CROSS-LEVEL RESEARCH

TESTING FOR CROSS-LEVEL INTERACTIONS: AN EMPIRICAL DEMONSTRATION*

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This study considers the challenge of cross-level interactions within multilevel analytical models. It illustrates the importance of examining such interactions by expanding upon previous research involving a social interaction variable, peer group interaction (PGI). Results indicate the presence of a cross-level interaction between individual- and aggregate-level PGI for individual job performance. Implications of this finding are discussed in terms of both the organizational context in which it occurred and multilevel research generally.

Key words: individual organism, group, organization, cross-level interactions, multilevel analytical models, peer group interaction.

MUCH OF WHAT GOES ON in work organizations occurs within a group context (Hackman, 1987). Individuals are typically members of work groups with certain characteristics, both ascribed (e.g., size, abilities, training, and experience) and behavioral (e.g., functional orientation, social conditions, influence, and conformity pressures). Work groups are located within departments, within divisions, and so on. Informal work associations also tend to be group-based (Farris, 1981).

It is a basic premise of most contemporary group research that group forces influence individual behavior and attitudes (Glisson, 1987). This influence is hypothesized to act both directly through interactions with group member characteristics and indirectly through the subtle but potent effects of a group as a totality (McGrath, 1986). Although organizational scientists are well aware that group processes substantially influence individual behavior and attitudes, a majority of group studies tend to ignore such multilevel effects (Firebaugh, 1980).

Three levels of effect are typically described within the group literature: (a) group-level (group-as-an-aggregate); (b) intergroup; and (c) interorganizational (Alderfer, 1977). While each of these levels refers to a conceptually distinct system, they are operationally interrelated (Miller, 1965, 1986). Indeed, since individual behavior is thought to be multidetermined, the effects of groups should be examined at all three levels. As Wells (1980) suggests, examining group effects in isolation is analogous to receiving a particular radio broadcast band. If one tunes into 101.5 FM, this does not mean that other frequencies are not being broadcast, but rather that one has just selected a particular station for listening. Focusing on intergroup effects does not mean that individual effects are absent, but only that one has specified a particular level of effect for investigation. This analogy suggests that group studies considering only one level of analysis may yield imprecise information where focal

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variables are determined by factors existing at higher (or lower) levels of analysis (Schneider, 1985).

Owing to the hierarchical nature of many phenomena in the organizational sciences, researchers have increasingly called for multilevel analyses (e.g., Glick, 1985; Mossholder & Bedeian, 1983a, Roberts & Sloane, in press; Rousseau, 1985). As defined here, multilevel analysis refers to an analytical paradigm that seeks to partition effects at one level of analysis among variables belonging to conceptually separate levels of analysis (e.g., individual and supraindividual units). A multilevel analysis involving individual and group level phenomena would include model terms operationalizing both types of effects. Such model terms might involve either measuring an individual-level variable (e.g., job satisfaction) and a group-level variable (e.g., group composition) or measuring individual-level variables and aggregating them to develop a group-level surrogate. Typically, raw scores are used to represent individual effects and aggregate scores (usually a group mean) are used to represent group effects (Markham, 1988). Multilevel analysis techniques thus allow the simultaneous estimation of the effects of variables operating at multiple levels.

With rare exception, current discussions of multilevel analysis are based on additive models that explicitly ignore cross-level interactions. For example, if an independent variable X has meaning at the individual level and also at the group level in the form of an aggregate $\bar{X}$, most analyses assume that the relationship between X and Y is similar across different values of $\bar{X}$ (Boyd & Iverson, 1979). Given the dominance of additive models in the current organizational science literature, it is perhaps not surprising that most researchers fail to test for the possibility of interactions across levels.

A cross-level interaction results in variation in the effect of a variable at another level. Thus, a cross-level interaction between an individual-level variable and a group-level variable suggests that the relationship between the individual-level variable and a focal outcome differs across values of the group-level variable. In viewing the totality of organizational influences on an employee, cross-level interactions should not be surprising. Metaphorically speaking, individuals and their work groups are like a tree and its ivy; they are inextricably linked. The strength of the linkage depends on factors such as the average tenure of group members and group maturity. That is, newer groups would not typically be as intertwined as mature groups (cf. Tuckman, 1965; Tuckman, 1977). (We are grateful to an anonymous reviewer for this helpful analogy.) Furthermore, the group cohesion literature suggests that as work groups become increasingly interlinked, group and individual susceptibility to influence increases (Cartwright & Zander, 1968, p. 150). Thus, it might be expected that group context would modify (i.e., interact with) the effects of individual variables on work behavior.

One type of interaction may be illustrated through adapting an example offered by Tate (1985). Consider the effect of work experience on employee performance. One could speculate that a group-level effect of experience on employee performance exists over and above an expected individual-level effect of experience. This speculation might be based on the notion that those managers whose work groups have low mean experience must devote most of their time to training employees on the more mechanical aspects of their jobs. By contrast, managers of work groups with high mean experience can spend less time on training and more time motivating individual or group interactions covering concerns unique to the task at hand. A positive effect on employee performance beyond that expected solely on job experience would be expected. Thus, experience at both the individual employee level and at the group level would have, in general, positive effects on individual employee performance.

Continuing the same illustration, assume further that the positive effect of individual-level experience within a work group varies systematically with mean group-level experience—that is, a cross-level interaction occurs between individual- and group-level experience. Managers of low mean experience work groups might direct extraordinary attention to less-experienced employees, thereby reducing the effect of individual-level experience on individual performance; managers of high mean experience work groups might provide less compensatory supervision. Given such conditions, reliance on additive models that provided only "main effect" descriptions would result in incomplete conclusions.

This paper illustrates the importance of testing for cross-level interactions by expanding on a prior research effort into the impact of a variable designated "peer group interaction" (PGI; Mossholder & Bedeian, 1983b). As defined, PGI incorporates behaviors such as encouraging team effort and attainment, developing and exchanging job-related information, and interpersonal supportiveness. Because various studies have suggested that positive affective intragroup processes have positive effects on group member behavior (McGrath, 1984; Zander, 1985), significant relationships were expected between individual PGI, group PGI, and various individual work outcomes (i.e., job satisfaction, tension, propensity to leave, and employee performance). Individual level effects were found, but group level effects were not.

The connection between PGI and individual level effects presented an opportunity to demonstrate cross-level interaction techniques while further exploring the substantive connections of PGI with various outcome variables. In this regard, there is reason to believe that PGI influence does not operate totally through its impact at the individual level (Shaw, 1981). Though Mossholder and Bedeian (1983b) did not find group-level PGI effects, they did not test for cross-level interaction effects. Despite the absence of a group effect, it is possible that the effect of individual PGI could vary systematically across levels of aggregate PGI. That is, the relationships between individual-level PGI and various individual work outcomes (i.e., job satisfaction, tension, propensity to leave, and employee performance) might be different in some work groups than in others, reflecting a cross-level interaction between individual- and group-level PGI.

In line with the illustrative intent of the current demonstration, no specific hypotheses are offered concerning the nature of these interactions. That such interactions could occur is supported by group research showing member behavior may have varying impacts on different criteria depending on level of group conformity or cohesiveness (Jewell & Reitz, 1981; Zander, 1985). Being a social interaction variable, PGI would presumably be subject to some of the same dynamics associated with these group variables.

METHOD

Subjects

Questionnaires were administered to 206 employees at a 1,100-bed hospital located in the Southeast. Respondents were drawn from all three shifts of the hospital's six services and 24 wards. For the present multilevel analysis, only respondents ($n = 168$) belonging to groups of three or more were studied. This reduced the sample to 26 groups ranging in size from three to 18 members. It should be noted that though the current sample overlaps that described by Mossholder and Bedeian (1983b), it includes additional respondent groups. The principal reason for this sampling difference is that while Mossholder and Bedeian (1983b) focused exclusively on nursing teams, the present study also includes ancillary work units. It was felt important to maximize the number of groups in the current demonstration to better address power issues associated with detecting interactions in regression models (Busemeyer & Jones, 1983).

Measures

PGI was measured using a composite of 18 items pertaining to intra-group interactions—peer interaction, work facilitation, peer goal emphasis, peer support, and group process (for psychometric details, see Mossholder, Bedeian & Armenakis, 1982). Since PGI was composed of perceptions held by individuals about group interaction processes, participant responses served as operational measures of PGI at an individual level.

Group level PGI was found by calculating unit group means and assigning the resulting mean score to each group member.

Employee performance was measured by supervisory ratings across five separate dimensions: quantity, quality, knowledge of work, dependability, and overall performance. The five dimensions were summed to form a global performance index.

Propensity to leave was gauged with a three-item instrument developed by Lyons (1971). Job tension was tapped by three items also developed by Lyons. Finally, job satisfaction was measured using five items taken from the Survey of Organizations questionnaire (Taylor & Bowers, 1972). The items gauged respondent satisfaction with work groups, job, organization, past and future progress in the focal organization.

Analysis

A special case of a general contextual model in which Y is expressed as a function of individual-level variables for the jth group was employed in the cross-level analysis (Boyd & Iverson, 1979). In the present investigation, PGI is the only individual-level variable, so the within-group model is

$$Y_{ij} = \beta_1 X_{ij} + \beta_2 \bar{X}_j + \beta_3 X_{ij}\bar{X}_j + e_{ij} \quad \text{where}$$

$$(i = 1, 2, \ldots.\ k;\ j = 1, 2, \ldots.\ m)$$

Y_{ij} (X_{ij}) refers to the response on $Y(X)$ for the ith person in the jth group, $\bar{X}_j$ is the group mean of the jth group, and $X_{ij}\bar{X}_j$ is the individual-level effect of X as a function of $\bar{X}$ (i.e., interaction term).

The amount of variance explained in the study's dependent variables when regressed on individual- and group-level PGI (the "additive" equation) was compared to that explained when the study's dependent variables were regressed on individual- and group-level PGI and their interaction term (the "interactive" equation). An F-test was conducted to test the significance of the difference in R^2 between the additive and interactive equations. A significant increment in explained variance would provide evidence for a cross-level interaction effect.

RESULTS

Descriptive statistics and coefficient alpha reliability estimates for all study variables are presented in Table 1. Individual level PGI was positively related to satisfaction and negatively related to tension and propensity to leave. A similar pattern held for group level PGI, although the magnitude of relationship was lower. Finally, the common variance between group and individual PGI was moderate. Coefficient alpha reliability estimates for all variables were acceptable, ranging from .76 to .96. Though some controversy exists concerning reliability estimates of aggregate measures (Glick, 1985), eta coefficients were computed to estimate within-group agreement across work groups following techniques suggested by James (1982). The eta coefficient (η) computed for homogeneity was .46. Thus, 21% of the total variation in PGI was associated with between-group differ-

TABLE 1
DESCRIPTIVE STATISTICS AND INTERCORRELATIONS AMONG STUDY VARIABLES

Variables	*M*	*SD*	*r* 1	2	3	4	5	6	7
1. PGI (individual)	3.26	.85	(.92)						
2. PGI (group)	3.26	.40	.47	(.94)[a]					
3. Job satisfaction	3.75	.83	.54	.33	(.76)				
4. Tension	2.57	.77	−.37	−.19	−.50	(.86)			
5. Propensity to leave	2.09	.89	−.19	−.16	−.41	.39	(.76)		
6. Employee performance	3.64	1.03	−.04	.11	.04	−.10	−.03	(.96)	
7. PGI (Individual × Group)	10.78	3.56	.94	.72	.54	−.35	−.22	.01	(—)[b]

Note. All scales were composed of 5-point response items. Coefficient alpha reliability estimates are in parentheses. Correlations greater than ±.15 are significant at p ≤ .05.

[a] Cronbach's alpha calculated from aggregate data.

[b] Not applicable.

ences. This level of homogeneity compares favorably to other studies employing aggregate measures (Jones & James, 1979), though no formal guidelines exist for establishing the minimal η^2 needed. Also, following a recommendation advanced by Jones and James (1979), the reliability of group-level PGI was assessed. Using Cronbach's alpha, work groups were treated as "subjects" and average within-group item scores were treated as "items." The obtained alpha, .94, suggests a high degree of internal consistency for this group-level construct.

Results of the analysis are given in Table 2. The table compares the predictive validity of the additive and interactive equations for the dependent variables. Increments (ΔR^2) in the explained variance caused by the cross-level interaction (interactive equation) over and above that caused by the main effects (additive equation) are indicated. The addition of the individual-by-group interaction term significantly increased the R^2 value only in the case of employee performance ($\Delta R^2 = .029$, F = 4.96, $p < .05$). This isolated effect indicates that the relationship between PGI and employee performance varies as a function of mean work group PGI.

Using a Y versus X format, Figure 1 presents a graphical representation comparing the additive and interactive equations for employee performance. Each line represents the estimated Y (performance) on X (individual level PGI) regression for a group with a given $\bar{X}$. An individual-level PGI effect would be reflected by the slope of a line, and the group-level PGI effect by the vertical distance between lines for a specific X value. A comparison of the patterns in parts (a) and (b) clearly indicates the effect of the interaction term for the current data. The additive equation graph shows the absence of X and $\bar{X}$ effects, as depicted by the minimal slope and close bunching of the regression lines. However, the interactive equation graph suggests a disordinal interaction between PGI and employee performance as a function of average work group PGI, which is shown by the regression lines of differing slopes. The estimated $\bar{X}$ effect ranges from moderately negative for high group-level PGI to essentially zero for average to low values at group-level PGI.

TABLE 2
RESULTS OF CROSS-LEVEL ANALYSIS FOR PEER GROUP INTERACTION WITH VARIOUS DEPENDENT VARIABLES

Dependent Variable	Additive Equation (R^2)	Interactive Equation (R^2)	ΔR^2	Incremental F
Job satisfaction	.300	.300	.000	.00
Tension	.134	.135	.000	.01
Propensity to leave	.045	.057	.012	1.33
Employee performance	.022	.050	.029	4.96*

* $p < .05$.

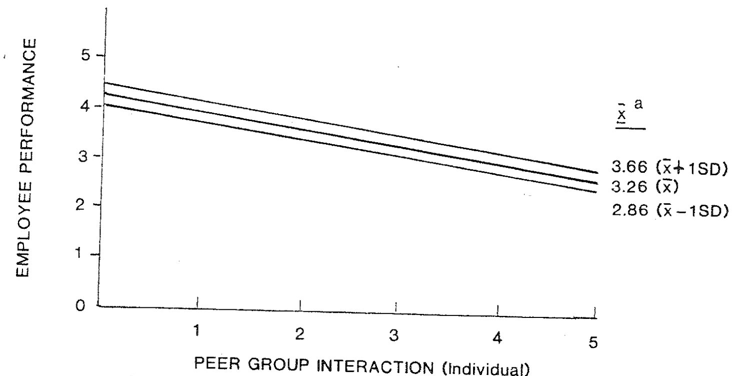
A decomposition of variance for the models in Figure 1 is also helpful in interpreting the isolated effect. As shown in Table 3, individual PGI, group-level PGI, and their interaction explain some 5% of the variance in employee performance. The residual variance is comprised of two components. The first, the group membership-plus-interaction residual, represents the inability of either equation to fit the level (intercept) and the slope of the within-group regression. The other, an individual-within-group residual, represents the inability of the within-group regression to gauge individual work group member scores.

Following Tate (1985), the group-plus-interaction residual was calculated by first creating a set of dummy-coded vectors representing group membership, and then constructing a set of vectors representing the product of an individual's PGI score and his/her coded group membership. The two sets of vectors were added to the additive and interactive equations. The incremental R^2, representing the group-plus-interaction residual was calculated at .292 and .264 for the additive and interactive equations, respectively. The difference between these values (.028; the explained variance attributable to the cross-level interaction over and above that caused by the main effect), indicates that this increased explanation comes from a decrease in the group-plus-interaction residual calculated for the additive model.

DISCUSSION

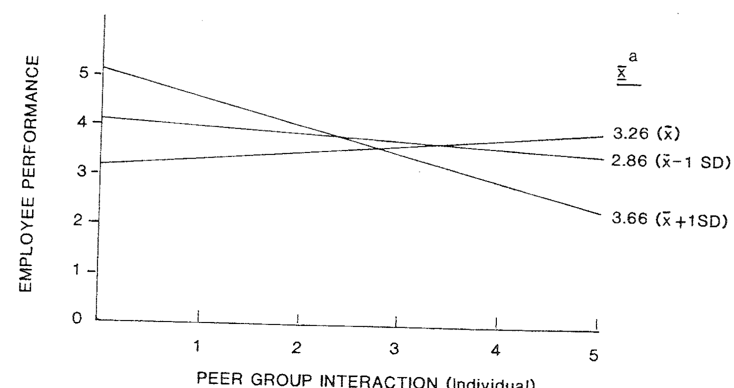
The purpose of this study was to demonstrate how multilevel analyses may be

(a) Additive $\underline{x}, \bar{\underline{x}}$



Note: [a] These values were chosen to represent average group PGI ($\bar{x}$) and ($\bar{x}$+1SD).

(b) Interactive $\underline{x}, \bar{\underline{x}}$



Note: [a] These values were chosen to represent average group PGI ($\bar{x}$) and ($\bar{x}$+1SD).

FIG. 1. Comparison of Additive and Interactive Graphs.

used to examine effects on various individual work outcomes. As argued above, particularly in the case of multilevel research, the issue of cross-level interaction has been ignored. The present analysis revealed a cross-level interaction. For groups with low and average PGI, individual PGI was unrelated to employee performance. However, in contrast, for groups with high PGI, employee performance and individual PGI

TABLE 3
VARIANCE DECOMPOSITION FOR THE EMPLOYEE PERFORMANCE INTERACTION

Source	Additive Equation Decomposition	Interactive Equation Decomposition
Regression	.022	.050
individual PGI	.002	.001
group PGI	.020	.020
PGI × GRP PGI	—	.029
Residual	.978	.950
group membership + interaction	.292	.264
individual-within-group	.686	.686

were negatively related. Thus, with high levels of group PGI, individuals perceiving high PGI were lower performers. Individual PGI implies a predisposition toward greater interpersonal activity. In groups where there is already a high level of group interaction, such activity could result in supervisor perceptions that greater employee involvement in interactive processes is counterproductive and wasteful.

As regards the present sample, these results might indicate that individual group members are being less attentive to patient services or, perhaps, are inexperienced to the point of needing excessive peer guidance. Another possible explanation might be that supervisors of work groups characterized as high on interpersonal interactions, and who are not actually part of those interactions, could feel alienated from their employees and express this alienation as lowered performance ratings for those who would be expected to be associated with the in-group (i.e., those employees high on individual PGI). What is important, in an illustrational sense, is that effects were uncovered in examining cross-level interactions that would have gone unnoticed with an additive model. These effects suggest that the interplay of individuals within the context of groups may be as interesting to study as individuals or groups per se.

Ironically, one conclusion that might be drawn from this study is that cross-level interactions are unimportant. Of the four dependent variables studied, only one was associated with a cross-level interaction. And, even at that, the size of the effect was small. Therefore, one might be tempted to dismiss an interactive model in favor of an additive model. In contrast, however, we suggest that the results of this study be viewed as encouragement for continued investigation of cross-level interaction hypotheses. We offer this encouragement because cross-level interactions provide a richer understanding of organizational processes. Organizational studies seldom account for more than 30% of the variance in criterion variables, suggesting that additional explanation is needed (cf. Starbuck & Webster, 1988). Cross-level effects serve as additional hypotheses that could be tested. In addition, when cross-level interactions are obtained, they provide opportunities for theory development.

Cross-level interactions may not be expected in every situation. As Mischel (1977) noted, situations can be characterized according to their relative strength. Some situations have well-entrenched standards of conduct which serve to constrain behavior (i.e., a strong or powerful situation), whereas other situations are less structured and permit individual differences to have more of an influence on behavior (i.e., a weak situation). Cross-level interactions would be more likely in weak situations because the context would not exert much influence. Mischel's notion might explain the results of the present study. Data were obtained from hospital employees. Work rules in hospitals tend to be highly structured and formalized. Thus, in Mischel's terms, a hospital might be considered a "powerful" situation. Given this perspective, it is not surprising that little evidence for cross-level interaction was obtained.

It is interesting to note, however, that the cross-level interaction obtained was for supervisors' ratings of job performance. Cross-level interaction was not found for self-reported measures of job satisfaction, propensity to leave, and job-related tension. A tentative conclusion that can be drawn from these findings is that job performance is more sensitive than job attitudes and perceptions to the influence of job context factors. Thus, the nature of a focal criterion may influence whether a cross-level interaction is observed.

In conclusion, we hope that this study will stimulate others doing group research to recognize the possibility of multilevel interactions. Given sufficient theoretical rationale, cross-level interaction analyses are appropriate whenever effects are postulated at several organizational levels. Such applications can be understood within the context of James and Jones's (1976) model of organizational functioning. They posit that an individual's behavior can be explained by a joint consideration of individual characteristics, environmental context, and process-oriented variables. Of particular relevance to our argument is that

James and Jones (1976) recognize the hierarchical structure of environmental context by including factors at the workgroup, organization, and environment levels-of-analysis. Investigations specifically into multilevel models such as theirs could benefit from tests for cross-level interaction effects. Because contemporary thinking regarding group behavior largely fails to recognize the potential for cross-level interactions, past organizational studies may well have analyzed data in a manner that concealed more than it revealed. Possible interactions between levels of analysis cannot be ignored if complete explanations of organizational processes are to be obtained.

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