Methologies and scenarios

# Designing E-Collaboration Technologies to Facilitate Compensatory Adaptation

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## Abstract

This article argues that e-collaboration technologies often pose obstacles to effective communication in complex collaborative tasks. The reason presented is that typically those technologies selectively suppress face-to-face communication elements that human beings have been designed by evolution to use extensively while communicating with each other. It is argued that technology users invariably react to those obstacles by engaging in compensatory adaptation, whereby they change their communicative behavior in order to compensate for the obstacles. The article concludes with a call for more research on how e-collaboration technologies can be designed to facilitate compensatory adaptation.

## 1 Media naturalness and obstacles to communication

The notion of media naturalness comes from the anthropological finding that the human species has evolved over millions of years communicating through two main interaction modes. One involves co-located face-to-face communication, and the other involves the use of sounds alone in situations where line-of-sight is obstructed. Both interaction modes involve synchronous communication with the use of sounds, which over millions of years have evolved from simple grunts to complex speech. The increase in complexity of speech seems to be positively correlated with the historical increase in hominid brain size (see Figure 1).

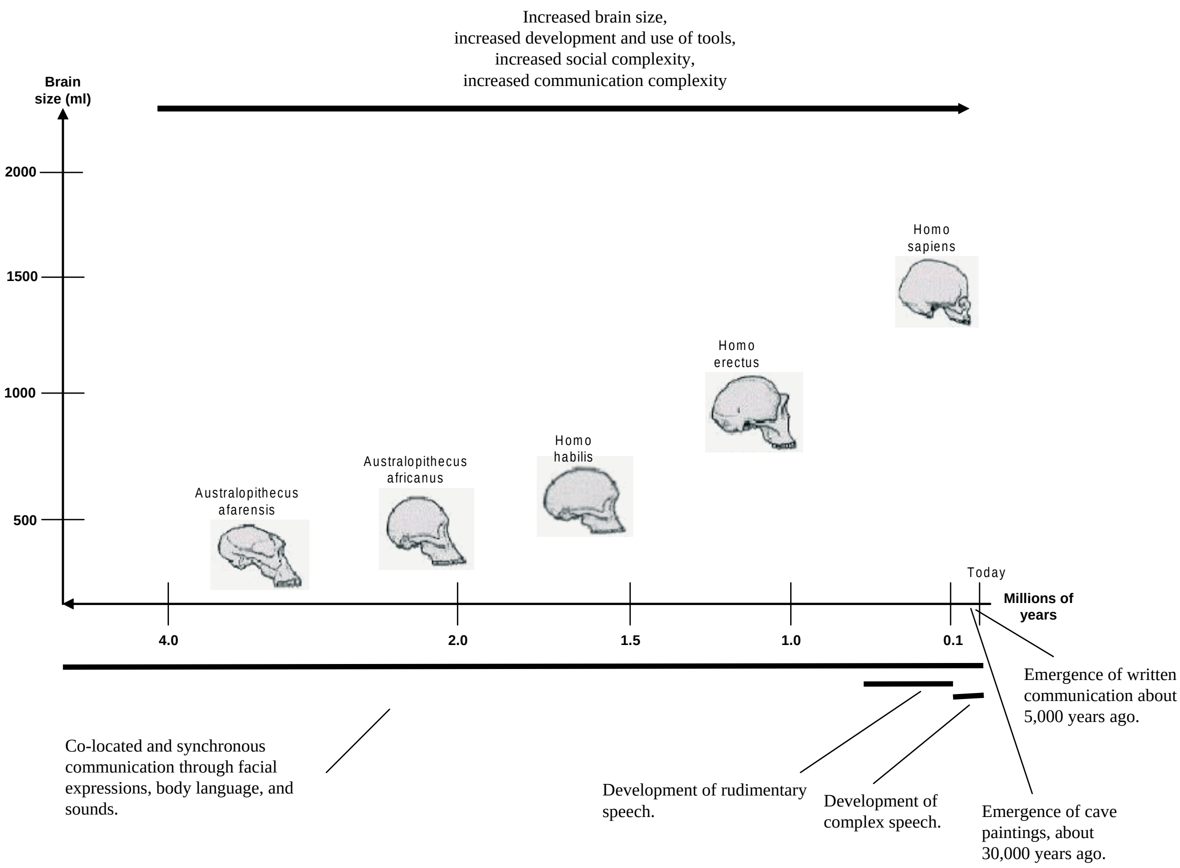


Figure 1. Hominid evolution stages and respective communication modes

The first and predominant mode, face-to-face communication, is one in which individuals see and hear each other. In this mode individuals communicate primarily through sounds, facial expressions, and body language; and to a lesser extent by touch and smell (e.g., through pheromones). This seems to have been the principal communication mode used for the exchange of knowledge, such as the knowledge involved in shaping a spear out of a stone or a tree branch.

The second main interaction mode, employing sounds alone, has arguably been necessary whenever line of sight was obstructed by trees or other objects. This latter mode of communication is extensively employed by modern primates for quick information exchange, which suggests that it has been used in similar fashion by our hominid ancestors. For example, chimpanzees use it while hunting, to indicate their position and the position of prey to other members of a hunting group. Several primates use this mode of communication while alerting others of the same group about the presence of predators, and when issuing mating calls.

Human beings have many obvious biological adaptations for synchronous and voice-enabled communication. Some of these adaptations are costly from a survival perspective, which suggests that they have also led to key survival (or mating) advantages of their own. For example, complex speech is enabled by a vocal tract whose design makes human beings much more likely to choke on ingested food and liquids than other primates. Therefore, complex speech must have conferred evolutionary advantages that offset the survival costs of having a vocal tract designed for complex speech.

The presence of observable biological adaptations for synchronous and voice-enabled communication implies the presence of corresponding brain adaptations. And, given the relatively recent emergence of written communication, it is reasonable to assume that our brain has not been shaped by evolutionary forces to handle written communication particularly well. The reason is that evolutionary pressures typically take a long time in slow reproducing species, like the human species, to shape biological traits. The first forms of written communication have emerged approximately 5,000 years ago, among the Sumerians in what is today Iraq. This 5,000 years period is a blink in a lifetime in evolutionary terms, and amounts to less than 1 percent of our hominid evolutionary history. Moreover, when we look at hominid evolution, we find a high correlation between brain size and the ability to employ complex speech for communication.

Some would argue that cave paintings are the main precursors of symbolic communication. Most of the evidence gathered by anthropologists however, suggests that cave paintings were not used for communication, but rather as the backdrop for rituals. This prevalent view is known as the “shamanist” theory of the origin of cave paintings. Even if cave paintings were seen as the first forms of symbolic communication, their relatively recent emergence (about 30,000 years ago) would also be considered too recent to have led to any major changes in our biological communication apparatus.

The media naturalness notion is essentially that we are not well adapted to employ communication media that suppress elements found in unconstrained face-to-face communication, particularly synchronicity and support for speech-enabled communication. This notion is analogous to the one that argues that our brain is designed to maximize our intake of high calorie nutrients, because high calorie nutrients were scarce in our ancestral evolutionary environment. Since high calorie foods and drinks are both cheap and abundant in modern urban societies, that brain design today leads to clogged arteries, heart disease, and a host of other health problems.

Using media of low naturalness, such as e-mail, is not hypothesized to lead to such pernicious health problems as those related to our attraction to high calorie foods and drinks. Nevertheless, using media of low naturalness (e.g., e-mail) is hypothesized to lead to higher levels of cognitive effort than more natural media (e.g., telephone), especially when communication of knowledge is the goal. One of the key pieces of evidence supporting this prediction is the dramatic decrease in communication fluency (i.e., number of words conveyed per minute) that results when one attempts to use a medium of low naturalness to convey knowledge. For example, while communication fluency has been found to be close to 100 words per minute face-to-face, it often drops to as little as 6 words per minute through e-mail, when what is being communicated is complex knowledge (Kock, 2001).

A reduction in fluency of this level of magnitude (i.e., 100 down to 6 words per minute) cannot be easily explained based on the known fact that people generally type slower than they speak. While it is mechanically more difficult to type than to speak, this difficulty alone usually leads to decreases in fluency of 50% or less. That is, let us assume that there were no other serious obstacles to communication, such as the cognitive obstacles discussed earlier. In that case, one would expect to see a drop in fluency from 100 to about 50 words per minute (or a 50% reduction), as one goes from interacting face-to-face to interacting through e-mail, not a drop from 100 to 6 words per minute (or a 94% reduction).

## 2 Compensatory adaptation as a reaction to obstacles

Those familiar with the notion of media richness, previously proposed by Daft and Lengel (1986), may be wondering what the differences between media naturalness and media richness are. There are a number of subtle differences that are discussed in more detail by Kock (2004; 2005), but for the purposes of this discussion one can assume that there is a very high correlation between the media naturalness and media richness of a communication medium. That is, a medium that is perceived as possessing a high degree of naturalness (e.g., the face-to-face medium) will also be perceived as possessing a high degree of richness.

One key difference, however, is that the notion of media naturalness allows for the prediction that the amount of cognitive effort required to perform a knowledge intensive collaborative task will go up as naturalness goes down, while the theory underlying the notion of media richness would predict that the quality of the outcomes of the task would be negatively affected. That latter prediction does not follow from the theoretical development underlying media naturalness, nor does it follow from the evolutionary ideas that served as the basis for that theoretical development. According to the media naturalness notion, users of low naturalness media could carry out a knowledge intensive collaborative task (e.g., developing a project report) and achieve a task outcome (e.g., a project report) with the same (or better) quality as that achieved by users of high naturalness media. Yet, the use of a medium of low naturalness would require additional mental effort from them. The reason is that the users would, often involuntarily, try to find ways of changing their communicate behavior in order to overcome the obstacles posed by low media naturalness. That would in turn decrease their communication fluency and leave them with the impression that the task was very mentally demanding.

How do users of low naturalness media compensate for obstacles created by those media? As far back as the 1970s, Short et al. (1976) already pointed out that telephone communication presents a significantly higher presence of verbal expressions of agreement and disagreement than face-to-face communication. That observation and others have led to the development of an influential theory of communication, known as social presence theory. Those researchers interpreted the higher presence of verbal expressions of agreement and disagreement as an attempt of the media users to compensate for the telephone's suppression of non-verbal cues of agreement and disagreement (e.g., head nods).

More recently, Walther (1997) provided evidence that individuals with significantly different cultural backgrounds exchange more personal information (including information about their physical appearance) when communicating electronically than they do face-to-face, with sometimes better task outcome results. This is something that Walther referred to sometimes as hyperpersonal communication (see also Walther, 1996).

Burke and Chidambaram (1999) and Majchrzak et al. (2000) built similar arguments based on data from groups performing complex tasks. That theme has also been picked up by Ulijn et al. (2001), who argued that the reduction in non-verbal cues associated with electronic communication media of low naturalness, particularly among individuals from different national cultures, drives the compensatory use of what they refer to as "meta-languages". Those meta-languages are characterized by a higher frequency of use of certain grammatical constructions, such as sentences employing first-person pronouns.

Kock and DeLuca (2007) investigated the use by eight business process improvement groups of an asynchronous and distributed e-collaboration tool. Four of the groups were conducted in New Zealand, and the other four in the U.S. The results of their investigation suggested two interesting and apparently contradictory findings, which were seen as providing strong support for the notion of compensatory adaptation. One of the findings was that the use of the unnatural e-collaboration medium seemed to increase the cognitive effort required from group members to communicate ideas related to business process improvement. The other finding was that the use of the unnatural e-collaboration medium apparently had a positive impact on knowledge sharing among group members and group outcome quality. These results were found to be consistent across countries, and were summarized through a graphical model (see Figure 2).

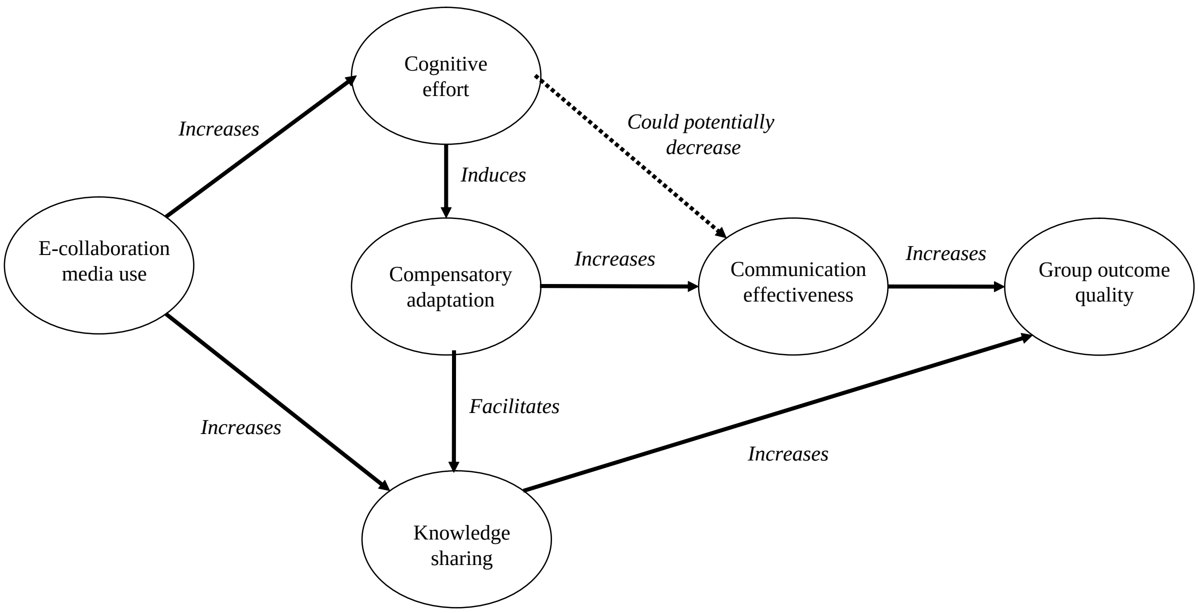


Figure 2. Interplay of effects leading to compensatory adaptation (adapted from Kock and DeLuca, 2007)

Qualitative data collected by Kock and DeLuca (2007) suggested one of the main ways in which business process improvement group members compensated for obstacles posed by the unnatural e-collaboration medium. That was essentially through the members' preparation of clear and carefully composed electronic messages before those messages were shared with other group members. As expected, this compensatory reaction was accompanied by a dramatic reduction in communication fluency; down to approximately 6 and 5 words per minute in New Zealand and the U.S., respectively. One representative comment by a group member is provided by Kock and DeLuca (2007, p. 18) to illustrate this point: "You think more when you're [interacting electronically], so you produce a better quality contribution. Take for example what [Jane Doe] wrote … she wrote a lot and it seemed that she thought a lot about it before she [posted] it to the group … [the electronic discussion] enabled me to gather more information and I felt pleased about that."

It should be noted that the choice of communication medium that one can use is often constrained by the collaborative task being accomplished. In some cases, the use of a medium of low naturalness is unavoidable, even when higher naturalness media would be preferable. One illustrative example is the Chip Ganassi Racing Team (Betts, 2004). Members of the Chip Ganassi Racing Team, which competes in the NASCAR and Indy Racing League, were looking for an alternative to voice communication with the racing car drivers. Voice communication through radio was problematic not only because it was difficult to find a usable radio channel, but also because of the background noise coming from the driver's car as well as other cars. These are two key constraints that are inherent in the car-racing task. The solution was instant messaging communication between the crew and the drivers, using an encrypted wireless local area network. In this example, key constraints associated with the collaborative task were stronger determinants of the choice of communication medium and related e-collaboration technology used than other elements, such as the perceived communication medium naturalness.

## 3 Designing technologies for compensatory adaptation

Given the discussion above, one could argue that it makes good sense to design e-collaboration technologies to facilitate compensatory adaptation. Yet, rarely one finds e-collaboration tools that have features designed to enable users to change their communication behavior in a way that makes up for the absence of face-to-face communication elements. One example is the absence of multimedia discussion board capabilities in many of the e-collaboration tools available today, including some widely used courseware tools such as WebCT. By multimedia discussion board capabilities what is meant here are capabilities that would allow one to respond to a text posting using a voice (or video) posting.

What is sometimes even worse than the absence of compensatory adaptation features in an e-collaboration tool is the inclusion of those features in such a way that they do not work as intended. For example, features that allow for the inclusion of emoticons in e-mails have been added to many e-mail systems, yet their use by e-mail senders often irritates the receivers. The irritation seems to be typically caused by the emoticons being used in ways that really add little meaning to the message being conveyed, and in some cases by the emoticon conveying the opposite of what was intended.

An instance of this type of miscommunication would be the following. A colleague wants to make a constructive critical comment about what someone else said, which in a face-to-face meeting would be accompanied by a smile to soften the tone of the critical comment. The goal of the smile would be to make the comment sound constructively critical, instead of a personal attack. The use of a smiley face emoticon instead, as a replacement for the smile in a face-to-face meeting, may add insult to injury by being interpreted as a mocking attempt.

The reason is that emoticons are perceived by many as cartoon-like and somewhat odd representations of facial emotions. Interestingly, their current use highlights the need of a better understanding of the nature of our biological communication apparatus. Evolution has endowed the human species with a very complex web of facial muscles, more complex than almost any other animal. That complex web of facial muscles seems to have been evolved chiefly for communication of emotional states. Very few of those muscles are used for purposes other than communication, such as chewing. Emoticons certainly do not convey the range of emotions that facial expressions do, and thus their indiscriminate use may lead to more harm than good.

As with emoticons, there are other examples of bad implementations of features aimed at incorporating media naturalness elements into e-collaboration technologies. Table 1 summarizes some of these possible implementations. For simplicity, the examples provided refer to simple implementations of media naturalness using standard e-mail systems. The reference to "speech synthesis" in Table 1 assumes that voice intonations are not automatically added when the text is read aloud. This could arguably be achieved in the future through artificial intelligence solutions that are not currently available, and make the widespread use of speech synthesis more promising in the context of e-mail communication.

**TABLE 1:**
**Media naturalness elements and examples of bad implementation through e-mail**

| Media naturalness element | Bad implementation | Why? |
|---|---|---|
| Support for use of speech | Use of speech synthesis to read aloud text from e-mails | Removes voice intonations that add meaning to messa-ges |
| Support for use of facial expressions | Emoticons added to e-mails | Do not capture the nuances of facial expressions |
| Support for use of body language | Stick figures signaling diffe-rent body positions added to e-mails | Do not capture the nuances of body positions and move-ments |

So how can e-collaboration technology designers figure out ways in which they can design technology features to effectively facilitate compensatory adaptation? The obvious answer here is that they must invest in behavioral research, whereby compensatory adaptation enablers are incorporated into technologies and their effects are tested through methodologically rigorous investigations. This approach, sometimes referred to as human factors research, has been and is being employed by some of the most successful software developers in the world today. Google, IBM and Microsoft have been doing that for years.

In the absence of much needed additional human factors research, particularly in connection with specific e-collaboration technologies and features used in specific organization contexts, certain assumptions may be made based on what we know now about good technology design practices. Table 2 summarizes what could arguably be presented as good implementations of features aimed at incorporating media naturalness elements into e-collaboration technologies. Those implementations should be aimed at facilitating compensatory adaptation by allowing for their selective use in specific contexts, and not by forcing their use all the time. As with Table 1, the examples provided in Table 2 refer to simple implementations of media naturalness using standard e-mail systems. The reference to "generic" files in Table 2 highlights the need for the use of files that will be easily viewed by users with commonly available and free multimedia players (e.g., RealPlayer, Windows Media Player, and QuickTime Player).

**TABLE 2:**
**Media naturalness elements and examples of good implementation through e-mail**

| Media naturalness element | Good implementation | Why? |
|---|---|---|
| Support for use of speech | Generic audio clip files attached to e-mails | Capture voice intonations that add meaning to messages |
| Support for use of facial expressions | Generic facial photo files conveying specific emotions attached to e-mails | Capture the nuances of facial expressions |
| Support for use of body language | Generic video clip files showing the sender's whole body attached to e-mails | Capture the nuances of body positions and movements |

Since e-collaboration technologies are often used in particular contexts, and to automate specific tasks, behavioral investigations of technology enablers of compensatory adaptation should also be carried out with those contexts and tasks in mind. That is, there is a danger in trying to derive conclusions about an enabler's effect in a particular organizational context, and extend those conclusions to a significantly different context. Let us say that we tested the use of multimedia discussion boards in the context provided by, say, drug development in a pharmaceutical company. The results of that test may not be very useful for conclusions about how the same technology would be used in the context of budget allocation in a government defense agency.

One main conclusion from the above discussion is that a lot more behavioral research must be conducted on e-collaboration, and that research should be closely tied to research on the design of e-collaboration technologies. Those two types of research are more often than not done in a disconnected manner. Moreover, that behavioral research on e-collaboration should be conducted more often in the organizations that use the e-collaboration technologies. Up until now most of that research has been conducted in universities and research centers, with some notable exceptions, and based on experimental scenarios that are frequently disconnected from the reality faced by organizations. An increase in the amount of action research (Kock, 2006) on e-collaboration would certainly meet that need head on.

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