DECISION SCIENCES, 1990, 21(2), 301-317.

Conceptualizing Effects of Office Information Systems: A Methodology and Application for the Study of Alpha, Beta, and Gamma Changes*

Ronald E. Rice
School of Communication, Information, and Library Studies, Rutgers University, New Brunswick, NJ 08903
Noshir S. Contractor
Department of Speech Communication, University of Illinois, Champaign-Urbana, IL 61801

ABSTRACT

This article applies the concepts of alpha, beta, and gamma changes to test whether the implementation of a new office information system with networking capabilities changes the way organizational members conceptualize office work. The traditional approach (*t*-test) was used to measure alpha change and indicated little change in how effectively the respondents felt they performed eight generic office activities before implementation (T1) and nine months after implementation (T2). However, considerable change was detected between effectiveness reported at T1 and a retrospective assessment of T1 effectiveness reported at T2 (called "then" assessments). Strong change was also detected between "then" assessments and T2 effectiveness reported at T2, indicating beta change. Multiple hierarchical tests showed that most of the change was actually gamma change; the T2 and the "then" factor structures and covariances differed significantly. This study supports propositions that using computers to accomplish organizational work may be associated with different conceptualizations of work, which may create ambiguity and uncertainty if training and management policies do not respond appropriately. Finally, this study provides an expanded version of a prior solution to detecting alpha, beta, and gamma changes.

Subject Areas: Information Processing, Job Design, Organizational Change, and Sampling and Survey Methods.

INTRODUCTION

Many reviews of organizational information and communication systems conclude that they make a difference, for good or for bad [10] [13] [14] [22] [23] [24]. For example, Giuliano [5] and Olson and Lucas [19] argued persuasively that integrated office systems will change many aspects of how organizational members will conduct their work, provide service to clients, and think about the relationships among office activities and among organizational members. At this point, one area of possible impact still remains speculative: does using the computer to perform tasks formerly conducted using tangible reports, physical trips, or personal contact change how users conceptualize their work?

Zuboff [32] [33] argued that one of the reasons for apparent resistance to organizational information systems is that they make work more abstract, frustrating, and likely to lead to overload. The nature of terminal-based information requires the ability to think abstractly, to reason inductively, and to theoretically conceptualize the processes indicated by the data. However, workers rarely receive the necessary training or managerial support for this new kind of work. Schuck suggested that workers must be able to learn higher-order cognitive skills so that they may "apply relevant concepts in order to make sense of experience" [28, p. 68].

*The authors wish to acknowledge two anonymous reviewers for their comments on an earlier draft of this article.

Johnson and Rice [11], Schuck [28], and Zuboff [33] proposed that the lack of training, preparation, or job redesign for such skills and the perceived threat of more highly skilled subordinates by their managers are expected but unfortunate consequences of some conventional policies. Particularly culpable are policies that consider information technologies only as ways to automate work rather than as opportunities to "informate" the organization by developing new ways to achieve organizational goals.

Weick [31] proposed that current systems do not allow people to perform through trial and error or to use several different measures to increase their confidence in a particular interpretation. He also argued that the ways in which procedures and systems are designed and implemented do not support social comparison through personal affiliation, are not designed (either by system designers or managers) to allow deliberation before taking action, and prevent cumulative learning that occurs when objects and activities can be placed in wider contexts. As a result, the representations of reality about an employee's work and interactions with coworkers and customers may be insufficient or flawed, systems do not allow users to generate and compare alternative versions of the reality, and users who do not have enough information processing capability to connect the apparent unrelated details ask for more data of the same type and further decrease their processing capabilities. Based on discussion by these and other authors, it seems plausible that major changes in conceptualization of office work are possible.

While these discussions and propositions are extremely intriguing and potentially significant, there is little evidence that computers do change the way people think about their work. How, then, can we measure and identify such change if it occurs? The following section discusses this question.

ALPHA, BETA, AND GAMMA CHANGES: CONCEPTS AND METHODS

Golembiewski, Billingsley, and Yeager [7] conceptualized three kinds of change on the premise that if organizational development efforts had actually succeeded, the very criteria for assessing the organization would have changed as well.

Alpha change is a variation in the level of some state given a constantly calibrated instrument related to a constant conceptual domain. For example, if organizational information systems simply improve a user's effectiveness at performing a task, a change in the mean of a measure of effectiveness from 3.7 at the first time period (T1) to 4.1 at the second time period (T2) on a 5-point scale may indicate an alpha change.

Beta change is a variation in the level or mean and the recalibration of intervals of the measurement continuum associated with a constant conceptual domain. If users perceive that greater effectiveness than before is now possible, they may reconceptualize effectiveness along a 7-point scale and report an increase to a value of 5.0 along that new scale. However, the highest value provided on the initial scale (5.0) is now two points lower than the highest reconceptualized potential effectiveness. Proportionally, a new 5.0 would be equivalent to a 3.6 (5/7) on the T1 scale. Due to beta change, the mean value reported at T2 may be lower than the mean value at T1 even if perceived work effectiveness has improved. Conversely, the initial 3.7 reported at T1 might be now reassessed at T2 down to 2.6 (i.e., $(3.7/7 \times 5)$. These both represent possible beta changes.

Gamma change is a redefinition of the conceptual domain. If organizational systems change how users conceive of office effectiveness (representing gamma change), the earlier scales may no longer be relevant or may be reconceptualized to represent new dimensions at T2. For example, some work activities that were conceptualized as separate categories before a system was implemented may now be reconceptualized as unidimensional because the system integrated the task flows by means of a common data base and communication channel. This process is an example of gamma change.

A review of all the methods and approaches to measure and conceptualize alpha, beta, and gamma changes is beyond the scope of this article. However, significant advances and proposals have included the following approaches to measuring different forms of change in some condition: (1) a test of item variances and congruence of factor coefficients before and after interventions [20]; (2) comparison of results to a control group where no change should be expected and a guarantee of equivalence of before and after groups when individual identities cannot be obtained [1] [20]; (3) the use of "ideal" value measures as the basis for comparing pre- and post-assessments of the condition [20]; (4) the use of "then" assessments which are reports at time two (T2) of the condition at the "pre-" state (T1) [29]; (5) a focus on changes in items for individual respondents ("profile analysis" or regressions for each individual) to isolate individual constraints on organizational development efforts [2] [29]; (6) the use of psychometrically reliable scales with multiple items and behavior anchors to reduce or remove possible beta change [15]; and (7) the use of other measures known to be associated with changes in dimensions of the condition of interest [6].

Schmitt [26] proposed an elegant way (on which Schaubroeck and Green [25] elaborated) to assess beta and gamma changes by examining the analysis of covariance structures. For instance, consider the measurement of multiple items at "pre-" (T1), "post" (T2), and "then" (T3) time periods. If only alpha change occurred, the interitem correlation matrices at T1, T2, and T3 should be identical. Inequalities among the correlation matrices at T1, T2, and T3 would reveal that respondents have changed their calibration (a beta change) and/or their conceptualization (a gamma change) of the measurement items. Confirmatory factor analyses of the correlation matrices at T1, T2, and T3 provide a method to isolate the beta and gamma changes. Inequalities among factor loadings, item variances, and factor variances indicate a recalibration of the scales and so reveal the presence of a beta change. In contrast, changes in the factor structure and/or inequalities in the covariance between factors at T1, T2, and T3 indicate a reconceptualization of the scales and reveal the presence of a gamma change.

Schmitt, Pulakos, and Lieblein [27] compared approaches (3), (4), (5) listed above, and the confirmatory factor approach. They concluded that the covariance approach, while problematic in some ways, was preferable to these other techniques. However, they did not analyze the "then" measures using the covariance approach. We propose that inclusion of the T3 measure in this approach may reveal effects that would not otherwise be identified.

EFFECTIVENESS

Of the many possible ways in which work can be reconceptualized, the present study looks at changes in perception of work effectiveness. Effectiveness (the application of a system to accomplish individual, unit, and organizational missions) should be distinguished from efficiency (the use of assigned resources to provide the information system to the users) [8] [9]. Comprehensive and valid evaluations

of information and communication system effectiveness are fundamentally difficult and there are as yet no widely accepted standard measures of perceived or objective effectiveness. This difficulty is due to changing and possibly contrasting objectives of both users and the organization, continuous evolution of hardware and software, differences between subjective and objective indicators, and potential conflict across functional groups. Therefore, evaluation studies generally should involve quantitative and qualitative data, multidimensional measures, and multiple evaluation viewpoints [4] [8] [9] [22].

Mohrman and Novelli [17] argued that, until recently, different office activities were supported by system features embedded in separate technologies (such as stand-alone word processors and management information systems). Such features were used very differently by organizational members in each of the three basic organizational roles: managerial, secretarial/clerical, and professional. However, this is changing because new systems are multifunctional and integrated, thus applicable and usable across all three roles. Wagoner and Ruprecht [30] agreed, proposing that software support in office work stations and information systems for the variety of office activities performed by knowledge workers should include communicating (including telephone and electronic mail), text processing, mail handling, filing (including retrieval and data base management), personal computing, and decision making.

Mohrman and Novelli's [17] study was intended to test the propositions that (1) more sophisticated and integrated office information systems would break down the boundaries between activities across these three roles and (2) such systems would occasion beta and gamma changes. Concerning the first goal, the authors found that a year after the office they studied had replaced a few stand-alone word processing terminals with 40 professional multifunctional work stations, respondents (approximately 50) in all three roles were doing more activities commonly associated with professional roles (such as proofing and preparing presentation materials) as well as more traditional managerial activities (scheduling and planning). They found evidence of integration of activities across roles (due to the local area network and the shared data bases) and across technologies (due to the multifunctional software and hardware).

Concerning the second goal, Mohrman and Novelli found that respondents' perceptions of changed effectiveness of activities that were less likely to be mediated by the particular work-station technology (i.e., filing, searching, copying, reading, and record keeping) showed little change according to tests of mean differences (alpha change). They did find an increase in perceived effectiveness in meetings and analyses. Mohrman and Novelli [17] attempted to assess beta and gamma changes by visually overlaying the factor structures of "pre-," "post," and "then" measures of these activities (see [24, pp. 90-94]). Only those activities that were frequently performed using the new work stations changed their factor groupings. Filing, mail handling, copying, and sorting remained on one factor and communicating (by phone, meeting, or conference) remained on another factor. Writing, reading, creating, analyzing, and calculating generally separate on the "pre-" measures, loaded on one "post-" factor; record keeping, scheduling, and planning showed the same change. "Then" factor structures showed some separating and some joining of these activities.

METHOD

A small, decentralized federal office in a major western city was surveyed just before it implemented a system of desktop personal computers (with office support

software) linked to an electronic mail package by a local area network; the office was surveyed again approximately nine months later. The system was consciously implemented to improve productivity for managers and professional and technical specialists [18]. Approximately 60 percent of the office staff were white-collar managers and professionals; the rest were clerical workers. A representative of the organization hand-delivered the questionnaire to each employee, who then returned it in a sealed envelope. At T1, 50 out of 62 employees returned their surveys—a response rate of 81 percent. At T2, 67 out of 86 employees returned their surveys—a response rate of 78 percent. A total of 36 individuals were employed in the office and returned their survey at both time periods. These 36 represent our sample for analysis, guaranteeing equivalency of samples across time periods as well as the small sample size.

Measures

This analysis focuses only on questionnaire items about the effectiveness perceived in the performance of eight generic office activities—recording, copying/collating, filing, searching for information, mailing, analyzing/reviewing, reading, and meetings with others—in an attempt to compare the results and extend the preliminary methodological approaches of Mohrman and Novelli's [17] unpublished study of alpha, beta, and gamma changes associated with the implementation of office work stations. Responses to the eight items before implementation were referred to as the T1 "pre-" measures. Responses to the same items after implementation were referred to as T2 "post-" measures. The T3 "then" measures represented the perceptions of effectiveness before implementation as viewed in retrospect. Item values for each time period were measured using 1 = very ineffective, 2 = ineffective, 3 = neutral, 4 = effective, and 5 = very effective. The item stem for "pre-" and "post-" was: "How effective do you feel you are in each of the following activities?" The item stem for the "then" items was: "Think back to before [the system] was installed in your office; how effective do you feel you WERE in each of the following activities?" Because the present study is concerned with potential changes in conceptualization of office work, measures of the users' subjective perceptions, rather than managerial perceptions of users' performance or objective measures of users' performance, are appropriate.

While the ability to extend a prior study in a research area with little or no precedents is of obvious benefit, this choice of focus (effectiveness) and the specific measures (eight generic office activities) are problematic because of the unknown psychometric properties of the measures. We attempted to improve this situation by choosing from the items in [17] those eight that conceptually represented two possible dimensions of office work (information management and communication-related activities) which loaded cleanly on these two factors at T1.

Analysis

Given the exploratory nature of this research, simple paired *t*-tests were used to detect any statistically significant changes in respondents' evaluations of effectiveness across the "pre-", "post-", and "then" comparisons. The presence of statistically significant differences suggests a variation in respondents' perceptions of effectiveness along a supposedly constantly calibrated scale—alpha change. However, as discussed earlier, this inference would only be conclusive if respondents do not recalibrate (beta change) and/or reconceptualize (gamma change) the

items used in the measuring instrument. The remainder of the analysis examined if respondents did recalibrate and/or reconceptualize the measurement items.

The eight items representing eight office functions were hypothesized to load on one factor representing information management office functions (recording, copying, searching, and filing) and on a second factor representing communication-related office activities (reading, meeting, and analyzing/reviewing). Mailing, which included both mailhandling (an information management function) and mailing messages (a communication-related activity), was allowed to load on both factors. Since the two factors were not conceptualized as necessarily independent, they were allowed to covary. Figure 1 shows the hypothesized two-factor model.

The factor loadings are represented by lambdas (λ_{ij}). For instance, λ_{21} represents the loading of "copying" on the "information management" factor. The values of λ_{11} and λ_{62} were set to 1 to serve as referent parameters. The unexplained variance associated with each of these items is represented by θ_1 to θ_8. The explained variance of each of the two factors is represented by ϕ_{11} and ϕ_{22}, and ϕ_{12} represents the covariance between the two factors.

LISREL [12], a program for analyzing linear structured relations by the maximum-likelihood method, was used to estimate the fit of the hypothesized two-factor model for each of the three comparison points. This approach provides (1) estimates (and significance tests) of the loadings of the two hypothesized factors on the eight measurement items and (2) estimates (and significance tests) of the extent to which the two hypothesized factors covary at each of the three comparison points (T1, T2, and T3). The six stages described next provide statistical tests of differences for the desired sets of comparisons using a set of nested models.

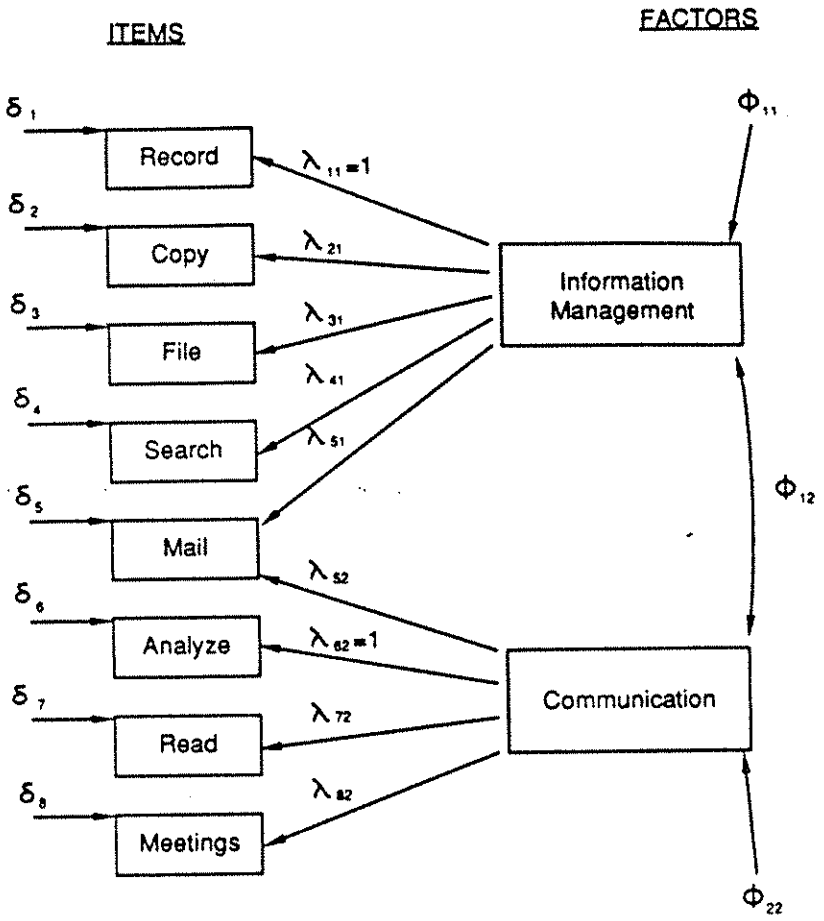
The first stage (A) statistically tests the differences in the covariances of the eight measurement items across the comparison points. A significant χ^2 statistic indicates that the covariances among the measurement items differed significantly across the three comparison points, providing evidence of the presence of beta or gamma change or both.

The second stage (B) statistically tests the fit of the hypothesized two-factor model across the three comparison points. A significant χ^2 statistic indicates that the patterns of the factor structure are not the same across the comparison points, providing evidence that respondents' perceptions of the conceptual relationship of communication-related and information management functions are not consistent across the three comparison points (gamma change). Each model is then compared to a null model. The null model specifies no relationships between the eight office activities and the two factors. A significant difference in the χ^2 statistic indicates that the two-factor model is significantly better than the null model.

The third stage (C) statistically tests the fit of the hypothesized two-factor model across the three comparison points after constraining the factor loadings to be the same across the comparison points. A significant χ^2 statistic indicates that the patterns of the factor structure and/or the factor loadings are significantly different across comparison points. In addition, the χ^2 statistic at this stage of the analysis can be compared to the corresponding χ^2 statistic at the second stage (B). A significant difference in the χ^2 statistics of stages B and C indicates that the factor loadings are significantly different across the comparison points, providing evidence that the two factors on the measurement items differed across the comparison points (beta change).

The fourth stage (D) of the analysis is similar to the third stage but with an additional constraint. Once again, the fit of the hypothesized two-factor model is

Figure 1: Measurement model relating effectiveness items to underlying dimensions and base for comparison across time periods.



tested across the three comparison points. However, at this stage and in addition to the factor loadings, the item variances are also constrained to be equal across comparison points. A significant χ^2 statistic indicates that the changes across comparison points can be attributed to differences in patterns of factor structure, differences in factor loadings, and/or differences in item and factor variances. To isolate the differences attributable to differences in item variances alone, the χ^2 statistic obtained at this stage is compared to the χ^2 statistics obtained in the previous stage (C). A significant χ^2 statistic indicates that the amount of variance in each item that is explained by the hypothesized two-factor model is not consistent across the comparison points, a second form of beta change.

The fifth stage (E) of analysis further constrains the model tested in stage D. Here, in addition to the constraints specified in stage D, the hypothesized two-factor model is tested after constraining the factor variances to be equal across the comparison points. A significant difference in the χ^2 statistic between this stage and the previous stage indicates that the explained variance associated with the two factors was not consistent across the three comparison points. This provides evidence that the ability of the items to measure the communication-related and information management activities was not consistent across the three comparison

points. Once again, a significant difference in χ^2 statistics between this stage and the previous stage (D) indicates the presence of a beta change.

The sixth and final stage (F) of analysis determines if there are any statistically significant changes in covariance between the two factors across comparison points. In this stage, the two-factor hypothesized model described in stage E is tested after constraining the covariance between the two factors to be equal across comparison points. A significant difference in χ^2 statistics between this stage and stage E indicates that the covariance between the two factors differs across the three comparison points, providing evidence of the respondents' conceptualization of the relationship between communication and noncommunication-related activities (gamma change).

The six-step method outlined above was first used to test for pairwise differences between the comparison points; these were "pre-" vs. "post-" (T1T2), "pre" vs. "then" (T1T3), and "post-" vs. "then" (T2T3). Next, the method was used to test for differences across all three comparison points: "pre-" vs. "post-" vs. "then" (T1T2T3). Finally, differences between the pairwise comparisons and the comparison across all three points (i.e., T1T2T3-T1T2, T1T2T3-T1T3, T1T2T3-T2T3) were computed to determine if those differences were primarily attributable to one of the three comparison points.

Additionally, because the χ^2 value is sensitive to sample size, Bentler and Bonnett [3] devised an index of change (called B2) that controls for the effect of χ^2 in hierarchical comparisons. Schmitt et al. [27] and colleagues calculated B2 to indicate the relative magnitude of change to complement the significance tests of the beta and gamma changes.

RESULTS

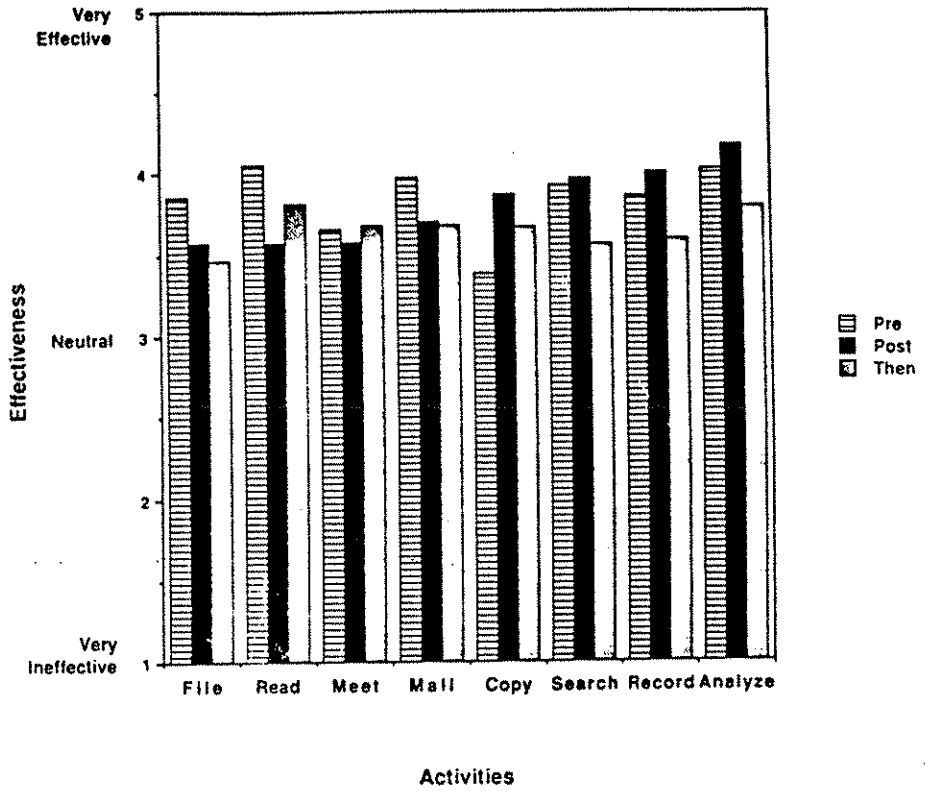
Alpha Change

Figure 2 shows the mean values of the "pre-," "post-," and "then" measures of the eight items. Table 1 provides descriptive statistics and results of the pairwise *t*-tests between the eight items at the three comparison points.

With one exception, there were no significant *t*-test differences between "pre-" and "post-" measures, indicating little evidence of an alpha change. The only statistically significant difference was a decrease in perceived effectiveness of meetings, although there were noticeable decreases in perceived effectiveness of filing and reading. However, note that the lowest mean on all items remained between neutral and effective. At worst, this shows that in some way the system interfered with the effectiveness of meetings, perhaps through failed attempts to schedule meetings through the system, an inability to access information easily during meetings, or for a number of other reasons. Difficulty with associating on-screen data base entries with actual physical files and with reading on-screen text are both possible problems with computer-mediated work [32].

In contrast, there were significant *t*-test differences between "post-" and "then" measures in spite of the small sample size. There is strong evidence that respondents feel they are significantly more effective at five of the eight generic office functions (record keeping, filing, searching files, copying/collating, and analyzing/reviewing) than they thought they had been before the system was implemented. This strong effect is based largely on their perceived negative reassessments of their previous effectiveness at the three information management activities of record keeping, filing, and searching files.

Figure 2: Comparison of "pre-," "post-," and "then" means of perceived effectiveness at eight generic office activities.



The results shown in Table 1 and Figure 2 provide some intriguing insights. If, as in most change-evaluation research, only "pre-" and "post-" measures had been compared, the results would indicate that introduction of the office information system had very minimal impact on respondents' perceptions of effectiveness. However, once the "then" measures are compared to the "pre-" and "post-" measures, it becomes evident that the respondents have changed their scales for rating office effectiveness, at least with respect to a criterion level (beta change) and possibly due to changes in the underlying dimensions by which effectiveness is conceptualized (gamma change).

Beta and Gamma Change

Table 2 shows the results from the confirmatory factor analyses used to test the fit of the hypothesized two-factor model at each of three comparison points: factor loadings, the χ^2 statistic assessing the fit of the factor structures to the data, and the correlation of the two factors. These results provide evidence of gamma change.

The estimates of the model using "pre-" measures show two independent dimensions ($r = .19$, not significant at $p < .05$), while estimates of the model using "post-" measures show that the two factors are no longer independent ($r = .62$, $p < .05$). Convergence of the two factors indicates that experience with the

Table 1: Descriptive statistics and *t*-tests across time periods.

	Pre-(T1)			Post-(T2)			Then (T3)			*t*-values for t-tests		
Variable Name	M	S	se	M	S	se	M	S	se	T2-T1	T1-T3	T2-T3
Record keeping	3.86	.80	.13	4.00	.95	.20	3.59	.96	.16	1.32	1.77	3.50**
Copying/collating	3.83	1.06	.18	3.87	.87	.18	3.67	.85	.15	1.59	.78	3.35**
Filing	3.86	.96	.16	3.57	.73	.15	3.47	.99	.17	-.46	2.10*	3.48**
Searching files	3.92	.91	.15	3.96	1.07	.22	3.56	.93	.16	1.23	1.82	3.55**
Mail handling	3.97	.84	.14	3.70	.93	.19	3.68	.77	.13	-.21	1.66	1.63
Analyzing/reviewing	4.03	.61	.10	4.17	.78	.16	3.79	.81	.14	.53	1.49	3.25**
Reading	4.06	.67	.11	3.57	.79	.16	3.82	.80	.14	-2.11	1.16	-.27
Meetings	3.66	.87	.15	3.57	.66	.14	3.68	.84	.14	-2.15*	-.34	-.57

*$p < .05$
**$p < .01$
Note: M=mean, S=standard deviation, se=standard error of the mean.

Table 2: Factor loadings and factor correlations.

	Factors and Factor Loadings					
	Pre-(T1)		Post-(T2)		Then (T3)	
Items	Information Management	Communication	Information Management	Communication	Information Management	Communication
Record	1.000*	—	1.000*	—	1.000*	—
Copy	.993*	—	.750*	—	.755*	—
File	1.024*	—	.579*	—	1.226*	—
Search	1.109*	—	1.159*	—	1.037*	—
Mail	.723*	.361	-.018	.943	.429*	.756
Analyze	—	1.000*	—	1.000*	—	1.000*
Read	—	.540*	—	1.144*	—	1.425*
Meet	—	.720*	—	.659*	—	2.105*
χ^2	28.44		27.55		38.17*	
d.f.	18		18		18	
Correlation between information management and communication factors	.19		.62		.43*	

*$p < .05$
Notes: χ^2 indicates fit of the raw and reproduced correlation matrices. Significant correlation indicates non-independence of the two factors at each time period. "Record" and "analyze" items constrained to be 1.00, referent parameter, on respective factor.

networked system, which is intended to integrate office tasks to some extent, changed individuals' conceptualizations of the tasks from two separate sets to one integrated set. The estimates of the model based on "then" (T3) measures indicate an intermediate shift ($r = .43$, not significant at $p < .05$), which represents a conceptualization midway between "pre-" and "post-". The reassessments of T1 from the vantage point of T2 (i.e., the "then" measures) indicate that respondents do not think they conceptualized the two dimensions of effectiveness as close together at first as they do now. In other words, a possible interpretation of the "then" loadings is that, with experience, the respondents at T2 are more aware of how unintegrated the eight office functions were at T1.

The loadings of the item dealing with the "mailing" function are particularly interesting. In the model based on "pre-" measures, the item loads strongly on the first factor (information management). However, the item shifts dimensions considerably when it loads more strongly on the second (communication-related) factor in the model based on "post-" measures. Finally, in the model based on "then" measures, the item loads more strongly on the information management factor but the coefficient has a smaller value than in the model based on "pre-" measures. This shift in loadings for the mail activity indicates that respondents considered mailing materials as simply another way to manage information, similar to filing and copying, before implementation of the system. However, after implementation and exposure to electronic mail, respondents considered mail to be more of a communication function, implying a greater sense of meaning and interacting with others rather than just handling the mail. Finally, respondents' "then" reassessments placed mailing with the information management activities but could not ignore the communication implications. The overall implication is that electronic mail is more than just an efficient way to distribute information—it represents a mediated form of interpersonal communication [21] [24].

The results presented in Table 2 and discussed above suggest that introduction of the integrated information system resulted in beta and gamma changes. To confirm these findings, the six-step analysis (stages A to F and the hierarchical tests between stages) described in the previous section was conducted. Table 3 provides the χ^2 values, the degrees of freedom, and the B2 index for the relevant null models and comparisons.

The results of the first stage (A) analysis indicate that the matrices at the three comparison points were significantly different from each other with respect to beta and/or gamma changes. This was true for the comparison points taken pairwise (i.e., T1T2, T1T3, and T2T3) as well as all three together (i.e., T1T2T3). Further, the differences between the three taken together and the pairwise comparisons (i.e., T1T2T3-T1T2, T1T2T3-T2T3, and T1T2T3-T1T3) were attributable to all three comparison points.

In the next stage (B), there were statistically significant differences for all the pairwise comparisons as well as for the three comparison points taken together. These results confirm that at least some of the differences that appeared in stage A of the analysis were the consequence of changes in factor structure across the comparison points. Further, there were statistically significant differences between the three taken together and two of the three pairwise comparisons (T1T2T3-T1T2 and T1T2T3-T1T3). This indicates that the differences were primarily attributable to respondents' perceptions after introduction of the information system and their retrospective assessment of the initial situation. Therefore, the results in stage B provide evidence that introduction of the office information system resulted in gamma change among the respondents.

Table 3: Comparisons, significance tests, and B2 index.

Tests		Comparisons						
		T1T2	T1T3	T2T3	T1T2T3	T1T2T3 -T1T2	T1T2T3 -T2T3	T1T2T3 -T1T3
Null models	a	279.9	292.9	265.7	419.3	139.4	153.6	126.4
	b	49	49	49	74	74	74	74
A. Equality of matrices	a	53.7	66.7	56.6	113.9	60.9	57.2	47.1
	b	36*	36***	36*	72***	36**	36*	36*
B. Gamma:	a	56.0	66.6	65.7	114.2	38.2	28.4	47.6
factor structure	b	36*	36***	36***	54***	18**	18	18**
C. Beta and Gamma:	a	68.1	74.4	83.3	120.1	52.0	36.8	45.7
factor structure factor loadings	b	43***	43***	43***	68***	25**	25	25*
C-B. Beta due to	a	12.1	7.8	17.6	5.9	13.8	8.3	1.9
factor loadings	b	7	7	7*	14	7	7	7
	c	.04	.03	.07	.01	.10	.05	.02
D. Beta and Gamma:	a	81.6	93.0	89.7	140.8	59.4	51.1	47.9
factor structure factor loadings item variances	b	51***	51***	51***	84***	33**	33*	33*
D-C. Beta due to	a	13.5	18.6	6.4	20.8	7.4	14.4	2.1
item variances	b	8	8*	8	16	8	8	8
	c	.05	.04	.02	.05	.05	.09	.02
E. Beta and Gamma:	a	82.3	93.6	89.8	141.8	59.6	52.0	48.2
factor structure factor loadings item variances factor variances	b	53***	53***	53***	88***	35**	35*	35*
E-D. Beta due to	a	.7	.7	.1	1.0	.2	.9	.3
factor variances	b	2	2	2	4	2	2	2
	c	.00	.00	.00	.00	.00	.01	.00
F. Beta and Gamma:	a	84.1	94.0	95.9	148.2	64.1	52.3	54.2
factor structure factor loadings item variances factor variances factor convariances	b	56***	54***	54***	90***	36**	36*	36*
F-E. Gamma due to	a	1.8	.4	6.1	6.4	4.6	.3	6.0
factor convariances	b	1	1	1*	2*	1*	1	1*
	c	.01	.00	.02	.00	.00	.00	.00

a. χ^2 total
b. Degrees of freedom for each comparison
c. B2 index of change in fit, controlling for magnitude of χ^2
*$p < .05$;
**$p < .01$;

The results shown in Table 3 also indicate that the difference between the two-factor model and the null model was significant in all cases. As a result, the two-factor models were significantly superior to the null models for each comparison.

Results from stage C (adding factor loadings) were similar to but stronger than the results for B. Results from D (adding item variances) showed all comparisons to be significant, as did results from E (adding factor variances) and F (adding factor covariances). The following hierarchical tests identify the unique contributions of the factor structures, loadings, variances and covariances, and item variances, indicating the various forms of beta or gamma change.

There was only one instance (T2T3) in which a statistically significant difference between stages B and C existed. This result indicates that the degree to which the respondents calibrated each of the eight office activities as an information management or communication-related activity did not differ significantly between the "pre-" and "post-" comparison points. However, their "then" retrospective assessments differed significantly from the "post-" measures, representing a 7 percent change according to the B2 index.

The statistically significant differences between stages C and D existed only in the T1T3 comparison. This indicated that the amount of variance in the hypothesized model associated with the measures of perceived effectiveness in performing eight office activities differed significantly only between the "pre-" and "post-" comparison points. This difference represented a 4 percent change according to the B2 index.

There were no statistically significant differences between the fit of models in stages D and E, indicating that the amount of variance explained for each of the two hypothesized factors did not differ significantly across the three comparison points. The 0 of zero percent B2 index mirrored this result.

Finally, there were instances of statistically significant differences between stages E and F, an indication that the covariance between the two hypothesized factors was not consistent across the three comparison points considered together (T1T2T3) (a form of gamma change). Pairwise comparisons indicate that these differences were primarily between the "post-" and "then" comparison points and involved only a 2 percent change. These results were further confirmed by examining the difference between the T1T2T3 comparison and the pairwise comparisons. Again, "post-" and "then" were sources of significant differences when the pairwise comparison values were subtracted from the T1T2T3 comparison values but the changes represented less than 1 percent of the null model χ^2.

Summary

In summary, the results provide statistically significant, but generally weak, evidence for the presence of two forms each of beta and gamma changes associated with the implementation of a networked office information and communication system. First, the respondents' calibration of each office activity as an information management or communication-related activity "post-" differed significantly from the calibration of their "then" retrospective assessments (one form of beta change). Second, the extent to which the respondents' initial "pre-" assessment of each of the eight activities was accounted for by the two factors differed from their "post-" assessments (a second form of beta change). Third, the respondents' initial "pre-" conceptualization of the eight activities as separate dimensions of office work differed significantly from their conceptualizations after introduction of the information system "post-" and from their retroactive assessments "then" (a form of

gamma change). Finally, the extent to which respondents conceptualized the relationship between information management and communication-related office activities after introduction of the information system "post-" differed significantly from their retrospective assessment of the relationship "then" (a second form of gamma change).

DISCUSSION

The present research identifies possible alpha, beta, and gamma changes associated with the implementation of a system of networked personal computers with office activity software, extending an earlier unpublished study on the question of whether office computer systems might cause users to reconceptualize their work [17].

Reconceptualizing the Dimensionality and Effectiveness of Office Activities

The overall conclusion is that implementation of the integrated office information system had modest but statistically significant effects, but not in the traditional way as measured by alpha change. Rather, the significant effects occurred in the way organization members conceptualize generic office activities; over time, those activities were seen as more integrated or unidimensional. At T2, respondents reassessed their effectiveness at T1 downward ("then") and conceptualized the underlying dimensionality of how effective they thought they had been midway between the conceptualized dimensionalities at T1 and T2. Both these results provide some support for propositions that computer-based organizational work creates cognitive challenges not present in noncomputer-based work and that such systems may enable (or force) users to reconceptualize their work. Further, the results indicate that users may downgrade their prior criteria for effectiveness because they come to perceive how they can be more effective.

Implications of "Then" Assessments

The approach presented here uses but differs from Schmitt's [26] approach. Schmitt argued that the adoption of analysis of covariance structures using "pre-" and "post-" measures eliminated the need to obtain a "then" measure (suggested originally in [29]).

The present research tested the efficacy of including the "then" measures. The results indicate that comparisons of the respondents' assessments before ("pre-") and after ("post-") the introduction are not the primary source of gamma change. Rather, the retrospective assessments ("then") of effectiveness are the root of conceptual change plausibly attributed to the implementation of the office system. In other words, respondents' changed conceptualization (usually negative) of how effective they thought they really were before implementation is the basis for most gamma changes. Our results show that the inclusion of "then" measures in the comparison provided us with additional insights not revealed by the "pre-"/"post-" comparisons.

A secondary conclusion from these results is that recall data about pre-implementation conditions are not suspect simply because of poor respondent memory or demand characteristics. Rather, if a new information system really does have subtle conceptual effects, recall data may be "then" measures of possible beta or gamma effects rather than surrogate "pre-" measures used to detect alpha change. Golembiewski [6] interpreted such implications as quite consequential; not

only are results from most cross-sectional studies potentially suspect but even those from overtime analyses that do not explicitly identify the types of changes involved are in doubt.

Qualifications and Extensions

The study reported here is preliminary but does provide one model for future research into managerial decision making about computer-mediated work. It is based on the experiences of one small office and uses nonstandardized but relevant measures of changes in effectiveness. These particular measures of generic office activities may confound measurement error with evidence of beta and gamma changes. Future studies should attempt to develop and use these and other more appropriate measures of perceived effectiveness [8] [9]. Larger samples will allow for testing differences in potential alpha, beta, and gamma changes among different roles. Perhaps managers would be less likely to exhibit gamma change because of an initially broader view of office activities. However, that assumption, if untested, may continue to contribute to resistance, frustration, and confusion of new users of computer systems, as suggested in the introduction. It would also be challenging to consider and evaluate whether certain kinds of systems (such as data processing, management information systems, decision support systems, office automation, or expert systems) are more likely to lead to these problems for certain kinds of workers.

Implications for Managing Office Information Systems

Implications for use, management, training, and evaluation concerning organizational information systems will be very different depending on how change is conceptualized and measured. As some researchers [31] [32] [33] have speculated, if such systems present new ways to conceptualize work, then management policies and training programs must not only prepare users for such changes but also provide workers with the tools to establish these new contexts. For example, job descriptions and reward systems that segment office tasks and workers based on traditional task boundaries and communication flows may hinder the performance of workers who can now see how these tasks are integrated through the use of computer-based communication and information systems but who do not know how best to use the systems to keep these new relationships in context. Bikson [4] found that after the introduction of work-station technology, workers in her large sample reported being able to perform more information tasks faster and better, leading to an increase in performance standards in over half of the 55 work units. They also reported new and higher skills involved in this work. However, job descriptions changed in only a third of the units and pay levels in only a fifth. Further, current managerial policies may actually punish workers who attempt to make sense of their new electronic environments by continuing to evaluate hourly inputs on the basis of less effective conceptualizations of tasks rather than to reward experimentation and learning in response to cognitive challenges and computing capabilities [11].

Many other factors influence the outcomes associated with office information systems (such as individual differences, work group communication, supervisory support, work unit structure, organizational policies, and environments [16] [23]). However, whether managers are directly affected by new systems or not, they must still make decisions about how to plan for and respond to these tensions relating

to how users of new systems reconceptualize their work. Indeed, differences in the traditional roles of managers, professionals, and secretarial/clerical workers may be disappearing because users are beginning to perceive the variety of office activities as unified rather than compartmentalized by job category. In the information age, all organizational workers can become knowledge workers, depending on implementation polices [5] [11] [33]. The implications for ignoring beta and gamma changes associated with the implementation of office information systems may be (and may already have been for many years) highly consequential. [Received: June 27, 1988. Accepted: March 9, 1989.]

REFERENCES

[1] Armenakis, A., & Zmud, R. Interpreting the measurement of change in organizational research. *Personnel Psychology*, 1979, *32*, 709-723.

[2] Bedeian, A., Armenakis, A., & Gibson, R. The measurement and control of beta change. *Academy of Management Review*, 1980, *5*, 561-566.

[3] Bentler, P., & Bonnett, D. Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, 1980, *88*, 588-606.

[4] Bikson, T. Cognitive press in computer-mediated work (Rep. No. N-2679-NSF/IRIS). Santa Monica, CA: Rand Corporation, 1987.

[5] Giuliano, V. The mechanization of office work. *Scientific American*, 1982, *274*(4), 148-165.

[6] Golembiewski, R. Contours in social change: Elemental graphics and a surrogate variable for gamma change. *Academy of Management Review*, 1986, *11*(3), 550-566.

[7] Golembiewski, R., Billingsley, K., & Yeager, S. The congruence of factorial structures: Comparisons of four procedures and their solutions. *Academy of Management Review*, 1976, *1*, 26-35.

[8] Hamilton, S., & Chervany, N. Evaluating information system effectiveness—Part I. Comparing evaluation approaches. *MIS Quarterly*, 1981, *25*(3), 55-69.

[9] Hamilton, S., & Chervany, N. Evaluating information system effectiveness—Part II. Comparing evaluator viewpoints. *MIS Quarterly*, 1981, *25*(4), 79-86.

[10] Huber, G. The nature and design of post-industrial organizations. *Management Science*, 1984, *30*, 928-951.

[11] Johnson, B., & Rice, R. E. *Managing organizational innovation: The evolution from word processing to office information systems*. New York: Columbia University Press, 1987.

[12] Joreskog, K., & Sorbom, D. *LISREL VI: Analysis of linear structured relations by the method of maximum likelihood*, (4th ed.). Mooresville, IN: Scientific Software, Inc., 1986.

[13] Kiesler, S., Siegel, J., & McGuire, T. Social psychological aspects of computer-mediated communication. *American Psychologist*, 1984, *39*, 1123-1134.

[14] Kling, R. Social analyses of computing: Theoretical perspectives in recent empirical research. *Computing Surveys*, 1980, *12*(1), 61-110.

[15] Lindell, M., & Drexler, J. Equivocality of factor incongruence as an indicator of types of change in OD interventions. *Academy of Management Review*, 1980, *5*, 105-108.

[16] Lucas, H., Jr. *Implementation: The key to successful information systems*. New York: Columbia University Press, 1981.

[17] Mohrman, A., Jr., & Novelli, L. Adaptively researching the impacts of information processing technologies in the office. Paper presented to the Academy of Management Conference, New York, August, 1982.

[18] OIRM. *Merlin—To improve productivity for: Managers, professional, technical specialists*. San Francisco, CA: Office of Information Resources Management, GSA, 1983.

[19] Olson, M., & Lucas, H., Jr. The impact of office automation on the organization: Some implications for research and practice. *Communications of the ACM*, 1982, *25*, 838-847.

[20] Randolph, W., & Edwards, R. Assessment of alpha, beta, and gamma changes in a university setting. In *Proceedings of the Academy of Management*. Mississippi State, MS: Academy of Management, 1978.

[21] Rice, R. E. Computer-mediated communication systems and organizational innovation. *Journal of Communication*, 1987, *37*(4), 65-94.

[22] Rice, R. E. Issues and concepts in research on computer-mediated communication systems. In J. Anderson (Ed.), *Communication Yearbook* (Vol. 12). Beverly Hills, CA: Sage, 1989.

[23] Rice, R. E. Organic organizations and centralized units: Use, contexts, and outcomes of word processing. In J. Morell & M. Fleischer (Eds.), *Advances in implementation and impact of computer systems*, (Vol. 1). New York: JAI Press, 1989.

[24] Rice, R. E. & Associates. *The new media: Communication, research and technology*. Beverly Hills, CA: Sage, 1984.

[25] Schaubroeck, J., & Green, S. Alpha, beta, gamma change as outcomes for organizational entry research. In *Proceedings of the Academy of Management*. Mississippi State, MS: Academy of Management, 1988.

[26] Schmitt, N. The use of analysis of covariance structures to assess beta and gamma change. *Multivariate Behavioral Research*, 1982, *17*, 343-358.

[27] Schmitt, N., Pulakos, E., & Lieblein, A. Comparison of three techniques to assess group-level beta and gamma change. *Applied Psychological Measurement*, 1984, *8*(3), 249-260.

[28] Schuck, G. Intelligent technology, intelligent workers: A new pedagogy for the high-tech work place. *Organizational Dynamics*, Autumn, 1985, 66-79.

[29] Terborg, J., Howard, G., & Maxwell, S. Evaluating planned organizational change: A method for assessing alpha, beta, and gamma change. *Academy of Management Review*, 1980, *5*(1), 109-121.

[30] Wagoner, K., & Ruprecht, M. *Integrated office systems: A management approach*. New York: Wiley, 1987.

[31] Weick, K. Cosmos vs. chaos: Sense and nonsense in electronic contexts. *Organizational Dynamics*, 1985, Autumn, 51-65.

[32] Zuboff, S. New worlds of computer-mediated work. *Harvard Business Review*, 1982, *60*(5), 142-152.

[33] Zuboff, S. Automate/informate: The two forces of intelligent technology. *Organizational Dynamics*, 1985, Autumn, 4-18.

Ronald E. Rice is an Associate Professor at the School of Communication, Information, and Library Studies at Rutgers University. He received his M.A. and Ph.D. from Stanford University. Dr. Rice is co-editor or co-author of *Public Communication Campaigns, The New Media, Managing Organizationl Innovation*, and *Research Methods and the New Media*. His research interests include communication campaigns, implementation and effects of organizational communication systems, network analysis, and diffusion of innovations.

Noshir S. Contractor is an Assistant Professor of Communication at the University of Illinois at Urbana-Champaign. He received his Ph.D. in communication theory and research from the Annenberg School of Communications at the University of Southern California, Los Angeles. Dr. Contractor's articles have appeared in several journals including *Organization Sciences, Communication Research*, and the *Journal of Broadcasting and Electronic Media*.