COVER SHEET

When Do Organizations Need to Change (Part II)? Incongruence in Action

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Abstract

Organizations that adapt to changes in their environment have a much better chance at achieving their mission and performing well. When organizations do adapt they usually alter their strategies, but rarely do they change their organizational structure even when that structure no longer fits the mission. To identify the conditions that will be salient enough to cause organizations to alter not only their strategies, but also their current structures, we used a model-based design process to create mission scenarios that were either matched (congruent) or mismatched (incongruent) with two organizational structures (functional, divisional). We then examined measures over time to identify ones that discriminated between congruent and incongruent conditions early in the mission scenarios. Several measures of communications, performance and workload appeared to be good candidates for leading indicators of the need for organizational change.

Introduction

It is well accepted that organizations that can adapt to internal changes or changes in their environment have a much better chance at achieving their mission and performing well. Indeed, it has been demonstrated that high performing organizations are adept at sensing changes in their environment and altering their strategies to accommodate these changes without compromising performance (Entin & Serfaty, 1999). Little, however, is known about the dynamics of change or the conditions that might lead organizations to alter their strategies or make changes to their current organizational structures. Moreover, while there is evidence that organizations will institute strategy changes, they appear quite reluctant to make changes to their structures (Entin, Serfaty, and Kerrigan, 1998; Hollenbeck et al., 1999).

To better understand and identify the conditions that will cause organizations to alter not only their strategies, but also their current structures, we need to know more about ways to facilitate structural adaptation. In other words, what are the diagnostic conditions, or leading indicators, that organizations could use to realize that their organizational

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structures no longer fit particular missions (incongruence)? And at what point does the "pain" of incongruence become so great that structural change is initiated? The purpose of this presentation is to explore the first question in order to identify leading indicators of the need to change. This work will set the stage for future empirical evaluations of structural adaptation in action.

The present paper builds on the manipulation of organizational congruence presented by Diedrich et al. (2003, this volume). The approach used by Diedrich et al. was to define two disparate organizational structures and then design two missions (scenarios) that exploited the differences between the two structures. Thus, the objective was for the first mission scenario to be "tuned" to organization 1 through a high degree of congruence, while also being "mismatched" (i.e., exhibit low congruence) with organization 2. The goal was for the reverse to be true for the second scenario. Thus, it was possible to observe an organization in both a mismatched (incongruent) and matched (congruent) situation.

Based on previous work (Diedrich, Hocevar, Entin, Hutchins, Kemple, & Kleinman, 2002; Hutchins, Kleinman, Hocevar, Kemple, & Porter, 2001; Moon, Hollenbeck, Ilgen, West, Ellis, Humphrey, & Porter, 2000), the two organizational structures that Diedrich et al. (2003) explored are commonly referred to as functional (F) and divisional (D). In this case, the functional structure was organized such that each participant specialized in one or two aspects of a mission such as strike using assets that were distributed across multiple platforms (ships). In contrast, in the divisional structure, each participant had control over a multifunctional platform that to a large extent was able to process a variety of functional tasks. Given these organizations, and based on the modeling supporting this effort (e.g., Kleinman et al., 2003; Levchuk et al., 2002, parts I &II; Levchuk et al., 2001) it was expected due to the greater coordination requirements for task processing, communications and perceived workload would increase in the incongruent conditions. Likewise, given the additional coordination and communication requirements, it was predicted that performance would suffer.

Overall, the findings reported by Diedrich et al. (2003) were consistent with these model-based predictions. These authors explored the F and D organizations in two scenarios, one of which was functional-favoring (f) and one of which was divisional favoring (d). Relative to the congruent cases (F-f, D-d), communications increased in the mismatched conditions (F-d, D-f), reflecting the model-based manipulation of the need for cross-participant coordination, which was the primary tool employed to engineer congruence. Similarly, consistent with these manipulations, the perceived workload also tended to increase, while the level of performance tended to decrease in the mismatched conditions. Collectively, these results provided strong evidence that the congruence manipulation was effective.

Based on these data, Diedrich et al. (2003) also suggested that communication strategies might provide suitable "leading indicators" of the need for structural change. Leading indicators are defined as measures that signal that an organization's structure is no longer congruent with its mission and that change is needed to optimize mission effectiveness. Strategies are interesting potential leading indicators because, when teams sense deterioration in their performance due to stress, increased workload, or other conditions, they tend to attempt to ameliorate these problems by adopting different strategies (Entin and Serfaty, 1999). In particular, communication strategies are important because communications are the vehicle through which teams attempt to deal collectively with mission execution. Consequently, Diedrich et al. (2003) argued that these strategy changes might offer insight into leading indicators of the need for change to the extent that they reliably reflect how an organization attempts to cope with the difficulties associated with incongruence. Consistent with this claim, results indicated that communication strategies did indeed change in the face of incongruence, but that the specific changes observed depended on the context provided by the organizational structures and mission scenarios.

However, these findings were based on measures taken over the course of the entire mission scenarios. While interesting, ideally speaking, leading indicators should predict the need for change early in a mission prior to any severe performance decrements. Accordingly, in this paper we explored potential leading indicators by concentrating on measures taken over time. Similar to Diedrich et al. (2003), we once again concentrated on measures of communication, workload, and performance. We believe that by examining measures taken over time, we can identify if and when the measures are sensitive to deteriorating conditions, thus shedding light on what measures might make good candidates as leading indicators.

Method

Participants

Forty-eight officers attending the Naval Postgraduate School served as participants. Most of the officers were 03 or 04 and several services and nations were represented. Participants were organized into eight teams of six individuals each. For complete details on scenario design, organizational design, and method, see Diedrich et al. (2003) and Kleinman et al. (2003).

Experimental Design and Independent Variables

There were two primary independent variables. The first, organizational structure, was manipulated as a between-subjects variable and was comprised of two levels (divisional (D) and functional (F)). Each team performed in only F or D. In the divisional organizational structure, team members "owned" a multifunctional platform (ship) that they used to process air, surface, and subsurface threats in a specified geographical area. For the functional organizational structure, each team member specialized in one or two aspect of the mission such as air warfare or ballistic missile defense. The assets necessary for a particular warfare area resided on various platforms distributed over the entire battle space.

The second primary independent variable was scenario, which was manipulated as a within-subjects factor with two levels (functional (f) and divisional (d)). Each team performed in both d and f across two replications (fddf or dffd). In brief, two scenarios were developed, one that was congruent with the divisional organizational structure (d) and one that was congruent with the functional organizational structure (f). Thus, by manipulating the presentation of the two scenario types across the two organizational structures, we created conditions of congruence (F-f and D-d) and incongruence (F-d and D-f).

Simulator and Scenario

The simulation was implemented in the Distributed Dynamic Decision-making (DDD) environment. The DDD is a distributed client server simulation that provides a flexible framework in which to study individual and team performance. DDD simulations involve individual (and team) decision-making about complex situations based on information and resources provided by the simulation (and other team members) (Serfaty & Kleinman, 1985; Kleinman & Serfaty, 1989). As presented in Kleinman et al. (2003), the F and D organizations and f and d scenarios were implemented in the DDD. To manipulate congruence or incongruence, several variables were employed including between-team member coordination requirements for processing mission tasks and task phasing (i.e., waves of attacks directed so as to overwhelm particular team members based on their mission roles).

Procedure

Participants began the experiment by first signing a standard consent form and then completing two hours of DDD "buttonology" training to learn how to control the various assets and how to use the various functions contained in the DDD simulation. A second two-hour session provided training designed to provide the skills necessary to perform either the divisional or functional scenarios, without creating a bias for either kind of scenario. Teams next engaged in a two-hour data collection session, where in a counter-balanced order, they performed a divisional and functional scenario. A second two-hour data collection session followed anywhere from several hours to several days later. Once again, teams completed a divisional and functional scenario. In general, the mission involved preparing a battlespace for the arrival of follow-on forces by engaging hostile assets perceived as immediate threats. Simultaneously, players were charged with destroying or capturing an enemy command post, two enemy air bases, two enemy naval bases, and a port. In addition, players had to defend neighboring foreign friendly areas from SCUD missile attacks. For complete details on the methodologies used see Diedrich et al. (2003).

Data Analysis

Dependent measures were derived from three different sources: instruments completed by trained observers, participant self-report measures, and measures derived from the DDD simulator. Below, we briefly describe the instruments employed for each of these areas in context of our emphasis on measures over time.

<u>Team Communications</u>. Verbal communications among the members of the team were captured by two observers at an intermediate level of detail that incorporated both semantic and quantitative aspects of the communication stream (Entin, 1999). During the conduct of a scenario the observers listened to the communications in real time, and used specially design software and a handheld, touch-sensitive screen computer to code the

source, recipient, time, and type of the verbal communications among the team members. One of the observers coded the communications for three of the team members, while the other observer coded the communications exhibited by the remaining team members. Types of communications were divided into three basic categories: transfers, requests, and acknowledgements. Both transfers and requests were, in turn, classified as requests for or transfer of information, action, or coordination.

Workload. At five-minute intervals throughout the scenario the DDD simulator prompted each team member to provide an estimate of the workload they were experiencing at the moment. The prompt was in the form of a window that opened on the display. The workload rating was made on a seven point Likert scale anchored at one end by the word "low" and the other end by "high." The windows, which were mildly intrusive, could not be closed until a rating was made.

Performance Measures. The DDD simulator provided several measures of performance over time. These measures included the number of tasks to be processed within a given time period, the number of tasks processed within a given time period (attacks), the time at which a task was processed, and a measure of accuracy of processing (resources applied/resources needed).

Results

Given our emphasis on leading indicators of the need to change, in this paper we analyzed our data *over time*, contrasting the congruent cases (D-d, F-f) with the incongruent cases (D-f, F-d). The goal of these analyses was to identify those variables that showed *early* signs of differences that could be used to signal the need for change. Our analyses focused on the same classes of measures described by Diedrich et al. (2003), including performance over time, communications over time, and workload over time. It should be noted that, in general, the differences between the congruent and incongruent conditions for each of measures listed above were all found to be significant when analyzed as end of trial measures (Diedrich et al., 2003). Building on these analyses, the measures for these variables over time also generated significant differences between the congruent and incongruent conditions over the time periods.

Tempo

We began these analyses by first deriving a measure of the tempo of the scenarios. In general, scenario tempo was created by the rate of delivery of the tasks into the game and the rate at which the tasks were processed or disappeared (i.e., timed out). Consequently, the tempo measure reflects the number of tasks on the screen to be processed. We present this measure first as we used it as a guide to understand how various measures (communications, performance, workload) might unfold over time. Results are shown in Figure 1, which plots time period by the maximum number of tasks to be processed. The time periods represent seven 5-minute periods that covered the entire scenario. These data show that in general, the average maximum number of tasks to be processed peaked in the middle of the scenario runs. This curvilinear pattern is also reflected in the various performance and process measures presented next.

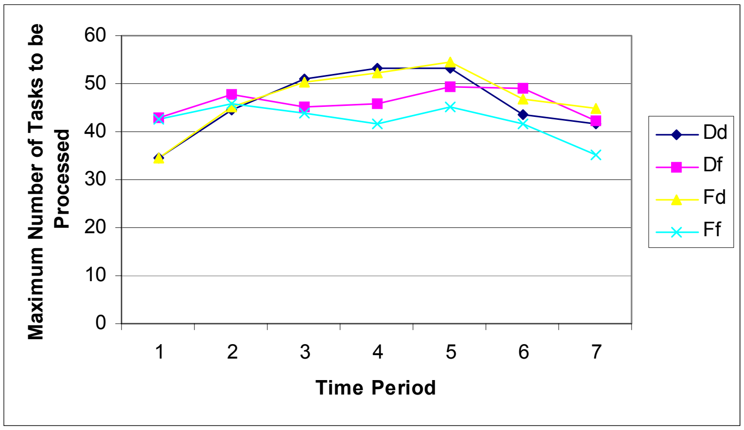


Figure 1. Scenario tempo (maximum number of tasks to be processed).

Communications Over Time

As noted above, the model-based manipulation of congruence hinged on coordination requirements, in that relative to the congruent conditions, performance in the incongruent conditions required much greater between-participant coordination to complete tasks accurately (Diedrich et al., 2003; Kleinman et al., 2003). Consequently, we predicted that communication volume would be enhanced in the mismatched conditions, as in general, a great deal of coordination is achieved through verbal exchange within the context of these types of mission scenarios (Entin and Serfaty, 1999). Consistent with results for the entire scenario (Diedrich et al., 2003), there were strong and consistent difference between conditions early in the scenarios. Figure 2 shows the between condition differences across seven 5-minute time periods. For the F organizations, across the entire mission scenario, communication volume in the incongruent case (F-f) greatly surpassed that seen in the congruent case (F-d). Similarly, for the D organization, with the exception of time period 5, communication volume in the D-f case surpassed that in the D-d case. In general, however, these latter differences were smaller than those seen in the F organization. Collectively, these data show that early in the scenario, differences in communications volume can potentially provide clues to incongruence. However, the magnitude of these differences depended on the specific scenario-structure pairings.

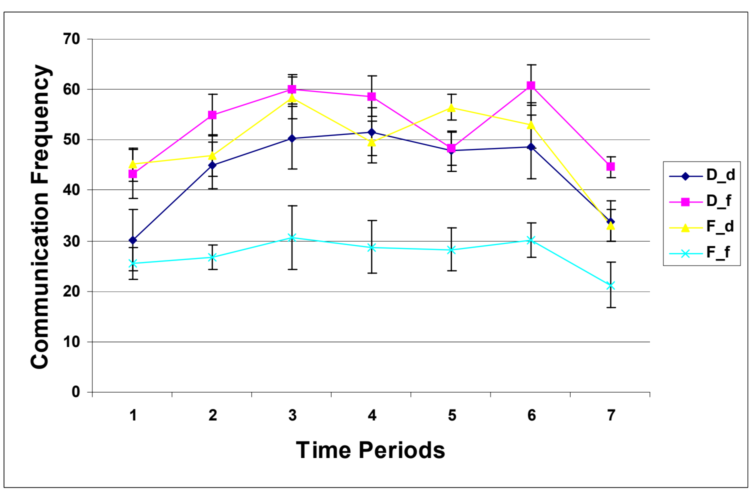
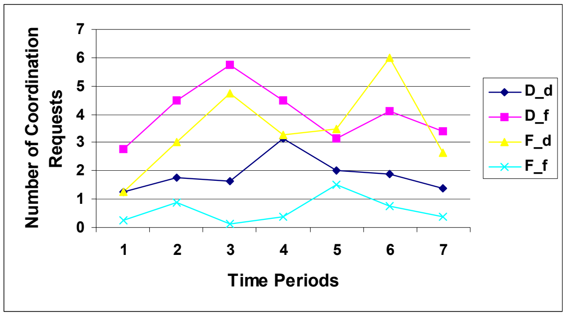


Figure 2. Total communication frequency for each congruency condition.

Similar to the overall communications volume, Figure 3 shows that the requests for coordination (e.g., "I need your help…") and statements that coordination will, is, or has occurred (transfers, e.g., "Ready to coordinate on …") are also higher in the incongruent than the congruent cases for almost all the time periods. Once again, these data are important in that they reflect the model-based manipulation of coordination requirements. In response to this manipulation, not only were communications in general increased, but likewise, communications specifically about coordination increased. Once again, these differences were present early in the scenarios.



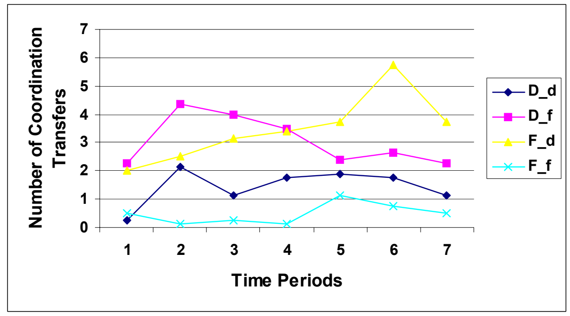


Figure 3. Frequency of request for coordination and coordination transfers for each congruency condition

In total, the communications data revealed that there were robust differences between the congruent and incongruent cases early in the scenarios. These differences were particularly profound for the F organization, and in addition, these differences appeared in both the overall communications and in communications specifically about coordination. These data suggest that communications might provide early, leading, indicators of the need for organizational change. However, the precise patterns depended on context of the organizations and scenarios (see also, Diedrich et al., 2003).

Workload Over Time

Since the manipulation of congruency hinged on coordination requirements, and since more coordination and communication is required to effectively process tasks in the incongruent conditions, we predicated that there would be an increase in perceived workload in the incongruent conditions. Over the course of the entire scenario, results tended to show higher perceived workloads in the incongruent conditions for both organizations D and F. Moreover, as shown in Figure 4, there were also differences in perceived workload over time. However, it is also clear that the patterns across the seven time periods are quite varied for the four conditions. Average workload scores for the two functional organization conditions showed a sharp drop in time period 7. Teams in the divisional organizational structure did not exhibit this pattern. In addition, Figure 4 shows that perceived workload for the four congruency conditions to be quite similar initially and then start to diverge in time period three. This suggests that, although differences in perceived workload across congruence conditions were present early, these differences were not present as early in the scenario as the communication differences.

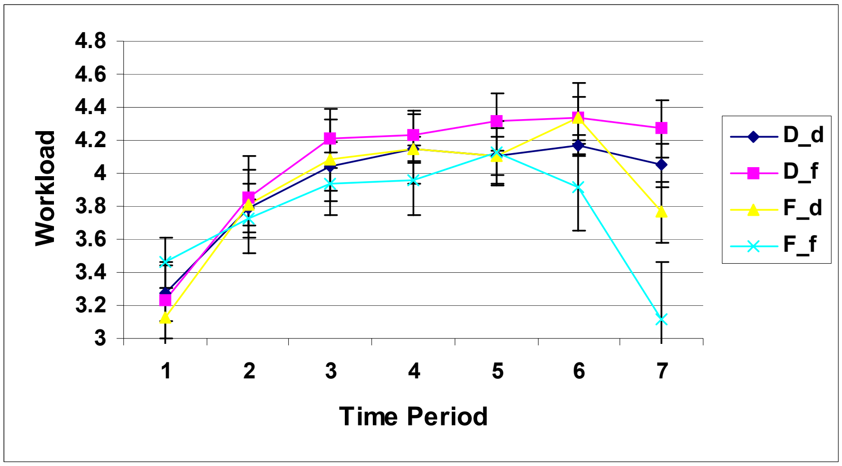


Figure 4. Self-reported workload aggregated by team and plotted over time.

Performance over time

Based on the enhanced coordination requirements, we expected that performance would be negatively impacted in incongruent conditions due to an inability to quickly and accurately process a large number of tasks. Indeed, this was true in terms of overall performance measures with respect to the percent of task processed (Diedrich et al., 2003). Building on these findings and to explore these data over time, we derived the number of attacks initiated by teams in each congruency condition. Once again, the mean number of attacks initiated was computed for each five-minute interval of the scenario and plotted by condition. Figure 5 shows that in terms of the number of tasks processed, the two congruent conditions, D-d and F-f, performed at a higher level than their corresponding incongruent conditions, D-f and F-d, across all of the time periods. Moreover, the differences between the congruent and incongruent conditions appeared right from the first time period and persisted over the seven time periods.

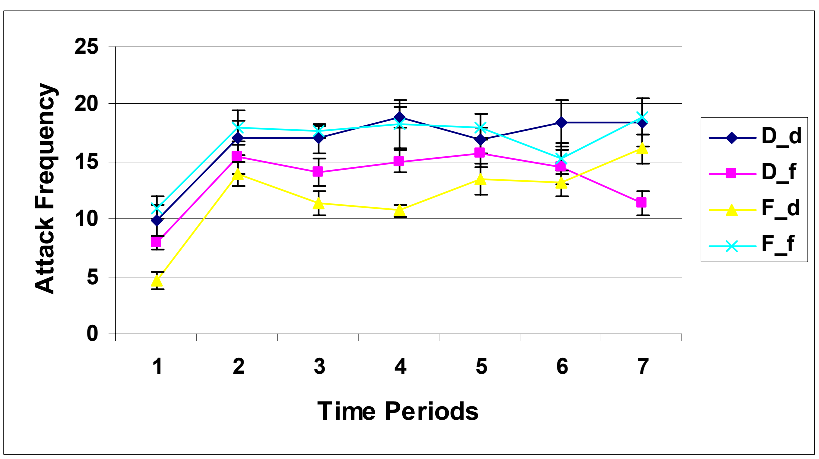


Figure 5. Frequency of attacks (tasks processed) over time.

To more fully explore performance over time, we then calculated a temporal performance measure that combined accuracy, timeliness and efficiency, plus task value, into a single metric and plotted it for a given mission scenario. Task value was included as it reflects the importance of the task relative to the commander's intent or priority. According to commander's intent, all tasks were not equally important (Kleinman et al., 2003).

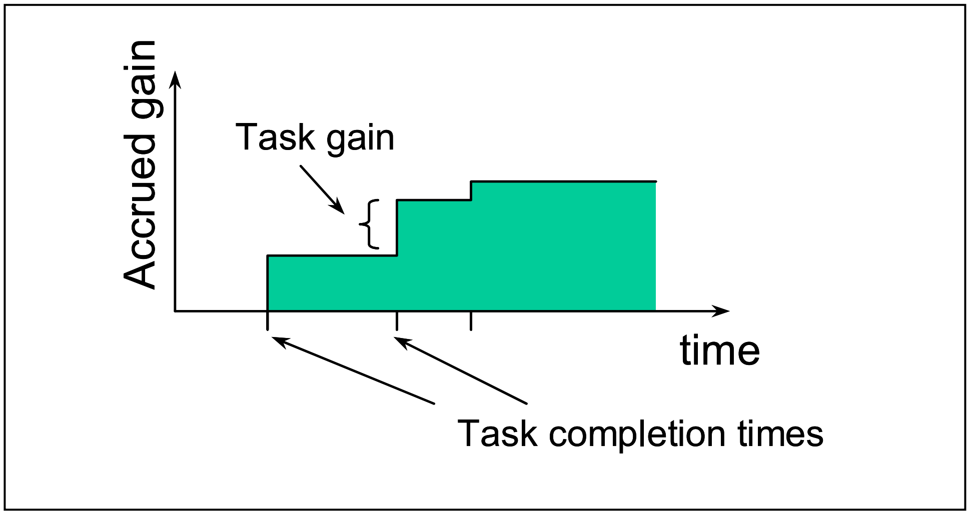


Figure 6. Accrued gain metric.

In order to understand the temporal measure, refer to Figure 6. Assume that task i with value Vi is competed at time ti with accuracy ACCi. (Note: different formulae might be used in computing ACCi depending on the experimental context.) The "gain" that the team accrues at time ti is defined as:

$$Gi = Vi * ACCi$$

Thus, the accumulated gain at time t, G(t) is the summation over all tasks i completed at or prior to time t:

$$G(t) = \sum Gi * u(t - ti)$$

where the unit step function, u(x) = 1 if x > 0, otherwise u(x) = 0. The plot of G(t) versus time t is thus the staircase function as shown in Figure 6.

In general, the accumulated gain G(t) has several desirable properties that are immediately evident. If tasks are processed sooner, the rise in G(t) is earlier. If tasks are processed more accurately, the rise in G(t) is steeper. (Note that the rise is also a function of processed task value.) A comparison of two gain plots would thus show differences in timeliness or accuracy or both. In addition, the area under the accumulated gain plot – either as an accrued area or a total area to the end of the scenario – provides an interesting *aggregated* measure of performance that subsumes a number of individual dimensions as noted above. This area from time 0 to time T is given by:

$$\text{Area} = \sum G_i * (T - t_i)*u(T - t_i)$$

Applying this measure to congruent and incongruent cases, the results for the divisional scenario were 45.8 (D-d) and 33.5 (F-d). For the functional scenario, the results were 42.8 (F-f) and 33.6 (D-f). The larger areas under the congruent condition curves and the smaller area under the incongruent conditions show that the teams were less timely and accurate processing tasks in the incongruent conditions. Figure 7 illustrates the over time results. Once again, from early in the mission scenarios, performance differences were present that could serve as leading indicators of the need for structural change.

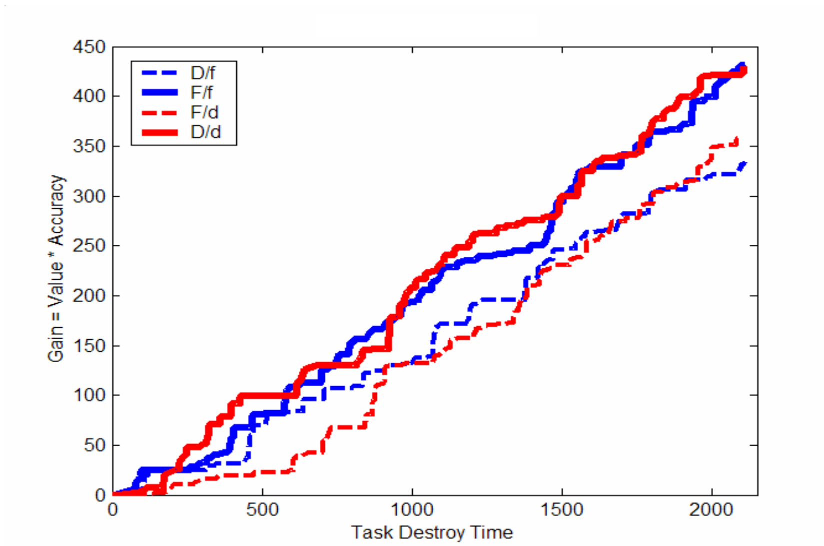


Figure 7. Temporal performance accrued gain measure plotted for the four congruence conditions.

Discussion

The goal of the over time analyses reported here was to identify candidate leading indicators that signal that an organization's structure is incongruent with its mission. Consequently, we examined measures over time to find ones that were sensitive to the incongruence early in the missions before performance decrements become overly problematic. In the main, our analyses were successful, as we identified several over time measures that have promise as leading indicators.

Our results showed that measures of overall communication frequency and communications specifically about coordination exhibited the differences early in the mission scenarios and that the differences generally persisted over the mission scenarios. Based on the modeling that created the congruent and incongruent conditions, we expected the observed increases. However, it remained to be empirically determined how early these difference would appear and how persistent they would be over the scenarios.

Thus, our findings were particularly noteworthy and satisfying. Similarly, the finding that perceived workload showed differences between the congruency conditions early in the mission scenarios also suggested that self-reported workload may qualify as a leading indicator. However, the workload measure seemed to lag behind the observed differences in communication strategies.

Results also indicated that the temporal performances measures were compelling. In particular, the accrued gain measure was interesting because it is a multidimensional measure that combines task accuracy, timeliness, and task value (i.e., importance or criticality) into a single easily displayed measure. There was, however, some question as to how sensitive the measure was to incongruence *early* in the missions. The lower temporal performance was revealed early in the scenario for the F-d incongruent condition, but this was not the case for the D-f incongruent condition. For the D-f condition, over 10 minutes (one-third) of the scenario went by before the drop in temporal performance became obvious. On the other hand, performance had not significantly deteriorated up to that point, compared to the congruent condition. Nevertheless, similar to workload, this measure seemed to lag behind the communication measures.

Consequently, although each of the measures explored here showed robust and promising differences, within the context studied here, in general the communication differences seemed to lead the other measures. Thus, the communication measures appeared to be particularly promising candidates for leading indicators. However, Diedrich et al. (2003) noted that the precise communication differences observed depended on the contexts created by the structures and the missions. Similarly, when measured over time, teams in the functional organizational structure drastically change their communication patterns compared to teams in the divisional organizational structure. These findings suggest that it is likely that as additional conditions are explored, several measures – both communication and performance based – may be necessary to accurately gauge congruence across multiple contexts.

Building on these data, then, our next goal will be to use these findings on leading indicators to design ways to support and then empirically explore structural adaptation. In general, we believe that several critical conditions will have to be met before a team will alter its organizational structure, ranging from training to cue salience. Thus, as one factor, we believe that by using leading indicators to provide organizations with some insight into how their structures are working, we may be able to help induce structural change. This supports the idea of a model-based "congruence meter" or "fit gauge" that would highlight the lack of congruence at any point in time. If this technological implementation were coupled with the proper training indicating that changes to organizational structure are not only acceptable, but sometimes required, then structural adaptation may occur in a manner that can support mission effectiveness.

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