacher also teaches multiple classes, we can also determine the extent to which effects associated with a particular teacher vary in different groups of students taught by the same teacher. Statistically significant variance components are a necessary prerequisite for supporting the construct validity of perceived climate measures.

To the extent that there is little or no agreement among students in the same class about the motivational climate, then such measures are of dubious value as measures of classroom climate. To the extent that the classroom climate does not generalize across similar classes (similar curriculum and age of students, but different groups of students) taught by the same teacher, then it may be unwarranted to claim that the classroom climate is due to the teacher. It is expected that there should be significant variance components (systematic differences between classes) for both individual student outcomes (i.e., students rate themselves) and class-level perceived motivational climate (i.e., students rate the general class climate or the teacher), but that variance components should be systematically larger for measures of perceived climate.

2. Task and Ego Goal Orientations

Task and ego goal orientations are predicted to be nearly uncorrelated, although some research suggests that the correlation may be slightly positive. Consistent with previous research, a task goal orientation is predicted to be positively correlated with all our outcome measures, particularly measures of intrinsic motivation (effort and enjoyment). Whereas previous research clearly suggests that an ego goal orientation should be less positively correlated with outcomes than a task goal orientation, it is not clear whether these relationships are positive or negative, or the extent to which the differences in the correlations vary with different outcomes.

Although most previous research has focused on correlations between motivational goal orientations, few studies have evaluated whether prior motivational goal orientations are associated with subsequent outcomes after controlling for prior measures of the outcomes. Hence our longitudinal predictions are not so well based on previous research. Nevertheless, we predict that T1 task goal orientation will have a positive effect on T2 outcomes even after controlling for the effects of parallel T1 outcomes, and that the corresponding effects of T1 ego goal orientation will be less positive than the effects of T1 task goal orientation. Finally, based on limited research, we predict a positive Task Goal × Ego Goal Orientation interaction such that students who are high in both motivational goal orientations will have particularly favorable outcomes.

3. Task-Involving and Ego-Involving Climates

Because the main focus of the present investigation was on class-average measures of climate, this will also be the focus of our predictions and research questions. Because the focus of nearly all previous research in sport and exercise psychology has been on individual student perceptions of climate, there is little research basis for predictions based on class-level measures of motivational climate. We expected that these climate variables would be relatively uncorrelated, although some research suggests that at least individual student perceptions of these climate variables may be negatively correlated. T1 task-involving climate is expected to have positive effects on T2 outcomes, whereas the effects of T1 ego-involving climate are expected to be less positive than the effects of task-involving climate. Also, we expected that a T1 task-involving climate should have a positive effect on T2 task orientation and that a T1 ego-involving climate should have a positive effect on T2 ego orientation.

Based on the logic of a "matching hypothesis" or a compatible person-environment fit, we anticipated aptitude-treatment interactions, reflecting positive effects of compatible climates and goal orientations, and negative effects of incompatible climates and goal orientations. Specifically, the effects of task goal orientations should be more positive on T2 outcomes (including subsequent task goal orientations) in classes where the task-involving climates are stronger, whereas the effects of ego goal orientations should be more positive on T2 outcomes (including subsequent ego goal orientations) in classes where the ego-involving climates are stronger (compatibility prediction). Similarly, the effects of task and ego goal orientations should be less positive in classes where the goal orientations and classroom climates are incompatible (high task goal orientations in high ego-involving classroom climates, high ego goal orientations in high task-involving classroom climates). Finally, we expected a positive Task-Involving × Ego-Involving climate interaction such that students were more advantaged in classes in which both task-involving and ego-involving climates were high.

Method

Measures

Perceived Classroom Climate Measures (Times 1 and 2). Students were asked to evaluate the motivational climate in their physical education class using Papaioannou's Learning and Performance Oriented Physical Education Climate Questionnaire (LAPOPEQ; Papaioannou, 1994): task-involving climate: perceptions of the PE teacher's emphasis on learning, a task-involving climate (7 items) (Papaioannou, 1994); ego-involving climate: perceptions of the PE teacher's emphasis on performance orientation, an ego-involving climate (6 items) (Papaioannou, 1998). Papaioannou (1994) demonstrated that responses to his instrument can discriminate between the perceptions of students in different classes and that both between- and within-class differences in motivational climate are related to individual student levels of motivation.

Individual Student Outcomes (Times 1 and 2). Student self-reports were used to measure 9 individual student outcomes: task orientation in PE classes (7 items) (Duda & Nicholls, 1992; adapted for Greek physical education by Papaioannou & Macdonald, 1993); ego orientation in PE classes (6 items; Duda & Nicholls, 1992; adapted for Greek physical education by Papaioannou & Macdonald, 1993); enjoyment: intrinsic motivation, enjoyment in PE classes (3 items) (McAuley, Duncan, & Tammen, 1989; adapted for Greek physical education by Diggelidis & Papaioannou, 1999); effort: intrinsic motivation, effort in PE classes (3 items) (McAuley et al., 1989; adapted for Greek physical education by Diggelidis & Papaioannou, 1999); attitudes toward exercise (3 items) (Theodorakis, 1994); intentions to exercise (2 items) (Theodorakis, 1994); perceived behavioral control toward exercise (3 items) (Theodorakis, 1994); actual exercise behavior in the last month (1 item) (Theodorakis, 1994); and physical self-concept (5 items) (Fox & Corbin, 1989; adapted to Greek by Diggelidis & Papaioannou, 1999).

Preliminary Confirmatory Factor Analysis. For present purposes we considered 11 factors measured at Time 1 and again at Time 2: two climate factors, task-involving and ego-involving; two motivational goal orientation factors, task and ego; and seven additional outcome factors, as well as three background variables. Hence there were a total of 25 factors inferred on the basis of responses to 95 items. In preliminary analyses we fit a highly restrictive a priori structure in which each indicator was allowed to load only on the a priori factor it was designed to measure. The factor structure was well defined, as all factor loadings were highly significant and substantial, the correlations among factors formed a logical pattern of relations, and the goodness of fit was very good in relation to traditional guidelines (e.g., root mean square error of approximation = .027). Although not a major focus of the present study, these results provided preliminary support for the construct validity of the constructs that formed the basis of subsequent analyses.

Procedures

Time 1 variables were collected shortly after the start of the school year (Sept.–Oct. 1998) whereas T2 variables were collected near the end of the school year (April–May 1999). The first data collection began at least 5 weeks after the beginning of the school year so that most students had at least 10 class sessions with the same teacher. At both times the anonymous questionnaires were distributed by nine research assistants and were completed by students in class. Student consent and permission from the Ministry of Education and the school authorities were required.

Participants

An important complication in the present study was the requirement (by law of the Greek Ministry of Education) that all questionnaires be completed anonymously. Hence, Time 1 and Time 2 cases were matched on the basis of class identification, gender, and date of birth. Because not all students provided a proper date of birth on both occasions, a large number of cases could not be matched. For present purposes we only considered classes for which there were at least 10 students at Time 1, at least 10 students at Time 2, and at least five successfully matched cases with data for Time 1 and Time 2. Excluded were teachers who did not participate in both data collections (teachers from a few schools had data only from Time 1) and classes that did not have the same PE teacher at Times 1 and 2. In preliminary analyses, we computed class-average variables for all students who completed the survey at either Time 1 or Time 2, since we did not need to identify or match students to complete class-average variables.

Next we excluded all students who did not have matched Time 1 and Time 2 responses. Hence we used class-average perception variables based on responses by 4,546 students (Time 1) and 4,390 students (Time 2) that represented a total of 200 classes taught by 67 teachers. In contrast, all subsequent analyses were based on the 2,786 students who were successfully matched for Time 1 and Time 2 responses. It is important to emphasize that many of the students who apparently had only Time 1 or only Time 2 responses actually had both Time 1 and Time 2 responses but could not be matched on the basis of available data. In summary, the main analyses were based on a broad selection of PE teachers ($N = 67$; 60% males) teaching a total of 200 PE classes at different levels of schooling (29% primary, 36% middle school, and 35% high school) as well as the individual students ($N = 2,786$; 50% boys) taught by these teachers.

Statistical Analysis: Multilevel Modeling

Variance Components. In preliminary analyses, we used a variance component model (Goldstein et al., 1998) to estimate how much of the variation in each dependent variable could be attributed to the teacher (Level 3), different classes taught by the same teacher (Level 2), and to the individual students (Level 1). Variance components were estimated for all T1 and T2 variables considered in the study. In addition, for each T2 dependent variable the corresponding T1 variable was included as the only predictor variable. This can be thought of as a variance-components model of change in responses over the T2–T1 interval. Changes in each measure—variance in each T2 measure that could not be explained in terms of the matching T1 measure—was also attributed to the teacher, class, and individual student level. Variance components can also be used to compute intraclass correlation, the proportion of variance due to teacher and class effects (i.e., sum of variance components for teacher and class divided by the sum of variance components for teacher, class, and students).

Multilevel, Multivariate, Longitudinal Path Models. The major focus of our multilevel analyses is on a set of multilevel, multivariate longitudinal path models, to test the effects of prior classroom climate and individual student motivational goal orientations on change in a set of outcome measures. In this approach, outcome measures at any one time are controlled for pretest measures collected once or more to assess residual change that can then be related to other variables. Goldstein (1995) refers to this as the "conditional" approach, noting that earlier measures are treated as covariates so that the approach is often appropriate when data are available from a small number of discrete occasions for all respondents and, perhaps, when pretest and posttest scores represent different variables. Also, the potentially difficult problem of establishing a common metric across the different measures is partially resolved and the approach seems particularly well suited for evaluating the causes of change. In the multilevel path analysis models used in the present study, the ordering of variables was determined by temporal ordering only. For each dependent variable, a set of three models was considered:

1. In Model 1 the predictor variables consisted of all background variables (gender, age, and their interaction), the T1 classroom climate variables, T1 goal orientation variables, and the entire set of T1 outcome variables corresponding to pretest measures. This set of T1 predictor variables was used to predict the set of T2 outcome measures. This is the central model in the present investigation.

2. In Model 2 a set of interaction effects was added to the predictor variables considered in Model 1. The purpose of the interaction effects was to determine whether there were interactions between classroom climate and individual student goal orientation variables.

3. In Model 3, T2 classroom climate measures were added as predictor variables (as well as T1 classroom climate measures) to determine whether the effects of classroom climate were stable over the course of the school year or whether changes in classroom climate influenced T2 outcomes beyond the effects of T1 measures of classroom climate.

These models are multilevel, multivariate, longitudinal path models. Intuitively, the analyses are like a multilevel counterpart of typical (single-level) multiple regression analyses used in path analyses. They are longitudinal in that we predict T2 outcomes from T1 responses. They are multivariate in that we simultaneously consider multiple dependent variables. They are multilevel in that the models appropriately combine effects associated with individual students, classes, and teachers (for further discussion, see Bryk & Raudenbush, 1992; Goldstein, 1995; Goldstein et al., 1998; Raudenbush & Bryk, 2002).

Data Transformations and Interaction Effects. We conducted several data transformations to facilitate interpretations and infer interaction effects. For students with successfully matched Time 1 and Time 2 responses, there was little missing data (1.5% of 61,292 responses by 2,786 students to 22 variables—the nine outcome measures and two motivational climates collected at T1 and T2). To address this issue, we implemented the Expectation Maximization Algorithm, the most widely recommended approach to imputation for missing data, as operationalized using missing value analysis in SPSS (1999).

Because there were moderate amounts of nonnormality in many of the variables, we began by using a normalizing transformation (SPSS, 1999) on each variable. We then standardized (z-scoring) all variables to have $M = 0$, $SD = 1$ across the entire sample (see Marsh & Rowe, 1996; also see Aiken & West, 1991; Bryk &

Raudenbush, 1992). In constructing these interaction effects, we used the product of individual (z-score) standardized variables (and the product terms were not re-standardized). Product terms were used to test interaction effects in Model 2. Unstandardized beta weights are reported, but because all outcome and predictor variables were standardized, these unstandardized beta weights correspond to standardized beta weights for all but the product (interaction) variables.

The representation of classroom climate measures in the multilevel models was a potential complication. The major focus of the present work was on classroom climate, and so classroom climate was represented as a class level variable—the mean classroom climate rating from all students in each class on each occasion. However, we also had some interest in the effects of individual student perceptions of classroom climate that had been the focus of previous research in this area. A potential problem is multicollinearity due to the fact that individual student perceptions and class-average perceptions were necessarily confounded to the extent that there was agreement among the students in the same class on perceptions of classroom climate (and because the responses by an individual student were also included as part of the class-average variable).

Bryk and Raudenbush (1992) noted that within a multilevel modeling framework it is appropriate to include both the individual level and group level representations, but that it may be advantageous to center the individual score at the group level mean. In this way the individual score represents the deviation of the individual response from the corresponding group mean; positive individual responses represent students with responses that are more positive than the corresponding class-average response, whereas negative individual responses represent student responses that are lower than the corresponding class-average response. Using this transformation, the relationship between classroom climate and each outcome measure is explicitly decomposed into its within- and between-group components, largely unconfounding the effects of individual student level and classroom (class-average) measures of climate.

Based on this strategy, classroom climate in our multilevel models is represented at Level 2 (classroom) as the class-average mean of students in each class, and at Level 1 (student) as the deviation between the response by the individual student and the class-average mean of the students' class. It is important to emphasize that the variance explained by models in which the individual student perceptions are represented as deviations from the class-average response in their class is the same as when individual student responses are represented as raw scores (see Bryk & Raudenbush, 1992); this represents a transformation of the original variables that provides a more useful representation of classroom climate perceptions at the different levels of analysis.

Model 3 contains both T1 and T2 measures of climate as predictor variables of T2 outcomes. This also produced potential multicollinearity problems to the extent that T1 and T2 measures were highly correlated. To circumvent such problems, we transformed both correlated variables to represent the sum (T1 + T2) and difference (T2 – T1) of the two variables. The sum represents the effect of classroom climate perceptions that are stable over time, whereas the difference represents perceived changes in classroom climate over the course of the school year. Again, note that the variance explained by models in which T1 and T2 classroom climate were represented as the sum and difference of the two scores was the same as when classroom climate was represented by the original T1 and T2 scores; this denotes a transformation of the original variables that provided a more useful representation of classroom climate perceptions.

Results

Teacher, Class, and Students Effects: Variance Components

Variance components, the effects of the teacher and class for the various motivational climate and outcome variables considered here, are listed in Table 1. Because almost all teachers taught several classes, the results also provided the unusual opportunity to unconfound the effects of the teacher and the group of students in a particular class. To the extent that class effects are due to the generalizable characteristics of the teacher, the teacher variance components should be substantially larger than the class variance components. The results also provided the opportunity to evaluate the stability of these class- and teacher-level effects over time in separate analyses of T1 and T2 responses, and for changes over time.

Motivational Climate. Particularly for perceived motivational climate variables, it is important to establish agreement among students in the same class. Without such agreement, support for the construct validity of the perceived climate ratings is dubious. For task-involving climate, the intraclass correlation (variance explained by teacher and class effects, see Table 1 footnote) was statistically significant and substantial (e.g., greater than 10% of the variance explained) for T1 and T2 (.201 and .188; Table 1). Furthermore, most of this variance was due to the effect of the teacher rather than the different classes taught by the teacher (the effect of class is small at T1 and not even statistically significant at T2). Whereas much of the variance in T2 ratings can be explained in terms of T1 ratings, the intraclass correlation (.101) for perceived changes in task-involving climate was still substantial, and most of this was attributable to the teacher rather than the particular class taught by the teacher. For perceived ego-involving climate, the intraclass correlation coefficients (.080, .059, and .043 for T1, T2, and T2–T1 changes, respectively) were smaller than for perceived task-involving climate. Furthermore, some of this modest agreement was associated with the particular class rather than the teacher. Hence these results provide good preliminary support for the construct validity of task-involving climate ratings, but support for the ego-involving climate ratings is somewhat weaker.

Variance components provide an estimate of the average correlation between any two students in the same class. Although these values are modest, the reliability of class-average ratings depends substantially on the number of students in a class, in the same way that the reliability of a test depends not only on the average correlation among items but the number of items (see Marsh, 1987). Hence, based on a typical class size of 30 students, the reliability of the class-average climate ratings would be .88 for task-involving climate (based on an intraclass correlation of .20 at T1) and .72 for ego-involving climate (based on an intraclass correlation of .080 at T1).

Motivational Goal Orientations and Other Outcomes. Interpretations of variance components are somewhat different for individual student outcomes. Here students were rating themselves in terms of characteristics that may or may not be similar to those of other students in their same PE class. However, to the extent that there are systematic differences due to teachers and classes, it is reasonable to

Table 1 Variance Attributable to Differences Due to Teachers, Different Classes Taught by Same Teacher, and Individual Students

Variance Components:	Teacher			Class			Student			Intraclass Correlation[†]		
	T1	T2	T2/T1	T1	T2	T2/T1	T1	T2	T2/T1	T1	T2	T2/T1
Perceived Motivational Climate												
Task-involved climate	**.167**	**.166**	**.071**	**.037**	.021	.007	**.809**	**.810**	**.693**	.201	.188	.101
Ego-involved climate	**.052**	.006	.006	**.028**	**.053**	**.032**	**.925**	**.940**	**.846**	.080	.059	.043
Individual Motivational Goal Orientations												
Task orientation	**.072**	**.087**	**.040**	**.034**	.015	.016	**.899**	**.897**	**.761**	.105	.102	.069
Ego orientation	.009	.006	.009	.008	**.026**	.020	**.983**	**.968**	**.796**	.017	.032	.035
Other Outcomes												
Enjoyment	**.192**	**.191**	**.075**	**.039**	**.034**	.016	**.771**	**.774**	**.663**	.231	.225	.121
Effort	**.243**	**.225**	**.079**	**.029**	.011	–.004	**.733**	**.755**	**.651**	.271	.238	.103
Attitude	**.024**	.011	.006	.018	–.002	–.005	**.958**	**.991**	**.889**	.042	.009	.001
Exercise intention	**.076**	**.103**	**.039**	**.034**	.014	.004	**.891**	**.881**	**.706**	.110	.117	.057
Perceived control	**.108**	**.168**	**.055**	**.048**	**.022**	.007	**.844**	**.810**	**.628**	.156	.190	.090
Behavior	**.079**	**.103**	**.079**	**.031**	.008	–.001	**.894**	**.887**	**.771**	.110	.111	.092
Physical self	**.119**	**.074**	**.021**	.005	.010	.014	**.881**	**.916**	**.744**	.123	.084	.045
Individual Motivational Goal Orientations												
Task orientation	**.072**	**.087**	**.040**	**.034**	.015	.016	**.899**	**.897**	**.761**	.105	.102	.069
Ego orientation	.009	.006	.009	.008	**.026**	.020	**.983**	**.968**	**.796**	.017	.032	.035

Note: For each outcome variable, individual student responses were evaluated in terms of the proportion of variance that can be explained in terms of the teacher, the different classes he/she taught, and residual variance due to individual students. Separate analyses were done for T1 responses, T2 responses, and change in responses over the T2-T1 interval (T2/T1, predicting the T2 response controlling for the matching T1 responses). Variance components more than twice their standard errors (those in bold) are statistically significant, $p < .05$.

[†] Intraclass correlations are the sum of variance components for teachers and classes divided by the sum of variance components for teachers, classes, and students, i.e., the proportion of variance due to teachers and classes. The sum of variance components for teachers, classes, and students (i.e., teacher + class + student) is approx. 1.0 for T1 and T2 for each variable because each variable was standardized ($M = 0, SD = 1$), whereas that for T1/T2 analyses is the sum of variance components for T2 responses less the variance that can be explained by T1 responses to the same variable.

evaluate the extent to which these class-level differences can be explained in terms of class-level variables such as class motivational climates which were the focus of the present work. The task and ego goal orientation variables were particularly interesting in that they more or less parallel the task-involving and ego-involving climate variables. Not surprisingly, the variance components for these individual student level variables were substantially smaller than the corresponding climate variables. There are some parallels, however, in that the variance components for task goal orientations were systematically larger than those for ego goal orientations. Also similar to the perceived climate measures, most of the variance associated with task orientation was due to the teacher whereas some of the variance associated with ego orientation was due to the particular group of students in a class rather than to the teacher per se.

The variance components for the two intrinsic motivation variables, enjoyment and effort, were surprisingly large. Not only were they substantially larger than any of the individual student outcome variables, but both were also larger even than the variance components associated with perceived task-involving climate. A closer look at the wording of these items, however, suggests why this might be the case. In each item, students were asked to rate their effort and enjoyment in their physical education classes, not their effort and enjoyment of physical exercise more generally. Hence it is not surprising that there are substantial differences between classes in relation to these outcome variables.

The next set of four outcome variables refers to attitudes, perceived control, intentions, and actual behavior in terms of physical exercise. These variables form the basis of motivational models such as Ajzen's (1988) theory of planned behavior. Although the Greek physical educational classes do not have an explicit intent to increase the levels of physical exercise of their students, this is a reasonable outcome of PE classes. These results indicated that variance components were very small for attitudes toward exercise, but larger for intentions, perceived control, and actual exercise behaviors. Furthermore, much of the systematic differences are due to the teacher rather than to the class.

The final outcome variable, physical self-concept, is important in many educational and sport settings. Whereas the variance components for T1 responses, and to a lesser extent T2 responses, were moderate, the intraclass correlation for self-concept changes over the course of the school year (.045) was not substantial.

In summary, a look at the intraclass correlations and variance components provides somewhat mixed results in terms of support for motivational climates and teacher effects on the set of individual student outcome variables. For motivational climates, the results are encouraging for task-involving climates but somewhat weaker for ego-involving ones. For the individual student outcome variables, there were large effects of the class and teacher for those variables that directly referred to the PE class (effort and enjoyment), but more modest effects for the more general outcome (exercise, goal orientations, and physical self-concept) measures where the focus was the individual student.

Effects of Climate on T2 Outcomes

Table 2 summarizes the results of a multivariate multilevel model (Model 1) relating climate variables to our set of nine T2 outcomes after controlling for student background variables and the parallel set of T1 outcome variables. This analysis is probably conservative in relation to showing the effects of climate variables, for

Table 2 Model 1. Effect of Time 1 Class Climate on Time 2 Outcomes Controlling for Effects of Time 1 Outcomes and Background Variables

Time 1 predictor variables	Dependent Variables: Time 2 Outcomes								
	Task-orient.	Ego-orient.	Enjoyment	Effort	Attitude	Intention	Control	Behavior	Phys S-C
Background									
Age	**–.09**	.04	**–.12**	**–.17**	–.04	**–.09**	**–.12**	**–.12**	**–.06**
Sex	.02	**–.10**	**–.04**	–.03	**.06**	–.02	–.01	**–.09**	**–.15**
Age × Sex	–.00	–.01	–.02	**–.04**	–.01	**–.05**	**–.04**	**–.05**	–.01
Time 1 Motivatonal Orientations									
Task-orientation	**.23**	–.03	.02	**.05**	**.05**	.03	.02	**.05**	.01
Ego-orientation	.01	**.37**	–.03	–.01	**.04**	.01	.00	–.01	**.08**
Time 1 Other Outcomes									
Enjoyment	.03	–.01	**.28**	**.07**	-.00	.02	.01	.01	**.04**
Effort	**.10**	**–.04**	**.04**	**.28**	.02	.01	.03	**.04**	.00
Attitude	.01	.03	–.02	–.03	**.27**	.02	–.02	–.01	.01
Intention	**.05**	–.01	.03	.02	**.08**	**.25**	**.14**	**.14**	.02
Control	.03	–.01	**.04**	.03	.00	**.16**	**.29**	.04	**.07**
Behavior	**.04**	.02	.01	.01	**.06**	**.13**	**.13**	**.26**	**.05**
Physical Self	**.07**	**.10**	.02	**.05**	–.02	**.07**	**.09**	**.07**	**.30**
Climate Variables									
Ind Task-C	**.08**	–.03	**.11**	**.06**	.03	.01	.02	–.03	–.00
Ind Ego-C	**–.05**	**.06**	–.01	.00	**–.07**	**–.04**	–.02	.00	.03
Class Task-C	.03	.01	**.14**	**.08**	–.00	**.04**	**.08**	.02	–.01
Class Ego-C	–.02	**.05**	–.02	.02	–.03	.02	**.04**	.02	**.05**
Residual Variance Components									
Teacher	.015	.020	.029	.020	.002	.003	.005	.014	.013
Students	.729	.772	.649	.625	.862	.660	.588	.720	.709

Note: All outcome and predictor variables were standardized ($M = 0$, $SD = 1$) so that beta weights correspond to standardized beta weights. All beta weights are statistically significant (those in bold) when they differ from zero by more than 2 standard errors. Climate variables consisted of class-average responses (mean response of students in each class) and individual student perceptions (using class-centered deviation scores). Ind Task-C = Individual task climate; Ind Ego-C = Individual ego climate.

two interrelated reasons. First, our climate variables were based on student ratings collected reasonably early in the year. Hence the results may not be an appropriate reflection of motivational climates developed over the course of the school year. Second, we were evaluating effects on T2 outcomes after controlling for the substantial effects of T1 outcomes. Because T1 outcomes were collected after the start of the new school year (at the same time as T1 climate variables), it is reasonable to suppose that some effects of the PE class were already experienced at T1. Hence it is possible that controlling T2 outcomes for T1 outcomes overcorrects, misattributing some true class effects as preexisting differences.

For each T2 outcome variable summarized in Table 2, the largest effect was the corresponding T1 outcome measure. This of course was not surprising, in that these variables were expected to be at least moderately stable over this period. Because the effects of the corresponding T1 variable have been controlled, however, the effective outcome measures are measures of change (i.e., T2 measures adjusted for the corresponding T1 measure). In evaluating the results of these analyses, our main focus is on the effects of motivational climate measures, and to a lesser extent the motivation goal orientations.

Effects of Motivational Climates. Our major focus is on the effects of class-level perceptions of motivational climate at T1 on T2 outcome variables. For this study we refer to class-average ratings of classroom climate as measures of motivational climates and distinguish these from individual student ratings of classroom motivation. Task-involving climate at T1 (i.e., class-average ratings of task-involving climate) had significant effects on four T2 outcomes (enjoyment, effort, exercise intentions, and perceived control), and all these effects were positive. Ego-involving climate at T1 had significant effects on three T2 outcomes (ego orientation, perceived control, and physical self-concept), and all these effects were also positive (see classroom ego-involving climate in Table 2). Individual perceptions of task-involving climate, the extent to which individual student perceptions differed from those of the class average, were significant for three T2 outcomes (task, enjoyment, and effort), and all three were positive (i.e., perceiving the task-involving climate to be stronger than did other students in the same class was positively related to subsequent outcomes). Individual perceptions of ego-involving climate were significant for four T2 outcomes (task, ego, attitudes, and intentions to exercise); three of the four (all but ego) were negative. Hence, perceiving the ego-involving climate to be stronger than did other students in the same class tended to be negatively related to subsequent outcomes.

Effects of Motivational Goal Orientations. It is also of interest to evaluate the extent to which T1 motivational goal orientations had significant effects on T2 outcomes beyond the effects of the motivational climate variables. Because the matching T1 outcome variable is one of the predictor variables for each T2 outcome, we are relating changes in outcomes to T1 orientations. T1 task orientation had significant effects on four of nine T2 outcomes (T2 task, effort, attitude, and exercise behavior), and all of these were positive. T1 ego orientation had significant effects on three outcomes (T2 ego, attitudes, and physical self-concept), and all these effects were positive.

Effects of Other T1 Variables on T2 Outcomes. The longitudinal design of the study provides a strong basis for evaluating the effects of a variety of T1 outcomes on T2 outcomes after controlling for the effects of T1 variables. Summarized in Table 2 are the effects of nine T1 outcomes collected early in the school year on a parallel set of nine T2 outcomes (including the two motivation goal orientations). A total of 38 of these 81 effects were statistically significant, and all but one was positive. Again, not surprisingly, the largest effect of each T1 construct is its effect on the matching T2 outcome. Particularly impressive were the effects of T1 intentions to exercise, actual exercise behavior, and physical self-concept in that each of these T1 variables had positive effects on a majority of the T2 outcomes.

Although not a focus of the present work, these results provide support for the reciprocal-effects model of academic self-concept and achievement (Marsh, Byrne, & Yeung, 1999) in a PE setting and an interesting application of multilevel modeling for evaluating such models. In particular, prior (T1) physical self-concept had significant positive effects on subsequent (T2) levels of physical activity behavior beyond the effects of prior (T1) physical activity behavior, even after controlling for the effects of the many other T1 variables. However, prior (T1) physical activity behavior had significantly positive effects on subsequent (T2) physical self-concept beyond the effects of prior (T1) physical self-concept. Hence the pattern of relationships between physical self-concept and physical activity behavior are reciprocal in that each is both a cause and an effect of the other.

There is also considerable and ongoing interest in relationships between these student characteristics such as gender and age, and our outcome variables. Results considered here are for changes in outcomes during the school year (i.e., T2 outcomes controlling for the effects of parallel T1 measures). Consistent with previous research and our earlier results, seven of nine outcome variables decline significantly with increasing age. The exceptions are ego goal orientations and exercise attitudes which are not significantly related to age. Girls had a significantly lower physical self-concept than boys, but they also had significantly lower scores in terms of exercise behavior, ego goal orientations, and enjoyment of PE classes. Girls, however, had significantly more positive attitudes about physical exercise than boys did. Although Gender × Age interactions were not large and only reached statistical significance for four of nine outcomes, these effects suggest that gender differences were increasing with age.

Motivational Climate and Goal Orientation Variables

In the next stage of the analyses, six interaction effects were added to Model 1 to form Model 2 (Table 3); these represented the interaction between the two goal orientation variables (task and ego), the one between the two class-average motivational climate variables (class-average task-involving and ego-involving climates), and the four possible two-way interactions between climate and goal orientation variables. Results are based on the entire set of 54 interaction effects (6 interactions per outcome × 9 outcomes). The interaction effects were not very large. Despite the large sample size, only 11 reached statistical significance and many of these were only significant at $p < .05$. Furthermore, the significant interactions were not easily summarized and do not seem particularly consistent with expectations.

There was some expectation of a positive interaction between task and ego orientations—that outcomes would be highest for students high on both orientations—but there was little support for this suggestion. Although 5 of the 10 significant interactions did involve the Task × Ego interaction, three of these were negative: task orientation, enjoyment, and attitudes. Only for physical self-concept and ego orientation were there positive Task × Ego orientation interactions. In summary, there was little support for the positive interaction between task and ego orientations.

There was also some expectation that the Task Orientation × Task-Involving climate and the Ego Orientation × Ego-Involving climate would interact positively (i.e., the compatibility part of the matching hypothesis). Thus we might expect that a task-involving climate would be most advantageous for students with a task motivational goal orientation, whereas an ego-involving climate would be

Table 3 Model 2. Effects of Individual Student Goal Orientations and Class Climate Variables (main effects) and Their Interactions

Time 1 Predictor Variables	Dependent Variables: Time 2 Outcomes								
	Task-orient.	Ego-orient.	Enjoy-ment	Effort	Atti-tude	Inten-tion	Con-trol	Beha-vior	Phys S-C
<u>Goal Orientations</u>									
Task-orientation	**.23**	–.02	.02	**.05**	**.04**	.03	.02	**.05**	.01
Ego-orientation	.02	**.36**	–.02	–.01	.04	.01	–.00	–.01	**.07**
<u>Motivational Climate</u>									
Task-C	**.05**	.02	**.18**	.11	–.00	**.04**	**.08**	.02	–.01
Ego-C	–.03	**.06**	**–.05**	.03	–.03	.03	**.05**	.04	**.05**
<u>Interactions</u>									
Task-O × Ego-O	**–.03**	**.03**	**–.03**	–.01	**–.04**	.00	.02	–.02	**.05**
Task-O × Task-C	–.03	.03	–.03	.01	–.01	–.02	.00	.02	.00
Task-O × Ego-C	**–.09**	–.00	.02	–.01	–.03	–.01	–.01	–.02	–.02
Ego-O × Task-C	–.01	**–.06**	.01	–.03	**.04**	–.01	–.01	–.02	**–.04**
Ego-O × Ego-C	.03	–.01	.01	.02	.01	–.01	–.01	.02	.02
Task-C × Ego-C	**.07**	–.01	**.05**	–.01	.02	–.01	–.03	.01	.02

Note: All outcome and predictor variables were standardized (M = 0, SD = 1) so that beta weights correspond to standardized beta weights. All beta weights are statistically significant (those in bold) when they differ from zero by more than 2 standard errors. Climate variables consisted of class-average responses (mean response of students in each class) and individual student perceptions (using class-centered deviation scores).

more advantageous for students with an ego motivational goal orientation. In contrast to expectations, neither of these interactions was statistically significant for any of the nine outcomes.

However, there was some support for the incompatibility component of the matching hypothesis. In particular, the positive effect of T1 task goal orientation on T2 task goal orientation was substantially undermined by a high ego-involving motivational climate. In a similar manner, the positive effect of T1 ego goal orientation on T2 ego goal orientation was substantially undermined by a strong task-involving motivational climate. There were four significant interactions involving incompatible constructs (Task Orientation × Ego-Involving climate or Ego Orientation × Task-Involving climate); three out of four of these were negative: Task Orientation × Ego-Involving climate on T2 task orientation; Ego Orientation × Task-Involving climate on T2 ego orientation; Ego Orientation × Task-Involving climate on T2 physical self-concept. Only the effect of the Ego Orientation × Task-Involving climate interaction on attitudes toward physical exercise was positive. In summary, there was no support for the positive effects of compatible goal orientations and motivational climates, but there was limited support for the negative effects of incompatible goal orientations and climates.

Two statistically significant interactions involved the Task-Involving × Ego-Involving climate. Interestingly, both were positive. The effect of a high task-involving climate on T2 task orientation was positive when the ego-involving climate was also very strong, but it was negative when the ego-involving climate was weak. Also, the positive effect of a strong task-involving climate on T2 enjoyment was even more positive when there was also a strong ego-involving climate.

Influence of Time 2 Motivational Climate

Because the T1 responses were collected early in the school year, we were concerned that the effects of T1 motivational climate might underestimate the effects of motivational climate during the ensuing school year. For this reason we added T2 climate measures to Model 2 to form Model 3 (Table 4). We also note, however, that caution is needed when evaluating these results, as the temporal ordering of the T2 outcome variables and the T2 motivational climate variables is not so straightforward. For present purposes, we transformed the T1 and T2 variables to represent the sum the T1 and T2 responses and the difference between T1 and T2 responses. It is important to note that this is a simple transformation of the data, as the set of T1 and T2 scores were equivalent to the set of sum (T1 + T2) and difference (T2 – T1) scores in terms of how much variance can be explained.

For class-average climate measures, there was a consistent pattern of results. Classroom task-involving climate demonstrated significant effects for five of nine outcomes. The effects of the T1 + T2 were significant for five outcomes (task orientation, enjoyment, effort, intention, and perceived behavioral control) whereas the effects of an increase in task-involving climate over time (T2–T1) were significant for three of these five variables (task orientation, enjoyment, and effort). The effects of the sum of the climate measures (T1 + T2) were consistently

Table 4 Model 3. Combined Effects of T1 and T2 Climate Variables

Time 1	Dependent Variables: Time 2 Outcomes								
Predictor Variables	Task-orient.	Ego-orient.	Enjoy-ment	Effort	Atti-tude	Inten-tion	Con-trol	Beha-vior	Phys. S-C
Classroom Climate Variables									
Task-C T2+T1	**.15**	.02	**.30**	**.21**	.01	**.07**	**.09**	.02	.02
Task-C T2–T1	**.10**	–.01	**.11**	**.09**	.00	.02	–.01	–.01	.02
Ego-C T2+T1	–.02	**.11**	–.03	.02	–.02	.02	**.04**	.02	**.11**
Ego-C T2–T1	–.01	**.08**	–.01	–.01	.02	–.01	–.02	–.00	**.07**

Note: All outcome and predictor variables were standardized (M = 0, SD = 1) so that beta weights correspond to standardized beta weights. All beta weights are statistically significant (those in bold) when they differ from zero by more than 2 standard errors. Predictor variables consist of class-average classroom climate responses at T1 and T2. Each pair of corresponding T1 and T2 climate variables (TSK-C = task-involving and EGO-C = ego involving) were used to construct new variables representing the sum of T1 and T2 climate variables (T1+T2) and the difference in T1 and T2 climate variables (T2 – T1). To conserve space, only new climate variables based on T1 and T2 responses that were added to Model 2 (see Table 3) to form Model 3 are shown here.

larger than the effects of changes in motivational climate (T2–T1). All statistically significant effects (high task-involving climate and increases in task-involving climate) were positive. Classroom ego-involving climate demonstrated significant effects for ego orientation, physical self-concept, and perceived behavioral control. For all three, the effects of the sums (T1 + T2) of the ego-involving climate measures were positive whereas increases in ego-involving climate (T2–T1) were significant for two of these variables.

These results are consistent with those based only on T1 climate measures (Table 2). T1 task-involving climate alone had significantly positive effects for four of the five outcomes that were significantly influenced by the sum (T1 + T2) of the task-involving climates. T1 ego-involving climate had significantly positive effects for all three outcomes significantly affected by the sum (T1 + T2) of the ego-involving climates. The combined effects of T1 and T2 climate variables, however, were systematically larger than those of T1 climate measures alone.

Discussion

The present investigation offers important methodological and substantive contributions to sport and exercise psychology. Although we have attempted to discuss these sets of contributions separately, it is important to emphasize that good substance and good methodology are inexorably intertwined, such that neglect of one undermines the other. In the present study, the application of new methodological approaches (multilevel, multivariate, longitudinal path models) allowed us to address substantively important questions that could not appropriately be addressed with single-level approaches.

Statistical and Methodological Contributions

Statistical Contributions. The statistical and methodological contributions are to demonstrate advances in the application of multilevel modeling to sport and exercise psychology. Single-level analyses typically violate statistical assumptions in a way that positively biases the tests of statistical significance when individual participants (athletes, students, or other members of a group) are clustered into groups (teams, classes, or gyms). Methodologically, this multilevel approach allows researchers to pursue important new questions about the simultaneous effects of individual- and group-level variables, how the effects of individual-level constructs vary from group to group, and how group variables influence individual ones. Although our focus was on psychological variables, the multilevel approach is also well suited to the evaluation of physical indices (e.g., fitness, strength, aerobic power, body composition) and performance measures. This approach also offers important advantages in evaluating how the effects of experimental interventions vary in multiple settings (different countries, teams, schools, or gyms) and how characteristics of these different settings interact with the intervention.

Even if a researcher has absolutely no substantive interest in any multilevel issues (which would be difficult to justify), multilevel analyses are still a more appropriate statistical approach than corresponding single-level analyses when the data have a multilevel structure. Consider for example a simple intervention study in which students from 10 classes (20 students per class) were randomly assigned to a physical activity enhancement program and students from 10 other classes were randomly assigned to a no-treatment control group. A single-level analysis (e.g., a *t*-test with df = 398, comparing postintervention physical activity for the 200 experimental students and the 200 control students) would be inappropriate because it ignores violation of independence associated with the multilevel structure of the data. Furthermore, this violation is particularly worrisome because the direction of the bias is to increase the likelihood of Type I errors (concluding that there was a significant difference when there was none).

The problem is that the estimated error term is likely to be systematically smaller (by a factor of 2 or 3 or more in many cases) when the data have a multilevel structure than if participants had truly been selected at random. The extent of this bias depends in part on the ratio of the number of classes to the number of students. In the extreme, when there are only two classes, with one class being given an experimental intervention while the other is not, there is little statistical justification for claiming that the effects of the intervention are statistically significant, since the effects are completely confounded with differences between the two classes.

When the data have a multilevel structure, it may be appropriate to conduct a single-level analysis on class-average means (e.g., a *t*-test with df = 18, comparing postintervention physical activity for the 10 experimental classes and the 10 control classes), but this test of statistical significance is unduly conservative in almost all applications. The more appropriate analysis would be a simple multilevel analysis in which students (Level 1) were nested within classes (Level 2) and the effect of the intervention on the individual student measure of physical activity was tested for statistical significance. However, the multilevel analysis would provide a much more heuristic basis of inference. Thus, for example, if the variance component associated with the intervention effect did *not* vary significantly as a function of classes, the results would provide strong support for the generalizability of the results of the intervention (positive, negative, or nonsignificant) across the different classes. If the variance component associated with the intervention *did* vary significantly as a function of classes, then the researcher could evaluate a priori (or, with appropriate caution, post hoc) explanations for such differences. Thus, for example, the effects of the intervention might vary with the quality of the implementations that were idiosyncratic to each class, individual student characteristics that differed from class to class (e.g., pretest levels of physical activity that were confounded with class differences), or class-level constructs (e.g., classroom climate). In summary, multilevel modeling has a very wide range of applicability in sport and exercise research whenever individual participants are clustered into explicit, implicit, or de facto groups.

Methodological Contributions. We began our research with a preliminary confirmatory factor analysis, providing support for the a priori factor structure consisting of three background variables, 11 T1 factors, and 11 corresponding T2 factors. These results provided clear support for the construct validity of our measures and a solid starting point for our subsequent analyses (even highly sophisticated statistical procedures require good measures). Next we pursued variance-components models that partition variance into components associated with teachers, different classes taught by the same teacher, and students. Normally it is not possible to unconfound the effects of the teacher (or coach) from the characteristics of students in a particular class (or team). In the present work we were able to disentangle these effects because there were multiple classes taught by each teacher. Hence an important contribution was to demonstrate that, particularly for perceptions of classroom task-involving climates, the effects of individual teachers generalized across different classes taught by the same teacher.

Motivational studies are typically correlational ones in which motivational variables are merely correlated with outcome variables collected at the same time. Although such research can provide important findings about the pattern of relationships among different variables, this design is inherently weak in providing evidence about the causal effects of motivational variables on subsequent outcomes. Causal interpretations should always be made with caution, but stronger inferences are warranted in multiwave, multivariable studies in which the same variables are measured more than once. In the present study, for example, we demonstrated that the motivational variables—both classroom climate and individual goal orientations—had positive effects on many T2 outcome variables beyond the effects to T1 outcome variables.

Substantive Contributions

Substantively, we demonstrated the relevance of this multilevel modeling approach by evaluating the simultaneous effects of classroom motivational climates in PE classes and the motivational goal orientations of individual students in these classes. Although the motivational goal orientation of the individual participant is clearly an individual-level variable, climate should be inferred at the level of the group, typically the classroom or team level in sport and exercise psychology research. In our physical education context, we found that class-average task-involving climate perceptions and individual student task orientations had positive effects on changes over time in a diverse set of outcome measures. On the other hand, less positive results emerged concerning the effects of ego-involving climate perceptions and individual student ego-orientation on outcome measures. Importantly, these issues are also relevant to studies of team climate where participants are individual athletes. Indeed, the effects of team climate in many sporting contexts are likely to be more intense and stronger than those in the typical PE classroom setting.

Independence of Task and Ego Constructs. Consistent with the literature, we found that class-average task-involving climate perceptions promote intrinsic motivation in PE (effort and enjoyment), exercise intentions, and perceived behavioral control toward exercise (Biddle, 2001; Papaioannou & Theodorakis, 1996). It also emerged that task orientation and individual perceptions of task-involving climate facilitated effort and enjoyment in the lesson as well as positive attitudes and intentions about exercise. Class-average ego-involving climate perceptions and ego orientation had positive effects on physical self-concept but no effect on intrinsic motivation. However, individual differences in ego-involving climate perceptions had negative effects on task orientation, and on exercise attitudes and intentions. Also, when high task orientation was combined with high ego orientation, there were positive effects on physical self-concept and negative effects on enjoyment and exercise attitudes. Whereas these findings are encouraging for promoting task orientation in physical activity contexts, they are not so supportive of ego goal orientations. Considering the positive association of ego orientation with aggression and immorality in sport and education contexts (Anderman, Griesinger, & Westerfield, 1998; Duda, Olson, & Templin, 1991; Papaioannou, 1997), one should be cautious about the value of ego orientation in PE settings.

The effects of T1 motivational climates on T2 outcomes were statistically significant, but modest, for many outcomes. We suggested that these effects might have been larger if motivational climates had been measured later in the school year when classroom climates were better established. Consistent with this suggestion, we found that classroom climate measures that combined both T1 and T2 class-average climate ratings had substantially larger effects than T1 measures alone. In order to minimize multicolinearity problems, we represented T1 and T2 climate variables as the sum (T1 + T2) and the difference (T2 – T1) of the corresponding measures. Whereas the strongest and most consistent evidence was for the sum of the matching T1 and T2 variables, there was also evidence of some positive effects associated with classes, in which the task-involving climate and the ego-involving climate were perceived to become stronger over the course of the year. Whereas these results provide systematically stronger support for the effects of motivational climate than do the results based on T1 motivational measures, the results should also be interpreted with caution because of the potential confounding of T2 outcomes and T2 climate.

In future research it might be useful to have three waves of data: T1 that is clearly before the classroom climate has been established (e.g., the first day of school) to provide pretest measures that are not contaminated with subsequent climate effects; T2 that is sufficiently after the formation of groups so that the climate is well established; and T3 that is near the end of the year to provide appropriate outcome measures for evaluating the effects of climate. The inclusion of more than two waves of data would provide a stronger basis for disentangling potential confounding between individual level outcomes and classroom motivational climate.

Historically, researchers have assumed that individual task and ego orientation factors were substantially negatively correlated (see Murphy & Alexander, 2000; Pintrich, 2000), or even that they represented bipolar opposites of a single underlying continuum in which the endpoints of the continuum were represented by task and ego orientations. Similarly, task-involving and ego-involving climates were seen as opposed to each other. Consistent with a growing body of research, we found that individual task and ego orientations were nearly uncorrelated—indeed the correlation was slightly positive. Interestingly, we also found that task-involving and ego-involving climates were nearly uncorrelated. Whereas there is a growing body of research showing that task and ego orientations are not bipolar opposites, and are not even substantially negatively correlated, the research has been less clear about documenting the independence of the task-involving and ego-involving classroom climates. Also clearly inconsistent with a bipolar representation of these motivational constructs was the finding that statistically significant effects of both individual task and ego orientations, and of classroom task-involving and ego-involving climates, were positive.

Interactions Between Individual Goal Orientations and Class Climates. Because these two goal orientations are clearly distinct constructs, it is reasonable to test interactions between the two individual goal orientations. We suggested there would be a positive interaction between task and ego orientations (outcomes would be highest for students high on both orientations), but there was little support for this proposal in the present investigation. There was, however, some support for a positive interaction between classroom task-involving and ego-involving climates.

Typically, previous research has not evaluated simultaneously the effects of both individual goal orientations and classroom climates adopting a multilevel approach. Hence there has been little basis for positing interactions between goal orientations and classroom climates. Here we posited a "matching hypothesis" in which students were deemed to be advantaged if their own goal orientation matched the climate of their classroom, i.e., a task orientation in a task-involving climate and an ego orientation in an ego-involving climate. However, there was no support for the compatibility aspect of the matching hypothesis. But there was some support for the negative effects of incompatible goal orientations and classroom climates. Thus the strong positive effect of T1 task orientation on subsequent T2 task orientation was undermined by a high ego-involving motivational climate, whereas the strong positive effect of T1 ego orientation on T2 ego orientation was undermined by a strong task-involving motivational climate. Importantly, the systematic evaluation of interactions between individual- and group-level variables is only possible in studies with appropriate multilevel designs and statistical analyses which take into account the multilevel structure of the data.

Similar findings emerged in a recent intervention in physical education aiming to cultivate a high task-involving climate (Diggelidis, Papaioannou, Laparidis, & Christodoulidis, 2003). In this study there was no substantial attempt to affect the ego-involving climate. Nevertheless, it emerged that the negative effects of the task-involving climate intervention on individual student ego-orientation were even greater than the positive intervention effects on task orientation. It seems that high ego-oriented students have few opportunities to exhibit their abilities in high task-involving climates, and this undermines their ego-orientation. Likewise, the preoccupation of high ego-involving PE classes with competitive games leaves little space for drills and exercises aimed at skill development. In this environment, high task-involving students cannot accomplish their goals and thus their task orientation is undermined.

Interestingly, a combination of high task- and high ego-involving climate had positive effects on both task orientation and enjoyment, whereas the effects of an ego-involving climate were negative when the task-involving climate was low (see related discussion by Treasure, 2001). This interaction between task-involving climate and ego-involving climate is explicable in the Greek PE environment in which good teachers typically begin classes with a structured skill development session followed by a session of competitive games to reinforce student enjoyment. The present findings seem to support these expectations. Although support is not particularly strong, this suggests that a good teacher can effectively combine a task-involving climate with some aspects of an ego-involving climate such that the effects of the ego-involving climate are positive. Whereas this interpretation is highly heuristic, there is clearly a need for further research to replicate this finding and to further evaluate how an ego-involving climate can be effectively combined with a task-involving climate.

Potential Limitations

Meaningfulness and an Effect Size Metric. Particularly in the social sciences, there is the ongoing quest for "magic rules" that allow researchers to translate effect sizes to some meaningful metric to which researchers can, independent of the context of the study, ascribe verbal labels such large/small, substantial/insubstantial, etc. This is typically inappropriate as the interpretation is usually highly dependent on the particular application. A "small" effect size may be highly important in one context and yet the same effect size may be unimportant in another context. Thus, for example, in Model 1 (Table 2) the largest effect for each T2 outcome is typically the effect of the corresponding T1 variable. Although relevant, this is hardly a surprising and may not be a highly important result. Some of the other effects, particularly those of the goal-orientation or class-climate variables, are more important even though their effects are smaller in size. However, in order to facilitate interpretations of the results, we standardized all variables prior to the multilevel analyses so that the coefficients would be in standard deviation units. Thus, a change in 1 *SD* in the independent variable is expected to result in a change equal to the beta coefficient (in *SD* units for the dependent variable).

Although there is still the problem of how to interpret the "meaningfulness" of standardized beta weights, this is a broadly recognized effect-size metric and the problem is not specific to the multilevel modeling approach advocated here. Researchers are cautioned, however, that there are some analyses in which it would be inappropriate to standardize variables or when interpretation of effects based on standardized may be misleading, as is the case with ordinary (single-level) multiple regressions (for further discussion, see Aiken & West, 1991).

Longitudinal Multilevel Designs. Longitudinal multilevel designs allows the researcher to look at the test-retest stability of group-level variables such as class climate and to test for the effects of T1 independent variables on T2 outcomes after controlling for the effects of other T1 variables. From our perspective, the issue is that a multilevel approach adds much to the appropriate analysis and interpretation of longitudinal designs. Critical issues in the design of longitudinal studies—how many time points, the appropriate time lag, the advantages of using longitudinal data rather than a single wave of data—are all general issues about longitudinal designs that are not specific to multilevel analyses. Thus, for example, we noted some limitations in the interpretation of class-climate effects in our study based on two waves of data. T1 measures of classroom climate may have underestimated its effects because the measures were collected too soon after the start of class for classroom climate to be well established. On the other hand, the use of T1 outcomes may have underestimated the size of change associated with classroom climate because some of its effects may have already taken place between the start of class and the collection of T1 measures.

In support of our concerns about T1 classroom climates, the combined effects of T1 and T2 measures of classroom climates were systematically larger than T1 effects. However, the T2 classroom climate effects might have been confounded with T2 outcomes that were collected at the same time. In future research it might be useful to have three waves of data, as noted in the section on Substantive Contributions, so as to provide a stronger basis for disentangling potential confounding between individual level outcomes and classroom motivational climate. Although clearly important, this issue has to do with the most appropriate design of longitudinal studies rather than the conduct of multilevel analyses per se. However, although not the focus of the present work, there are important new developments in growth modeling with longitudinal data that can be approached from a multilevel perspective (see Raudenbush & Bryk, 2002). In summary, whereas the appropriate design of longitudinal studies introduces new issues not specific to multilevel analyses, the multilevel approach has many advantages for analysis of longitudinal data, particularly if the longitudinal data has a multivariate structure.

Summary

In summary, Duda (2001) emphasized that it may be incorrect to analyze individual athletes who are part of teams as if they were one group, ignoring the effect of teams. Instead, she argued that stronger multilevel analyses and designs are needed to tease out the effects of individuals and groups. Taking this challenge as our starting point, the present investigation demonstrates an exciting new statistical analysis—multilevel modeling—appropriate to this challenge that apparently has not been used in sport and exercise research. Since so much data in sport and exercise research is inherently multilevel, this multilevel modeling should have broad applicability.

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