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17. MEDIA NATURALNESS REDUCTION AND COMPENSATORY CHANNEL EXPANSION: A STUDY OF ONLINE AND FACE-TO-FACE SECTIONS OF THE SAME COURSE

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Abstract

The study discussed here provides a test of media naturalness and channel expansion theories' predictions in the context of university online learning. Data was collected from undergraduate students at the middle and end of a long semester in which the students took an introductory course in management information systems. Approximately half of the students took the course face-to-face, and the other half online. As predicted based on media naturalness theory, perceived communication ambiguity and cognitive effort were higher in the online than in the face-to-face condition. As a result, grades were significantly higher in the face-to-face than the online condition at the middle of the semester. Consistently with predictions based on channel expansion theory, the difference between grades obtained at the middle of the semester disappeared at the end of the semester.

Keywords

Media Richness Theory, Media Naturalness Theory, Channel Expansion Theory, Online Learning, General Linear Modeling, Partial Least Squares

1. Introduction

One of the most widely cited theories of professional communication is media richness theory (Daft & Lengel, 1986; Daft et al., 1987). Even though the theory was developed well before the emergence of online learning in university contexts, its key propositions can be used to predict the performance of students in those contexts. Media richness theory argues that if equivocal, or knowledge-intensive, tasks are accomplished through media of low richness, task outcomes will be negatively affected (Daft & Lengel, 1986). Electronic media in general are considered less rich than face-to-face media. It is reasonable to assume that the task of learning university subjects is equivocal. Therefore one can conclude based on media richness theory that students

learning about university topics online will perform more poorly in tests covering those topics than students learning about the same topics face-to-face.

This type of deterministic prediction usually follows logically from media richness theory, even though Daft & Lengel (1986) might not have intended this. Many studies in the past departed from this type of prediction, and reached conclusions that suggest little or no support for media richness theory (Bélanger & Watson-Manheim, 2006; Burke & Aytes, 2001; Crowston et al., 2007; Dennis & Kinney, 1998; El-Shinnawy & Markus, 1998; Hasty et al., 2006; Kock et al., 2006; Markus, 1994). Moreover, the widespread use of online learning in universities (Newlin et al., 2005; Summers et al., 2005) is an indication that this type of deterministic prediction cannot be correct. It would be unlikely that online learning would be widespread in universities if student learning outcomes were being negatively affected in a material way.

Media naturalness theory (Kock, 2004; 2005) is an attempt to move away from the deterministic predictions of media richness theory. The theory explains an intuitive finding; most people have the perception that media that suppress face-to-face communication elements (e.g., the ability to use tone of voice) pose obstacles for the effective communication of knowledge (Daft et al., 1987; Kock & DeLuca, 2007; Kock et al., 2006). It does so by arguing that the biological communication apparatus of modern humans, which includes various brain modules, is largely designed for face-to-face communication (Kock, 2004). It follows from this argument that the removal of face-to-face communication elements from a medium will lead to increased communication ambiguity, increased cognitive effort, and reduced excitement associated with knowledge communication interactions (Kock, 2005).

Can one argue based on media naturalness theory that students learning about university subjects online will perform more poorly in tests covering those subjects than students learning about the same subjects face-to-face? The answer is no, for at least two reasons. The first is that media naturalness theory does not make predictions about task outcomes. The second is that media naturalness theory itself argues that low media naturalness effects (e.g., increased cognitive effort) can lead users of unnatural media to develop mental schemas that will make them better users of those unnatural media. That is, users of unnatural media will adapt to those media in a compensatory way. This adaptation is predicted by Carlson & Zmud's (1999) channel expansion theory, and is thus called here compensatory channel expansion.

This paper discusses a study that tests the predictions of the media naturalness and channel expansion theories, and finds general support for them. Data was collected from undergraduate students at the middle and end of a long semester. The students took an introductory course in management information systems; approximately half of the students took the course face-to-face, and the other half took the course online. As predicted based on media naturalness theory, perceived communication ambiguity and cognitive effort were higher in the online than in the face-to-face communication medium condition. As predicted based on channel expansion theory, the difference between mean grades obtained at the middle of the semester, which was significant, subsided at the end of the semester.

2. Research background and hypotheses

The focus of this study is on hypothesized relationships between communication media used for instruction in an introductory undergraduate university course in management information systems, as well as perceptions and outcomes related to the task of taking the course. The hypotheses of the study are described in this section. A more detailed discussion of the methods employed and of the results is provided in the next section.

The study was aimed at testing four key hypotheses. Three of the hypotheses guiding the study followed directly from media naturalness theory (Kock, 2004; 2005), and one from channel expansion theory (Carlson, 1995; Carlson & Zmud, 1999). Media naturalness' predictions regarding the impact of a medium's degree of naturalness on communication ambiguity, cognitive effort, and physiological arousal led to hypotheses H1, H2 and H3, listed below.

H1: *Students in the online course delivery medium will experience higher levels of perceived communication ambiguity than students in the face-to-face medium.*
H2: *Students in the online course delivery medium will experience higher levels of perceived cognitive effort than students in the face-to-face medium.*
 H3: *Students in the online course delivery medium will experience lower levels of perceived excitement than students in the face-to-face medium.*

As it can be seen from hypothesis H3, perceived excitement was used as a proxy for physiological arousal, since it seemed to be a good choice as the basis of a perceptual measurement of physiological arousal. That is, it was assumed that a medium effect on physiological arousal would manifest itself through an effect on perceived excitement. (This might have been a bad choice, as it will be explained later.)

Channel expansion theory's prediction that over time users of a particular medium will essentially become more adept at using the medium for a particular task, even if the medium poses obstacles for communication (Carlson, 1995; Carlson & Zmud, 1999), opens the door for the prediction that task outcome quality will be moderated by this longitudinal channel expansion effect. This longitudinal prediction is reflected in hypothesis H4, which is stated below.

H4: *Students in the online course delivery medium will have lower grades than students in the face-to-face delivery medium in the middle of the semester, but not at the end of the semester.*

Hypothesis H4 is not only important because it illustrates the combination of an evolutionary theory with a non-evolutionary one. Its importance also comes from the fact that empirical support for it is in direct contradiction with one of media richness theory's key predictions (Daft & Lengel, 1986; Daft et al. 1987). The prediction in question is that task outcome quality will suffer if the choice of medium is constrained and the medium used is lean, which was the case in this study from the moment students had to choose either the online or the face-to-face course delivery medium. That is, eventual support for H4 illustrates the need for media naturalness theory in combination with channel expansion theory, because the hypothesis addresses one of the chief differences between the media naturalness and richness theories.

As it will be seen in the next section, the results of the study generally supported the combined theoretical model. The only exception was hypothesis H3, which was not supported by the results. The study is one of the first to test media naturalness theory, and also one of the first to test channel expansion theory. Its results are consistent with other studies that tested the theories either fully or partially; see Simon (2006) for a previous test of media naturalness theory, and Hasty et al. (2006) for a previous test of channel expansion theory.

3. Research methods

A total of 155 undergraduate students participated in the study. Data was collected at the middle and end of a long semester in which the students took an introductory course in management information systems, thus yielding 310 data points. Approximately half of the students took the course face-to-face. The other half took the course entirely online, with no face-to-face meetings. Both media conditions employed the same course materials and covered the same course content. That is, the main difference between media conditions was in the communication medium employed for course delivery.

The online courseware suite used was WebCT. The course materials used in both sections were essentially PowerPoint slides and online papers. No textbook was used in the course; the students were required to review all the course materials provided (as opposed to read a textbook) to do well in the course. In the online section, audio clips for each of the slides were made available to the students as generic RealMedia files, and discussions on papers were conducted through an online discussion board available in WebCT. No student reported problems playing the audio clips, using WebCT, or accessing any of the course materials.

Forty-six percent of the students were males. Their ages ranged from 18 to 48, with a mean age of 24. The students' grade point averages (GPAs) ranged from 1.8 to 3.9 (out of 4), with a mean GPA of 2.9. In terms of years of work experience, students ranged from 0 (zero, or no work experience) to 40 years, with a mean of 6 years. Since students self-selected their media conditions, there were small variations in these variables (i.e., gender, age, GPA, and work experience) across media conditions. Given that these variations could have affected grades in the middle and end of the semester, these variables were included as control variables and/or covariates in the analyses.

Communication ambiguity, cognitive effort, and excitement were defined as latent variables and measured through multiple indicators (Hair et al., 1987; Kline, 1998). The media effects on these latent variables (hypothesized through H1, H2, and H3) were tested through quantitative analyses employing the partial least squares technique (Chin, 1998; Chin et al., 2003), a structural equation modeling technique (Kline, 1998) designed to test effects in connection with latent variables.

The media effects on grades (hypothesized through H4) were tested employing the general linear modeling and partial least squares techniques. Midterm and final exam grades were used, and those grades were independent from each other. That is, midterm and final grades were obtained based on exams on topics covered in the first half of the course (midterm), and in the second half of the course (final).

The general linear modeling technique is traditionally used in comparisons of means analyses with no latent variables (Hair et al., 1987; Rencher, 1998), and grades were not measured as latent variables. Nevertheless, the partial least squares technique was also used in the test of media effects on grades for two reasons. The first is completeness, since it was also used in the test of hypotheses H1, H2, and H3. The second and most important is the quasi-experimental design used in this study, which calls for the use of nonparametric methods. The estimation of chance probabilities in the partial least squares technique is done through a nonparametric algorithm, usually bootstrapping or jackknifing (Chin, 1998; Gefen et al., 2000). In this study, the algorithm employed was bootstrapping (Diaconis & Efron, 1983; Nevitt & Hancock, 2001). Nonparametric estimation of chance probabilities is generally considered more appropriate when the study employs a quasi-experimental design (Siegel & Castellan, 1998). This is the case in this study since student subjects were not randomly assigned to each media condition.

Since media naturalness theory does not make any predictions regarding longitudinal effects, the tests in connection with communication ambiguity, cognitive effort and excitement relied on analyses of the whole dataset. That is, those analyses were run on data at the middle and end of the semester, with a corresponding sample size of 310. Conversely, since channel expansion theory makes predictions regarding longitudinal effects, separate analyses of media effects on grades were conducted in the middle and end of the semester, each with a corresponding sample size of 155.

4. Validation of the measurement model

Whenever latent variables are used in data analyses some tests must be conducted in order to assess the validity and reliability of the latent variable measurement model (Kline, 1998). Reliability is usually assessed through the calculation of reliability coefficients, such as Cronbach's alpha and the composite reliability coefficient, and the comparison of those coefficients against a threshold, usually .7 (Fornell & Larcker, 1981; Nunnaly, 1978).

As for validity, two types of tests are normally employed in latent variable measurement model assessment, namely convergent and discriminant validity tests. Convergent validity is normally assessed through the comparison of factor loadings calculated for each latent variable indicator with a threshold value, which is usually .5 (Hair et al., 1987). Discriminant validity usually relies on the calculation and comparison of correlations between each pair of latent variables and square roots of the average variances extracted for each latent variable (Fornell & Larcker, 1981).

Table 1 shows factor loadings associated with each latent variable. The loadings were calculated through a factor analysis employing principal components as its extraction method, and varimax as its rotation method (Ehremberg & Goodhart, 1976; Thompson, 2004). Also shown in the last two columns on the right are reliability coefficients. All factor loadings associated with their respective latent variables are higher than .5, suggesting that the measurement model presents acceptable convergent validity. All reliability coefficients are higher than .7, suggesting that the model also has acceptable reliability.

	Comm. ambiguity	Cognitive effort	Excitement	Alpha	CR
Ambig1	.747	.286	.114	.901	.930
Ambig2	.857	.221	.080		
Ambig3	.908	.157	.087		
Ambig4	.886	.085	.077		
Cogeff1	.054	.720	.337	.830	.886
Cogeff2	.145	.829	.185		
Cogeff3	.232	.833	.078		
Cogeff4	.385	.705	.059		
Excite1	.155	.125	.834	.825	.869
Excite2	.038	.111	.827		
Excite3	.088	.246	.862		

Notes:

Alpha = Cronbach's alpha reliability coefficient

CR = composite reliability coefficient

Table 1: Latent variable loadings and reliability coefficients

Table 2 shows correlations between each pair of latent variables and square roots of the average variances extracted for each latent variable. For each latent variable, the square root of the variable's average variance extracted is higher than any of the correlations involving the variable. Therefore it can be concluded that the latent variable measurement model has acceptable discriminant validity (Fornell & Larcker, 1981).

	Comm. ambiguity	Cognitive effort	Excitement
Comm. ambiguity	(.877)		
Cognitive effort	.432	(.813)	
Excitement	.194	.365	(.832)

Notes:

All correlations are significant at the .01 level

Square roots of average variances extracted (AVEs) are shown on diagonal

Table 2: Latent variable correlations and square roots of AVEs

The latent variable measurement model tests above allow for the conclusion that the results of latent variable analysis techniques, such as the partial least squares technique (Chin, 1998; Chin et al., 2003), can be trusted. If our study did not employ latent variables, for example, by focusing only on the media impact on grades, the above measurement model tests would not be necessary. However, such a study would only address the channel expansion effect (on grades) and no media naturalness effects.

5. Results of the statistical analyses

Table 3 summarizes the results of partial least squares analyses of media effects on communication ambiguity (hypothesis H1), cognitive effort (H2), and excitement (H3). The columns labeled "Online" and "Face-to-face" show the means for each latent variable in the online and face-to-face media conditions, respectively. The column labeled "t" shows the t statistics associated with the path coefficients (from the partial least squares technique) between the medium condition (i.e., the independent variable) and the latent variables communication ambiguity, cognitive effort, and excitement (i.e., the dependent variables). These t statistics are equivalent to, but not the same as, the statistics that would be calculated through an independent samples comparison of means t test (Rosenthal & Rosnow, 1991).

	Online	Face-to-face	t	P(t)
Comm. Ambiguity	3.666	3.423	1.630	< .05
Cognitive effort	5.299	5.037	1.587	< .05
Excitement	5.612	5.503	1.041	.149

Notes:

    Measurement scale range = 1 to 7

    t = t statistic associated with path coefficient (PLS analysis)

    P = chance probability associated with t statistic

Table 3: Partial least squares analysis results

As predicted based on media naturalness theory, perceived communication ambiguity and cognitive effort were higher in the online than in the face-to-face communication medium condition. These results provide support for hypotheses H1 and H2. However, no significant difference was found in perceived excitement between media conditions. This latter result is not consistent with hypothesis H3.

Table 4 summarizes the results of general linear modeling and partial least squares analyses of media effects on grades at the middle and end of the semester (hypothesis H4). The columns labeled "Online" and "Face-to-face" show the mean grades at the middle and end of the semester in the online and face-to-face media conditions, respectively.

	Online	Face-to-face	F	P (F)	t	P (t)
Grade middle	74.23	83.07	11.350	< .001	3.225	< .001
Grade end	76.19	77.60	.336	.563	.590	.278

Notes:

    Grade middle = mean grade at the middle of the semester

    Grade end = mean grade at the end of the semester

    F = F statistic associated with difference between media means (GLM analysis)

    t = t statistic associated with path between medium and grade (PLS analysis)

    P = chance probability associated with statistic

Table 4: General linear modeling and partial least squares analyses results

As predicted based on channel expansion theory, the difference between mean grades obtained at the middle of the semester subsided at the end of the semester. This provides support for hypothesis H4 and the related notion that there was a channel expansion effect. That effect

arguably led to no differences in performance observed across media conditions at the end of the semester, when the students in the online condition were more familiar with the use of the online medium for the learning task.

6. Discussion and conclusion

The results discussed in the previous section generally support the combined theoretical model on which the hypotheses were developed (see Table 5). Only one out of 4 hypotheses was not supported by the data, namely hypothesis H3. The lack of support for hypothesis H3 suggests two paths of action. One of them is the refinement of media naturalness theory, perhaps through the removal of the physiological arousal prediction in connection with the theory. The other path of action is to change the measurement model used and conduct future empirical tests using the modified measurement model.

Theory	Hypothesis	Supported?
Media naturalness	H1: Students in the online course delivery medium will experience higher levels of perceived communication ambiguity than students in the face-to-face medium.	Yes
Media naturalness	H2: Students in the online course delivery medium will experience higher levels of perceived cognitive effort than students in the face-to-face medium.	Yes
Media naturalness	H3: Students in the online course delivery medium will experience lower levels of perceived excitement than students in the face-to-face medium.	No
Channel expansion	H4: Students in the online course delivery medium will have lower grades than students in the face-to-face delivery medium in the middle of the semester, but not at the end of the semester.	Yes

Table 5: Summary of the results vis-à-vis the hypotheses

The combined theoretical model was generally but not fully supported, as indicated by the lack of support for hypothesis H3, and further testing may require a change in the measurement of the construct associated with H3. The key reason for this is the original formulation of the prediction by media naturalness theory that led to hypothesis H3. That original formulation built on the notion of physiological arousal (Kock, 2005), which was measured through a latent variable whose indicators (Hair et al., 1987; Kline, 1998) reflect perceived excitement. For example, one of the question-statements used was: "Taking this course has been very exciting".

The prediction that a medium's naturalness has a positive effect on physiological arousal comes from a key argument made by media naturalness theory. The argument has three main parts. The first part, already discussed earlier, is that we have evolved a biological communication apparatus designed to excel in face-to-face communication, and that apparatus includes a customized vocal tract, brain modules and other elements. The second part of the argument is that evolution is an economical agent that rarely endows an organism right at the moment of birth with all that is needed for the organism to successfully spread genes associated with certain traits (Kock, 2004; 2005). Instead, evolution relies on an organism's interaction with the environment to shape its traits, often creating mechanisms to compel it to engage in practices that will form a biological apparatus, which will contribute to the organism's reproductive success (see also, Wilson, 2000). One such practice in the human species is, arguably, a great deal of face-to-face communication.

The above line of reasoning leads to the third part of the argument in the context of media naturalness theory that: "…evolution must have developed mechanisms to compel human beings to practice the use of their biological communication apparatus, mechanisms that are similar to those compelling animals to practice those skills that play a key role in connection with survival and mating. Among these mechanisms, one of the most important is that of physiological arousal, which is often associated with excitement and pleasure" (Kock, 2005, p. 123). As a corollary, media naturalness theory predicts that the use of media that are unnatural will prevent physiological arousal from being fully experienced, which is expected to lead to a sense of dullness in connection with the task for which the media are used. This is expected to be particularly true in tasks involving a great deal of communication through the media in question.

A substantial amount of evidence exists that is consistent with the above prediction. This evidence suggests that electronic communication media with low degrees of naturalness are generally perceived as less exciting, duller, or less emotionally fulfilling than face-to-face communication (Ellis et al., 1991; Kiesler et al., 1988; Reinig et al., 1995; Sproull and Kiesler, 1986; Walther, 1996). However, most of this evidence associates low naturalness with negative perceptions (e.g., less exciting). This would suggest that a more appropriate proxy latent variable for the study reported here would have been one reflecting perceived *lack* of excitement, or dullness, instead of excitement. This could be incorporated into additional tests of the combined model through a revision of the indicators and related question-statements used to measure physiological arousal.

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