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The E-Collaboration Paradox: A Study of 290 New Product Development Teams

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ABSTRACT

There has been significant evidence that electronic media pose obstacles to communication when used to support collaborative tasks, especially tasks that involve intense communication. Yet, there is also a substantial body of empirical evidence suggesting that the impact of electronic communication media use on task outcome quality is insignificant, which is paradoxical in light of the evidence pointing at obstacles. This study reports on a structural equation modeling-based analysis of 290 teams whose main task was to develop new products in a variety of industries. The findings support the electronic collaboration paradox notion discussed above, and appear to be consistent with predictions of two complementary theoretical models, the psychobiological and compensatory adaptation models.

INTRODUCTION

The effects of electronic communication technologies on teams performing complex collaborative tasks have been extensively studied in the last 25 years. Those studies' findings have been somewhat paradoxical in that they generally suggested that electronic communication use: (a) is often associated with significant obstacles to good communication, in the eyes of the team members; and (b) does not have a significant effect on the performance of teams.

The paradoxical findings above led to the development of the e-collaboration paradox notion (Kock and D'Arcy, 2002). Simply put, one would reasonably expect that the existence of communication obstacles should negatively affect the performance of teams of individuals engaged in complex collaborative tasks.

What is the explanation for the e-collaboration paradox? One could argue that the use of electronic communication does not actually create obstacles to effective interaction, and that the findings that indicate otherwise are likely due to the use of poor data collection instruments. Similarly, one could also argue that the lack of significant effects in connection with team performance has been due to measurement errors. However, these explanations are difficult to accept in light of the large amount of behavioral research in connection with the use of electronic communication by teams, and the consistency with which the findings that characterize the e-collaboration paradox have been obtained.

The main goal of this paper is to take four related steps aimed at shedding light into the underlying reasons for the existence of the e-collaboration paradox. Those steps, which are described in more detail in the following sections, are: (a) to advance a generic alternative theoretical explanation for the e-collaboration paradox; (b) to formalize the generic explanation as a structural model with a set of specific hypothesized effects between theoretical constructs; (c) to test the structural model; and (c) to discuss the results in light of the e-collaboration paradox.

EXPLAINING THE E-COLLABORATION PARADOX

There are at least two well-known theoretical frameworks that purport the notion that electronic communication media pose obstacles to communication among people, because those media suppress important elements from the communication channel. One of those frameworks comes from social presence theory (Short et al., 1976). The other is related to media richness theory (Daft and Lengel, 1986).

An aspect shared by the social presence and media richness theories is that both postulate that the face-to-face communication channel incorporates several characteristics that are very important for efficient and effective communication. Among those characteristics are synchronicity, co-location, and support for the use of facial expressions, body language, and speech (so that non-verbal cues can be conveyed). Yet, neither theory has provided a convincing explanation as to why those characteristics of the face-to-face communication channel are important.

The psychobiological model (Kock, 2001; forthcoming) addresses the above limitation by taking a Darwinian perspective in its interpretation of human behavior toward technology. It argues that Homo sapiens is the result of an evolutionary process that took place over millions of years, and that during over 99 percent of that evolutionary process our species' ancestors communicated primarily face-to-face. Therefore, the model hypothesizes that the human brain must have been chiefly designed for face-to-face communication, and that thus communicating through media that suppress face-to-face communication elements (i.e., synchronicity, co-location, and support for the use of facial expressions, body language, and speech) leads to an increase in the amount of cognitive effort required from the individuals engaged in a communication interaction.

The psychobiological model provides a reasonable scientific explanation for the first part of the e-collaboration paradox notion, namely the part that relates the use of electronic communication media to significant obstacles to good communication. However, the psychobiological model does not explain the second part of the e-collaboration paradox (which, incidentally, is what makes it a paradox). That second part is associated with repeated research findings suggesting that the use electronic communication media does not have a significant effect on the overall performance of teams.

The above limitation is addressed by a complementary theoretical model, called the compensatory adaptation model (Kock, 2001b). This model argues that, under the appropriate circumstances, the cognitive obstacles posed by electronic communication media, which are hypothesized by the psychobiological model, induce a behavioral response called compensatory adaptation. Such behavioral response comes in many forms, depending on the media being used, and other circumstances. For example, let us assume that an individual is asked to use a communication medium that suppresses the individual's ability to

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convey certain non-verbal cues that are indicative of his cultural identity (e.g., accent, tone of voice, body language). According to the compensatory adaptation model, this may trigger an adaptive response on the part of the individual that is characterized by an increase in the use of verbal elements that are aimed at subconsciously conveying information about the individual's cultural identity (e.g., regional expressions, self-describing cultural adjectives).

Several circumstances are conducive to compensatory adaptation. The level of desire to succeed in the collaborative task is one of them, which usually follows from the collaborators having a stake in the outcomes of the collaborative task. Thus, one should not expect the same level of compensatory adaptation in an experimental collaborative task conducted by student subjects as one could expect in a "real world" team task such as business process improvement (Kock, 2001b). In the latter, quite often the business process improvement team members will have to "live with" the consequences of their business process change decisions. Another important circumstance that is conducive to compensatory adaptation is the degree of awareness of the obstacles, or how intensely they are perceived. This would allow us to expect that less technology-oriented individuals would "compensate more" for the obstacles posed by electronic communication media than more technology-oriented individuals, as the latter would be less aware of those obstacles.

The compensatory adaptation model puts forth two key arguments (Kock, 1998; 2001b) that can be seen a providing a reasonable "solution" to the e-collaboration paradox puzzle. The first argument is that the obstacles hypothesized by the psychobiological model induce compensatory adaptation behavior by members of teams interacting electronically while performing complex collaborative tasks. The second argument is that the triggered behavioral response is strong enough to suppress the effects of the obstacles on team performance.

HYPOTHESES AND STRUCTURAL MODEL

In this section, the generic theoretical explanation provided above for the e-collaboration paradox is formalized as a structural model with a set of specific hypothesized effects between theoretical constructs. The structural model addresses a type of task performed by a particular type of team, which is referred to here as the new product development team. Teams of this type develop new products, either from scratch or (more commonly) by improving existing products. The products in question may be goods (e.g., a car engine), services (e.g., a life insurance), or data (e.g., a computer program).

New product development teams are characterized by intense communication of knowledge, as they usually involve individuals with expertise in different areas (e.g., engineering, sales, production). Moreover, the work of new product development teams involves a great deal of coordination among different team members. The psychobiological model allows us to predict that the use of electronic communication media will bring about obstacles to communication and also coordination. Yet, the compensatory adaptation model suggests that those obstacles will not have a negative effect on team performance. This leads us to hypotheses H1 and H2 below.

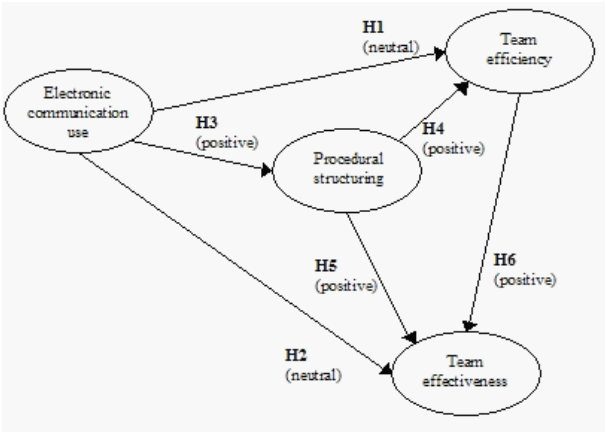
H1: The degree of electronic communication use by a new product development team will have a neutral effect on team efficiency.

H2: The degree of electronic communication use by a new product development team will have a neutral effect on team effectiveness.

Team efficiency refers to the cost and time dimensions of the new product development effort. The less time and cost involved in the development of a new product, the higher is the team's efficiency. Team effectiveness, on the other hand, refers primarily to the market success of the product developed.

Given the heavy communication and coordination demands involved in conducting new product development teams, it is reasonable to expect that teams will compensate for related obstacles by trying to better structure communication and coordination activities – a behavioral response known as procedural structuring (Burke and Aytes, 2001). This leads us to hypothesis H3 below.

Figure 1. Structural model and hypotheses



H3: The degree of electronic communication use by a new product development team will have a significant positive effect on the degree of procedural structuring employed by the team.

It follows from the discussion above, in light of the compensatory adaptation model, that procedural structuring will mediate between the obstacles posed by the use of electronic communication and the neutral effect on team efficiency and effectiveness – otherwise that effect would not be neutral. This expectation is formalized through hypotheses H4 and H5 below.

H4: The degree of procedural structuring by a new product development team will have a significant positive effect on team efficiency.

H5: The degree of procedural structuring by a new product development team will have a significant positive effect on team effectiveness.

Team effectiveness is primarily related to the final outcome of a new product development team. That is, team effectiveness is assessed based on how well the new product (e.g., a new car part) is received by its customers, and how well it fares in the marketplace. Team efficiency, on the other hand, is a characteristic of a new product development team that temporally precedes team effectiveness. Thus, it is reasonable to expect that team efficiency will have an impact, likely a positive one, on team effectiveness. This expectation is formalized through hypothesis H6 below.

H6: The degree of efficiency displayed by a new product development team will have a significant positive effect on team effectiveness.

Since the hypotheses refer to a set of causal links involving several constructs, an integrated representation can be provided in the form of a structural model. Such structural model is shown in Figure 1, with an indication of the hypotheses and the specific causal links to which they refer.

RESEARCH METHOD

The main method for data analysis employed was partial least squares (PLS), implemented through the PLS-Graph software package (Chin et al., 1996; Chin, 1998). The data was collected through a survey instrument (i.e., a questionnaire) developed based on prior research on new product development teams (Kessler and Chakrabarti, 1999; Lynn et al., 2000).

The dataset used in this study refers to 290 new product development teams that conducted their projects in a variety of companies located

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in Northeastern US. Company executives participating in an executive education program provided that data by answering the questionnaire.

The companies from which new product development team data was collected represent a variety of industries, including: military and defense, telecommunications, chemicals manufacturing, computers and electronics, aerospace, software development, machinery manufacturing, pharmaceuticals, and food manufacturing.

All of the four constructs shown in the structural model in Figure 1 were measured based on multiple indicators. The electronic communication use construct was measured in a formative way; the other constructs were measured in a reflective way (Diamantopoulos, 1999; Diamantopoulos and Siguaw, 2002).

As previously discussed, compensatory adaptation is a phenomenon that is associated with human beings' perceptions about cognitive obstacles posed by communication media, often communication media implemented by technologies. Thus, it is reasonable to expect that the level of technological orientation of a team may have an effect on team efficiency and effectiveness, in the context of electronic communication use to support collaborative new product development. Therefore, a fifth construct, namely technology orientation, was included in the analysis as a control variable. That construct was measured based on a single indicator.

The question-statements used for each indicator are listed in the Appendix. Table 1 shows the item-to-construct loadings for the constructs measured in a reflective way.

The loadings shown in Table 1 suggest that the reflective measurement model employed presents an acceptable level of internally validity (Carmines and Zeller, 1979; Rosenthal and Rosnow, 1991).

Table 2 shows the composite reliability and average variance extracted coefficients for each reflectively measured construct.

The coefficients shown in Table 2 suggest that the reflective measurement model employed presents an acceptable level of reliability (Nunnaly, 1978; Rosenthal and Rosnow, 1991).

RESULTS

Figure 2 shows the structural model with the partial correlations (²'s) and percentages of explained variance calculated (R^2's). Partial correlation coefficients followed by an asterisk were significant at P<0.001 in a one-tailed T test, where T values were calculated through the bootstrapping method. The other coefficients (i.e., the ones not followed by an asterisk) were not significant at any acceptable level, with the P<0.05 level seen as the upper threshold of acceptability (Rosenthal and Rosnow, 1991).

As it can be seen in Figure 2, the degree of electronic communication use by new product development teams had a neutral effect on both team efficiency and effectiveness. These findings provide support for hypotheses H1 and H2.

Figure 2 also suggests that the degree of electronic communication use by new product development teams had a significant positive effect on the degree of procedural structuring employed by the teams, which support hypothesis H3.

Two other related findings suggested by Figure 2 are that the degree of procedural structuring by new product development teams had a significant positive effect on team efficiency, but no significant effect on team effectiveness. These findings provide support for hypothesis H4, but not for hypothesis H5.

Additionally, Figure 2 suggests that the degree of efficiency displayed by new product development teams had a significant positive effect on team effectiveness, which supports hypothesis H6.

Finally, Figure 2 suggests that the relationships depicted in the structural model account for approximately 12 percent of the variance in the procedural structuring construct, 23 percent of the variance in the team efficiency construct, and 32 percent of the variance in the team effectiveness construct.

DISCUSSION

The findings of this study are generally aligned with the e-collaboration paradox. Arguably, the compensatory adaptation behavior observed, measured through the procedural structuring construct, was in response to obstacles posed by electronic communication use. It is also reasonable to argue that such behavioral response led, in the end, to electronic communication use having no significant effect on the overall performance of teams (both in terms of efficiency and effectiveness). Both assumptions were explicitly tested through the assessment of the structural model, and supported by it.

The structural model assessment also provides general support for the combined theoretical framework discussed earlier in this paper, which brought together predictions based on the psychobiological and compensatory adaptation models (Kock, 2001; 2001b; forthcoming). That

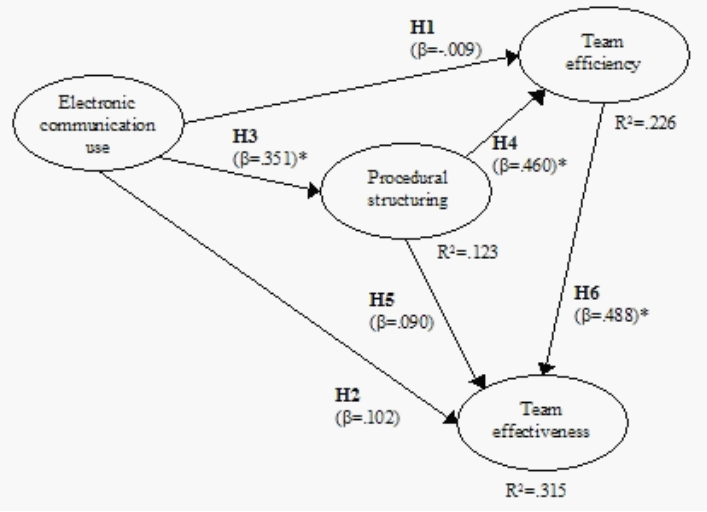
Table 1. Item-to-Construct Loadings

Construct	Item	Item-to-construct loading
Team effectiveness	EFFE1	.93
	EFFE2	.95
	EFFE3	.84
	EFFE4	.95
	EFFE5	.91
	EFFE6	.90
	EFFE7	.90
Team efficiency	EFFI1	.90
	EFFI2	.89
	EFFI3	.83
	EFFI4	.80
	EFFI5	.80
Procedural structuring	PROC1	.85
	PROC2	.89
	PROC3	.81

Table 2. Construct Reliability Measures

Construct	Composite reliability	Average variance extracted (AVE)
Team effectiveness	.97	.83
Team efficiency	.92	.71
Procedural structuring	.89	.72

Figure 2. Results of PLS Analysis



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combined theoretical framework puts forth a generic theoretical explanation for the e-collaboration paradox.

However, the hypothesis that the degree of procedural structuring by a new product development team will have a significant positive effect on team effectiveness (hypothesis H5) was not supported. That hypothesis had as its basis the compensatory adaptation's model blank assumption that adaptive behavior will have similar elements and consequences whether we look at team efficiency or effectiveness. That assumption appears to be incorrect, which points at a need for a revision of the compensatory adaptation model.

There seems to be a temporal relationship between team efficiency and effectiveness, with team efficiency preceding and influencing effectiveness. The existence of this relationship is perfectly compatible with the combined theoretical framework put forth in this paper, even though the framework does not explicitly propose that temporal relationship.

The structural model's assessment also suggests that there is a strong indirect effect of procedural structuring, mediated by team efficiency, on team effectiveness. It seems, based on the model's assessment, that when this indirect effect is taken into consideration, the direct effect of procedural structuring on team effectiveness is insignificant.

Since team effectiveness is the main dependent construct of the structural model, and the estimated degree of explained variance regarding that construct was 32 percent, it is reasonable to argue that the model provides a relatively robust perspective on the antecedents of new product development team performance.

CONCLUSION

Global competition has been dramatically increasing over the past decade. The impact of inexpensive goods from China and Mexico (the latter resulting from the North American Free Trade Agreement) have forced many companies in the US to restructure their operations, in many cases locating different business functions to low-cost countries. In this new globally competitive environment, the process of developing and bringing new products to market is becoming more complex.

The findings of this study indicate that organizations may be able to rely on electronic communications tools to help coordinate and manage the various functions in a new product development team, whose members can be dispersed throughout the world (engineering, manufacturing, sales, etc.), with an overall positive effect on team efficiency and no significantly negative effect on team effectiveness.

The findings of this study also open up new lines of inquiry in connection with the e-collaboration paradox, and two complementary theoretical frameworks that are used to explain the paradox – the psychobiological and compensatory adaptation models. This study also suggests areas in which the latter model can be refined and improved.

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APPENDIX: CONSTRUCTS AND MEASURES

Except for the "technology orientation" construct, a Likert-type scale (0 = "Strongly Disagree" to 10 = "Strongly Agree") was used for each of the construct measurement items listed below.

Electronic communication use

The team used:

1. E-mail to fellow team members (1 to 1).
2. E-mail to team distribution lists (1 to many).
3. Team messaging boards or team discussion forums.
4. Shared electronic files.
5. Lotus notes to facilitate sharing information among team members.
6. Electronic newsletters that covered project information.
7. Auto routing of documents for team member and management approval.
8. File transfer protocols (FTP) to attach documents to e-mails and Web pages.
9. A Web page dedicated to this project.
10. A Web page for this project that contained project specs, market research information, and test results.
11. Voice messaging.

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12. Teleconferencing.
13. Video conferencing
14. Desktop video conferencing
15. Attaching audio files to electronic documents.
16. Attaching video files to electronic documents.

Team effectiveness

The product:

1. Met or exceeded volume expectations.
2. Met or exceeded sales dollar expectations.
3. Met or exceeded the 1st year number expected to be produced and commercialized.
4. Overall, met or exceeded sales expectations.
5. Met or exceeded profit expectations.
6. Met or exceeded return on investment (ROI) expectations.
7. Met or exceeded overall senior management's expectations.

Team efficiency

1. The product was launched within or under the original budget.
2. The product came in at or below cost estimate for development.
3. The product came in at or below cost estimate for production.
4. The product was launched on or ahead of the original schedule developed at initial project go-ahead.
5. Top management was pleased with the time it took us from specs to full commercialization.

Procedural structuring

1. The team followed a clear plan — a roadmap with measurable milestones.
2. There were adequate mechanisms to track the project's progress.
3. There were adequate mechanisms to track the project's costs.

Technology orientation

This project (please select one):

___ 1. Involved no new technology whatsoever.
___ 2. Involved some new technology or some technical features that added a certain level of uncertainty
___ 3. Used several new and key technologies that, for the first time, were integrated together, but these technologies existed inside or outside of our industry.
___ 4. Used non-existing or non-proven technologies; these technologies did not fully exist at the start of this project.

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