AFFORDANCES FOR INTERACTION: THE SOCIAL IS MATERIAL FOR DESIGN

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ABSTRACT

In this article, I explore an ecological approach to social interaction, using the concept of affordances to describe material properties of the environment that affect how people interact. My examples come mainly from the design of technologies that support collaboration. The physical properties of paper and electronic media—for instance electronic mail or video communication system—affects how they can be used and how people can use them to interact. Many of these effects are due to differences in the degree to which the media afford prediction and exploration. Because they are based on material properties, these affordances run deep, and trying to design against their grain is not easy. Difficulties of design, however, can shed light on subtleties of interaction that might otherwise be overlooked. Thus design is both guided by, and can guide, an ecological approach to social interaction. Nonetheless, design is only one example of the wide range of issues an ecological approach to social behaviour might address. Such an approach may provide as fundamental a challenge to existing perspectives on social interaction as it has to traditional theories of perception.

INTRODUCTION

In this article, I explore an ecological approach to social behaviour. This perspective suggests that just as perception and action are best understood with reference to the lawful physical world in which they have evolved, so social behaviour should be understood as embedded in and shaped by its material context as well. If social interaction is considered in terms of its environment, seemingly arbitrary social behaviours often become clearer. One way to do this is to recast the physical properties of the environment in terms of their affordances for perception and interaction. In this way, social behaviour can be grounded by a relevant ecological physics.

An ecological approach to social behaviour is also useful for guiding the design of things meant to support interaction (e.g. office layout, or collaborative computer systems). This is an area in which the connections between the material and social worlds are most immediately obvious. The more we can understand social behaviour in terms of its material context, the better can design efforts be focused on relevant attributes. From this point of view, an ecological approach to social phenomena can help fulfil the promise for design offered by disciplines such as sociology, ethnomethodology, and anthropology.

More than this, design itself can serve as a methodology for better understanding social behaviour and its underlying affordances. Any design is an instantiation of theories about material influences on behaviour, whether explicit or implicit (Carroll & Kellogg, 1989). But crucial aspects of behaviour, particularly social behaviour, tend to be peripheral and unspoken, and thus difficult for theories to capture. Because of this, new technologies seldom simply support old working practices with additional efficiency or flexibility. Instead they tend to undermine existing practices and to demand new ones. In this disruption, subtleties of existing social behaviours and the affordances upon which they rely become apparent, as do the new affordances and social behaviours offered by technology.

I develop these themes in this article using a number of examples to illustrate an ecological approach to social phenomena, suggest its potential for design, and show how new technologies can shed light on existing affordances. I begin with an example from everyday life that illustrates the kind of

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ecological approach to social phenomena I have in mind, and which shows how such an approach might demystify social phenomena. After setting this foundation, I turn to issues involving the design of technologies.

Height, Status, and Accessibility

Most existing approaches seem to downplay material influences on social behaviour, and even to emphasise examples suggesting that arbitrary conventions overwhelm material factors. For instance, in an article about the way artifacts are incorporated into social practice, Brown and Duguid (1994) discuss the importance of a material attribute—elevation—on the perceived status of commercial facilities. They point out that elevation has different meanings for offices and retail establishments: In general, height and status are proportional for offices, but inversely proportional for retail establishments. That is, while a penthouse office is the pinnacle of achievement for a law firm, being stuck at the top of a building would be disastrous for a bookstore. Conversely, a site on the ground floor of a busy street would be ideal for the book sellers, but humiliating for the lawyers. Elevation has very different meanings for the two sorts of business.

This sort of phenomenon, in which seemingly similar material conditions are incorporated into seemingly different social behaviours, is grist for the sociological mill. Brown and Duguid (1994) explain this in terms of different social conventions surrounding the interpretation of various “genres” of commercial establishment. From this point of view, we learn to “read” meaning into the characteristics of different places much as we learn to read books. And just as the genre of the source—newspaper, art criticism, western novel, or cookbook, perhaps—will change the way we interpret text about, say, dead cows, so the different meanings of elevation for offices and retail establishments are supposed to stem from their representing different “genres” of commercial establishment. From this perspective, the physical attribute of elevation becomes a foil against which to appreciate the subtleties of social mediation.

To be fair, I am pulling this example out of the overall context of Brown and Duguid’s (1994) article. The body of their discussion is an admirable account of the interactions between culture and the physical environment, one that raises issues about the loss of materiality in electronic artifacts similar to the ones I will discuss later. They take a balanced view of culture and physicality, however, and this is something I want to avoid in this article. My aim, in contrast, is to see whether the idea of environmental shaping of social actions can be pushed far enough to avoid the need to appeal to convention as an explanatory principle. Thus I want to this example as a starting point for exploring an ecological view, one which suggests that social meanings are based on facts of the physical world.

For it is possible to turn this account of elevation and status on its head, and to take social behaviour as a measure of the profound effects of the material world. From this perspective, the fact that social status increases with physical height for offices but not for retail establishments can be seen to hinge on the fact that elevation has an inherent meaning for physically embodied creatures such as ourselves: namely, that increasing height implies decreasing accessibility. Offices benefit from privacy and lack of disruption, in this view, while retail establishments usually depend on being convenient for shoppers. This inherent "meaning" of elevation helps to explain social behaviour, rather than the other way around. Instead of taking people's interactions with physical artifacts as an index to their social organisation, we can take social practices as a sign of complex material influences. This kind of shift is the point of departure for this article.

Affordances for Social Interaction

Recasting height as accessibility is an example of moving to a description of the environment in terms of its affordances. Such a move is fundamental to the contribution that the ecological approach can make to understanding social phenomena. The concept of affordances, as introduced by Gibson (e.g., 1979), provides a way to describe the world that cuts across traditional subject-object dualities. Affordances go beyond value-free physical descriptions of the environment by expressing environmental attributes relative to humans. At the same time, they go beyond subjective interpretations (e.g., associations, schemas, or social conventions) by describing meaning relative to an objective physical world.

For example, the physical measure of height, which has no inherent meaning, can be recast in terms of the affordance of accessibility, which does. Because accessibility emerges from the relation between elevation and people's physical characteristics (e.g., the necessity of expending energy climbing to higher surfaces of support), it is an objective fact about a situation. It can thus serve as a useful alternative to arbitrary conventions in explanations of individual and social behaviour.

Affordances are primarily facts about action and interaction, not perception. This contrasts with the common impression that affordances refer to—approximately—situations in which one can see what to do. As the example concerning accessibility suggests, the concept is useful for describing situations in which questions of perceptibility simply do not arise. They allow meaning to be understood in terms of the relations of humans and their environment. The question can then arise about whether these attributes are perceptible. This is the sense in which Gibson (1979) introduced the notion as a way of reconsidering the objects of perception. When affordances are perceived, a tight link between perception and action may ensue. But the concept is also useful in describing situations in which perceptual information is misleading about possibilities for action, or those in which affordances exist but information for them does not. In general, the perceptibility of an affordance should not be confused with the affordance itself.

Affordances exist not just for individual action, but for social interaction as well, as the example of accessibility suggests. This sort of affordance has not been discussed in the ecological literature. Studies of affordances such as passing through a doorway (Warren & Whang, 1987) or climbing stairs (Warren, 1982) are concerned with understanding how individual activities are shaped by the environment, and how individuals can orient to the relevant environmental attributes. Research on "social affordances" (e.g., Still & Good, 1991; Goldring, 1991) focuses on the possibilities for action that people offer one another and on the role of other people in pointing out new affordances (e.g., to babies). What I am concerned with here is the possibilities offered by the physical environment for social interaction. These are not social affordances, as defined above, but affordances for sociality. I believe they offer new opportunities for basic research and a powerful tool for design.

Affordances and Design

The concept of affordances encourages a focus on the material features that are relevant for behaviour, and thus it can be a useful concept for design. For instance, recasting the relationship between status and elevation to one between status and accessibility suggests alternatives to elevation as a means of controlling accessibility. Ground-floor offices, for example, might be designed for reduced accessibility by screening them with fences or vegetation. Upper-story shops, on the other hand, can be made more accessible visually via signs, and physically via elevators or escalators. Finally, some shops may actually increase their status by decreasing their accessibility—whether via elevation or via, for instance, locked doors and appointments—in order to earn the cachet of exclusivity.

There is an increasing need for designers to understand social phenomena. New computer systems, for example, have increasingly been aimed beyond single users towards more extended groups, working in the same place or in distributed locations, at the same time or asynchronously. Even products designed for individual users are increasingly recognised as used in the context of larger communities. Because of this, the contributions sociological and anthropological approaches have to offer have become increasingly respected, as have, more generally, the sorts of phenomena they study.

Conversely, designing for social contexts turns out to be a valuable domain for studying social behaviour. Because new designs change the environment for interaction, they show old behaviours in a new light, and illustrate how new behaviours emerge. For instance, designs meant to increase or reduce accessibility might produce unintended results due to overlooked factors—plantings meant to reduce accessibility might turn out to attract more people to an establishment, for example. The insights gained from unexpected properties of these "artificial" environments often allow a new view on unexamined aspects of behaviour in the "ordinary" environment for everyday interaction. Studies of behaviour in designed environments can thus be generally relevant for understanding social phenomena in any environment.

In the rest of this article, I focus on examples that further illustrate how an examination of a situation's affordances can help illuminate social behaviour. These examples center around the tendency for electronic technologies to reduce the affordance of predictability supporting everyday social behaviour. I start by suggesting that paper's integration of storage and display offers affordances for predictability that are lost in electronic documents, which separate the two. I explore the social consequences of losing predictability with informal observations about how the attributes of particular electronic mail (email) systems influence the ways different communities form, mesh, and fail to mesh. Finally, I describe design meant to increase predictability, in this case using an understanding of the everyday world as a lawful medium for collaboration to guide the design of a novel system for audio-video networking. In the end, I discuss how difficulties in designing new affordances shed light on existing affordances and behaviours. Throughout, my aim is to show that the notion of affordances is a powerful one to bring to the design of systems meant to support collaboration, and more basically to an understanding of social behaviour in general.

THE AFFORDANCES OF PAPER

Designing new technologies often requires speculation about their social effects, a form of social theorising that often proves naive when actual events run contrary to expectation. For instance, the card catalogues traditionally used in libraries have increasingly been replaced by computer databases. This move has been expected to produce a number of benefits (e.g., reduced storage space, decreased vulnerability to loss, and the ability to access information quickly and remotely). But there is a wide gulf between the rich tangibility of paper and the abstracted formality of electronic documents that has led to strong criticisms of computer catalogues. Even if original cards are digitally scanned (and usually they aren't, but instead their formal entries are keyed into computers) the information conveyed by the idiosyncrasies of each card—the font of its formal text, the appearance and content of handwritten annotations, its physical wear and tear—are inevitably lost in the translation between the media. The result is a catalogue that can be searched at blinding speeds and from far away, but one which loses the individuality of its history.

The difference between card catalogues and computer databases are useful as an orienting example of the differences between paper and electronic documents. In this section, I start by outlining three obvious sets of differences between the affordances of paper and electronic documents. These differences are superficial enough, I suggest, that they might be overcome by advances in technology. But there is a fourth distinction between paper and electronic documents, related to mechanical discontinuities between storage and display, which seems fundamental enough to encourage more lasting differences in the ways the media are used.

Display, Input, and Embodiment

The first set of differences between paper and electronic documents have to do with their affordances for the display of information. Paper has a resolution that is far higher compared to computers, allowing far greater subtlety and expression in the marks it displays than can be achieved on screens (Hewson, 1995). In addition, though different types of paper may affect the visual quality of marks made upon them, the same piece of paper can support a variety of visual styles from four-colour graphics, to formal typed entries, to informal handwritten annotations and sketches. This property allows the rich mixture of formal and informal information carried by catalogue cards, information that is usually lost when cards are keyed into electronic catalogues. Finally, paper conveys information by gradations of reflected light, not emitted light, allowing paper to merge with its surrounds more effectively than computer displays do with theirs.

The second set of affordances are those relevant for input. There is a wide variety of ways to make marks on paper. Tools include the vast assortment of hand-held marking devices such as pencils, pens, brushes, crayons, etc., as well as the growing variety of printers, from printing presses to ditto machines to typewriters and laser printers (which externalise information from computers). This allows a flexibility that far exceeds that available for computers. Not only does this underlie the variety of annotations already found on catalogue cards, but it makes the continuing accretion of annotation on electronic cards seem unlikely. In addition, paper lends itself to use in very different

social situations from computers, because it is generally far less interruptive to jot down somebody's telephone number on a scrap of paper, for instance, than it is to input it on a computer. Finally, the nature of making marks on paper via the computer means that their qualities carry essentially the opposite implications. For paper, straight, precise lines imply formality, and rough, sketchy ones informality. For computers, in contrast, rough lines imply formality while rigid ones imply informality. The difference between the implications of marks' visual qualities is a direct consequence of the affordances of mark-making tools, and may lead to the development of new interpretative practices.

A third set of paper's affordances involves its physical embodiment. This has allowed catalogue cards to be evolving records, both because they are relatively inexpensive to reproduce and because the ways they change and wear themselves become valuable information. Paper is practically free when compared to computers, encouraging the profligate use of paper to write notes, scribble maps, and so forth. Though there is an increasing awareness of the less obvious environmental costs of indiscriminate paper use, it is difficult to imagine that we would ever casually pass out bits of computer hardware to strangers, for instance, instead of business cards. Moreover, paper is portable, requires no power, and works despite a variety of transformations (e.g., folding, tearing) that are inadvisable for current computer displays.

The differences between paper and electronic media in terms of display, input and physicality are important in understanding why paper continues to be used. Nonetheless, new technologies are beginning to reduce the differences between old and new media. Very high resolution displays rival paper's ability to display subtle and fine markings. New input devices allow people to write or paint on a computer much as they do on paper. Scan and print systems can allow information to flow easily from paper to computer and back again, merging the two worlds. Finally, a variety of small, relatively robust hand-held computers are available which can rival paper's physical convenience. These developments seem to suggest the possibility that paper might be supplanted by computer technologies after all.

Integration of Storage and Display

There is a final and more fundamental difference between paper and electronic media, however, that seems likely to outweigh their increasing similarities in determining how the two are used: For paper, the medium for storage and the medium for display are the same, whereas for computers the two are different. This leads to paper being strongly predictable as a medium in a way that electronic media are not. It seems to underlie many of the fundamental strengths and weaknesses of each medium. Moreover, it emphasises that the media are complementary, not rivals. In the end, it raises doubt that one will be replaced by the other.

The dissociation of storage and display is responsible for many of the most useful capabilities offered by computers. It allows the equivalent of thousands of pages of text and graphics to be stored and manipulated on a portable computer that weighs about 5 pounds. It allows that material to be edited so that changes merge seamlessly with the original. Finally, it allows storage of temporal information that cannot be represented on a static page—e.g., video and sound—making computers a new medium in their own right. All this depends on the ability to store information digitally, separately and in a different form from the way that it is displayed. This separation is at the heart of the computer's powers.

For paper, in contrast, the fact that the medium of storage is the same as the medium of display is responsible for many of many of its most useful affordances. The fact that we can thumb through a book and gauge our progress through it, for instance, depends on the fact that the pages both store and display information, so that their heft is lawfully related to the amount of information they contain. The fact that we can spread out a number of pages of paper to get a sense of the structure of an article is due to the content of that article being stored on different displays (pages) so that it takes no extra resources to display them all simultaneously. The integration of paper's storage and display is at the heart of its appeal.

The different affordances of paper and electronic media have many effects on the social conventions that surround them. On the one hand, because of the independence of electronic document's storage and display, it is easy to create formatted electronic documents, to edit them in order to correct mistakes and change content, to tailor them for their intended audiences, and to distribute multiple copies cheaply and quickly. To appreciate the social effects of these new affordances, one need only reflect on the changing roles and responsibilities of secretaries in light of the fact that a few decades ago this article would have been written by hand until a final version was ready to be typed, undoubtedly using carbon paper to make multiple copies.

On the other hand, the fact that it is difficult to make changes to paper documents without changing their appearance, but easy to modify electronic ones, raises issues concerning originality and authenticity. For example, some legal firms now insist that official documents should not be signed in black ink, but rather blue or purple, to ensure that signatures are not electronically reproduced. Nonetheless, any paper document has a unique identity, an actuality, that is difficult for electronic ones to achieve. For example, a number of different versions of papers such as this may circulate as drafts are modified and replaced. Though drafts may be explicitly labelled to avoid confusion with a completed product, even early ones are genuine documents in their own right (e.g., "hey—that's my copy!" "I liked the first version better...") Electronic documents are fluid, flowing smoothly from iteration to iteration. But paper is a stable medium, so printed documents take on a self-sufficient reality that does not rely on, and is not affected by, the labile electronic environment from which they appear.

Far from causing the so-called "paperless office," the advent of computers has greatly increased the amount of paper people use. This is because paper and computers are complementary media. They lend themselves to different sorts of uses, and different sorts of social practices. Despite their increasing miniaturisation and flexibility, computers still require focused attention to use, drawing us into a virtual world that is only partially made perceptible. Paper, on the other hand, can be used as a peripheral part of ongoing activities, because it is stable, flexible, and manifest. Its role in society may change with the growth of computing, but it is unlikely to be supplanted entirely.

THE AFFORDANCE OF PREDICTABILITY

Many of paper's underlying strengths depend on an affordance for *predictability* that its integration of storage and display makes possible—a predictability that electronic media trades for novel uses. The fact that paper's medium for storage is also its medium of display places constraints that allow information to be unequivocally mapped between the two functions. The meaning of a given mark is apparent, both formally in terms of its symbolic functions and informally in terms of its history and origins, in that it is the sole representation of that meaning rather than the outward manifestation of some deeper level of storage. It is difficult to change the content of a paper document without changing its appearance, or to change its appearance without changing its underlying content.

The fact that a computer's medium for storage is separable from its medium of display, in contrast, allows an unspecified mapping between content and appearance. A given display may reveal only a part of the information stored by the computer, and is unlikely to reveal a great deal about its history. It is easy to change the content of an electronic document without noticeably changing its appearance, and to change, modify, or customise its appearance without changing its underlying content. In general, the lack of constraints on electronic documents means that they do not afford predictability in the same way as paper documents do.

Calling predictability an affordance seems controversial in a number of ways. From the perspective of traditional psychology, prediction may evoke notions of associative learning, probability, and causal reasoning that have been treated extensively in the literature (e.g., Shanks, 1994). From the perspective of the ecological approach, it may seem too far removed from the sort of organism-environment mutuality that might be perceptually specified. But it seems useful to consider predictability as an affordance because it stresses that even as mental an act as prediction depends fundamentally on the perceptible regularities of an environment, whether natural or artificial.

Predictability is as lawful, as physical, and as dependent on the mutuality of person and environment as are affordances such as climbability or graspability. When a system's structure is consistent and perceptibly available, then it affords prediction. When it is relatively unconstrained and unavailable for perception, then it is difficult for people to use in guiding their actions. Considered as an affordance, predictability implies the mental activity of predication. It doesn't imply, however, any particular model of prediction, whether associationist, cognitivist, connectionist, and so on. Instead, prediction could be taken simply as the act of perceiving environmental regularities; the crucial consideration, highlighted by calling it an affordance, is whether those regularities exist and are perceptible.

The affordance of predictability is often lacking in electronic and computational artifacts. The differences between paper and electronic documents are only one example. In general, new technologies are so malleable and unconstrained that they support a vast range of behaviours, but make none obvious. There are few causal links between the functionality of new technologies and the way they appear. The result is that, at a very deep level, such technologies do not afford prediction. Of course, the lack of constraint on electronic and computational systems brings advantages as well as disadvantages. It is not that they are worse than physical ones, but such systems have different affordances, and fill different social niches.

The unpredictability of most electronic systems has a common social consequence of forcing previously implicit behaviours to be made explicit, and of causing the unspoken to be spoken. People using such systems find they cannot easily coordinate their activities and instead have to explicitly negotiate their collaboration. This may actually make them appear to be collaborating more intensely, simply because they talk more. But collaborative work doesn't always require focused communication (see, e.g., Heath & Luff 1991), and systems that require it may disrupt fluid working processes.

Trying to recreate the affordances of mechanical media such as paper in electronic systems may be an intractable problem. The predictability of paper, for instance, and the affordances related to it, depend crucially on the necessary physical connection between storage and display. This implies that electronic media can only imitate these properties superficially. For instance, it is easy to imagine creating margins on either side of a text file that would vary in thickness to emulate the heft of pages before and after a given page. It might even be possible to do this tactually—to mechanically vary the thickness of the display device itself by analogy with books. Such feedback might prove useful, but there is a crucial difference between information conveyed by physical necessity and that provided by design that makes it difficult to circumvent the fundamental affordances of a medium. The fact would remain that such devices *could* be wrong, that some programming or mechanical error could produce inaccurate information. This makes the status of this sort of feedback more provisional than that provided by the everyday world, and reduces the degree to which the device affords prediction.

PREDICTABILITY, EMAIL, AND COMMUNITY

The discontinuities of storage and display inherent in electronic media often affects social interactions that involve them. The social practices that grow around electronic mail (email) provide a good example of this. For instance, how should unanswered email be interpreted? If you send a message to a colleague and receive no reply, should you consider yourself snubbed, assume that it has disappeared en route, or infer that it has been buried under newer messages? How soon do you know that your colleague hasn't answered in the first place? A week? A day? Half an hour?

Clearly the interpretation given to unanswered communications varies depending on the medium. For instance, the delay between sending postal mail and deciding it has gone unanswered is much longer than that between dialling a telephone number and deciding it will not be picked up. The different time scales involved are not a matter of interpretation or social convention. They are facts of the media, and they shape the ways societies work with them.

The properties of email also constrain the social interactions that it mediates. Because email is newer, less predictable, and more varied than other media, however, the behaviours that form are less stable and more open to examination. Subcultures have formed whose uses of email vary analogously to the

differences between telephone and postal mail use. Some groups use email incessantly, monitoring it continuously and replying to messages almost immediately after they are received. Others use email only occasionally, reading new messages once a day or less, and replying to them only after some period of thought. And some regard email as a high-tech curiosity to which they would never entrust any important communication.

These communities do not reflect arbitrary differences in local culture, however, but the affordances of the email systems they use. If email is troublesome to access, slow, difficult to operate, prone to breakdown, and expensive, then intensive email cultures are unlikely to develop around it. If email systems are slow, they may be used analogously to postal mail – relatively formally and infrequently. If they are unreliable, then they cannot support formal communication well at all and will tend to be used as an unimportant novelty. In general, for a community to develop that uses email as intensely, frequently, and informally as telephones, systems must be ubiquitous, easy to use, fast, and reliable.

I have recently experienced this myself in moving from an environment that had continuous, high-bandwidth email access to every desktop machine to one which has a single central computer that can be connected to the Internet only by a dial-up service. It should not be surprising that my email usage has dropped significantly: The former system afforded an intense email culture, the latter does not. The properties of email systems may not *determine* the communities that eventually form around them—I still use email a great deal compared to others in my local culture—but they do strongly *constrain* the cultures that might develop.

Email Between Communities

The system used by a particular community will shape the way that unanswered email is interpreted. The more reliable the system, the less likely is the lack of an answer to be excused on a technical fault. The faster the system, the sooner will it seem that a given message has gone unanswered. The more the system is used for formal (e.g., business related) purposes, the more serious is a breach of communications, and so on. In general, the "message" of unanswered email depends crucially on the attributes of the system being used, and the communities that form and stabilise around various systems may be understood in terms of these attributes.

The system a particular community uses shapes the way it interprets email, but typically only the most intense email cultures—the ones with the most continuous, fast, and reliable systems—devote a considerable proportion of their mail to internal use. For the most part, email is exchanged between different communities, and this means that senders and recipients are likely to use different sorts of systems. The mismatch between systems, and thus between community expectations, raises interesting social difficulties. For instance, my wife recently received a message from a colleague asking her to call him regarding an urgent manner. Noticing that the message had been sent only a few minutes before she read it, she quickly emailed her reply. A few hours later, however, her colleague telephoned to ask why she hadn't called. He hadn't seen her message because he only used email as a poor substitute for telephone answering machines, while the speed and availability of her system prompted her to use it as a substitute for the telephone itself.

A range of social behaviours can thus form around the differing affordances of email, with the fact that it is viewed as a single medium confusing their coordination. Too quick a response can seem inappropriate to someone using a "slow" system, for instance, who might feel it indicates undue urgency or too much free time on the part of the sender. Conversely, the leisurely reply that such a user might give can seem lazy, provincial, or even insulting to an intense email user. Unanswered email will be interpreted differently by the two communities. Moreover, the sender and recipient may have different interpretations of the same unanswered email, leading to new confusion and tensions.

The problem is not only that different email standards engender different community practices, but that the differences themselves are unavailable, or at least not obvious, to the sender and recipient. The sender may not be aware that the recipient has an inaccessible, slow, and unreliable email system, and thus react to an unanswered message based on the conventions built around his or her local system. Conversely, the recipient may not understand the sender's email system and culture, and thus wait too

long before replying, or even reply too quickly. Although experienced email users may gain some clues from domain addresses (with some clearly being on the wrong side of the information superhighway) in general it is difficult to determine the sort of system to which email is being sent, and thus the sort of cultural norms that may be expected to apply.

As with other systems meant to support collaboration, email's lack of predictability encourages users to make explicit things normally left implicit. There are several devices that email senders may use to prompt recipients about their expectations. For instance, unanswered messages may prompt a follow-up message saying simply "are you there?" When more formal messages go unanswered (usually for a period of days or longer), some senders will resend the original message with a covering note asking if the original was received. Finally, a friend recently told me of a more elaborate version of this last ploy: When a message of his went unanswered, he sent another message with a special field in its header that, like a registered letter, automatically sent a new message back to him when his message was received. The important point was that he told the recipient in the body of his message both that he had attached the header and what it did. Making clear the level of information that he would receive insured that he received a reply within hours rather than days; this can be seen as a way of explicitly increasing and making evident the predictability of the situation.

EXTENDING MEDIA SPACE

It is difficult to use electronic systems to recreate the affordances produced by mechanical restraints, as the example of email indicates. But it is still a typical aim of design to capture in new media at least some of the characteristics of their everyday precursors. The purpose of many electronic systems is to extend the ability to perform existing tasks, whether in scale, in speed, or over larger distances. Moreover, basing design on existing examples allows a continuity that is useful for motivation and learning: Inventions that modify existing practices tend to be easier to conceive and more practical to implement than those that create wholly new functions. Thus the design of such systems is often an iterative process in which the affordances of existing systems are recreated in new ones, while new affordances are also understood and developed.

For example, over the last few years several research laboratories have developed and used various forms of *media spaces*, computer-controlled networks of audio and video equipment designed to support collaboration (Bly et al., 1993; Gaver et al., 1992). Media spaces differ from more common videophone and video-conferencing systems in that they do not seek to recreate and extend the affordances offered by telephones, but instead those offered by copresence in the everyday environment. They are continuously available environments rather than periodically accessed services, and so may support fluid movement among a range of collaborative activities that vary in the degree of planning and attentional focus involved. Experimental evidence for their success is sparse (e.g., Fish et al., 1992), though anecdotal evidence does suggest that media spaces can support collaborative relationships (e.g., Dourish et. al, 1994). In general, assessments seem to depend on how success is measured and, crucially, on the time a community has had to form around a given system. Whatever their success however, it has become increasingly clear that only some of the characteristics of everyday physical spaces have been recreated by media spaces, and that this affects the forms of interaction they can support.

Analysing the affordances offered by media spaces is useful in understanding their differences from the everyday medium, in part because it suggests design possibilities relatively directly (Gaver, 1991). Several limitations on the perceptual information media spaces convey become clear from such an analysis**.** For instance, video tends to have a relatively narrow field of view and low resolution, it provides little information for depth in the remote scene, and there tends to be discontinuities between scenes caused in part by the separation of camera and monitor. Each of these factors affects how media spaces are used for collaboration.

Perhaps the most important affordance of the everyday world lacking in media spaces is the ability to move. As Gibson (1979) emphasised, movement is fundamental for perception. We move towards and away from things, look around them, and move them so we can inspect them closely. Movement also has implications for other constraints produced by video. If we can look around, we increase our

effective field of view, compensate for low resolution (Smets et al., 1995), and obtain movement parallax information about three-dimensional layout (Overbeeke et al., 1987). Finally, movement might allow people to compensate for the discontinuities and anisotropies of current media spaces (Gaver, 1992; c.f. Heath & Luff, 1991).

Designing For Movement

From this point of view, social interactions in media space would be better supported if people could explore remote sites as easily as they can move around their own rooms. A recent attempt to provide this capability involved implementing a version of the Delft Virtual Window system for media space (Gaver et al., 1995; Overbeeke et al., 1987; Smets et al., 1987). The basic idea of the Virtual Window is that moving in front of a local video monitor causes a remote camera to move analogously, thus providing new information on the display. To see something out of view to the right, for instance, the viewer need only "look around the corner" by moving to the left; to see something on a desk, he or she need only "look over the edge," and so forth. The result is that the monitor appears as a window rather than a flat screen, through which remote scenes may be explored visually in a natural and intuitive way.

The Virtual Window, as used in media space research, is an attempt to use technology to recreate the affordances for movement and perceptual exploration offered by the everyday world. However, experience with implementing and testing a prototype version of the system serves as a good example of the difficulties of this endeavour.

Implementing a Virtual Window requires three basic components. First, the location of the viewer's head with respect to the monitor must be determined; second, the head location must be mapped to a desired camera location; and third, the camera must be physically moved in the remote site. In our implementation the image from a "tracking camera" mounted on the local video monitor was processed to extract the viewer's head location. This information was sent via a digital network to a computer in the remote office, and used to control a transport mechanism that physically moved a remote camera over a small area. Head location determined the lateral movement of the camera, while the focal point around which the camera rotated was set manually by the viewer. The picture from the viewing camera was sent back to the local office, as was audio from the remote office.

To test the system, six pairs of participants used the prototype Virtual Window in pursuing two simple collaborative tasks (drawing one another’s room and designing an overhead projector). Several advantages of the Virtual Window became clear. Most importantly, the Virtual Window succeeded in allowing participants to explore their partner's office visually, and the mapping between local movements and remote views appeared natural to the users. For instance, when one participant wanted to look down and to the side, he simply stood up and moved to the side, without saying anything to his partner. The fact that this is possible at all, and that it seemed so natural, indicated that the Virtual Window system successfully offered affordances for movement.

A number of other affordances offered by the system became clear as well. Because information is gathered over time as well as space, the system offers a greatly expanded field of view as well as an increase in effective resolution. The ability to move also reduced discontinuities at the edges of the remote scene, or between multiple images where more than one camera is used. The view is also more continuous with the local scene, since movement causes the same kinds of visual flow in each. Finally, the ability to move helps support coordination with remote colleagues. For example, there were several instances in which a participant would move slightly to achieve a better view on something his or her partner was displaying; the system appeared to allow subjects mutually and implicitly to negotiate orientation. In addition, there were occasions in which the system seemed to help participants maintain awareness of their partner's field of view, by increasing their awareness of the camera and its orientation.

Going Against the Grain

Unfortunately, our experiences with the Virtual Window were far from uniformly successful. The first two pairs of participants used the system on a day with bright sun and patchy cloud – severely

disrupting the head-tracking algorithm, which relied on the stability of a "reference image" of the viewer's office taken at the beginning of a session. The results were difficult for participants to interpret, as the movements of the view were only partially related to their own movements. The only way to correct problems was to duck out of sight of the tracking camera to take a new reference image. The result was that, when a useful view did come onscreen by chance, participants would often freeze in an attempt to keep the camera from moving. Ironically, in these circumstances a stationary camera would have been more useful than our prototype; when the Virtual Window didn't work, it actually interfered with the technology's more fundamental affordances.

Recreating everyday affordances in new media can be a difficult goal to achieve, as our mixed success with the Virtual Window suggests. Just as trying to mechanically emulate paper's properties is problematic because of the different causal constraints involved, so all technologies have their own affordances which can be difficult to modify or overlook. For instance, even though the Virtual Window system is relatively successful at affording remote movement, there are enduring constraints in the sort of movement it allows. Some of these constraints have to do with the mechanical and computational implementation: It is physically difficult to move the mass of a camera smoothly and quickly over an area, and accurate head tracking is demanding as far as processing goes. Other constraints are more endemic to the system: If a single camera is being moved, for instance, it is difficult to know how to allow multiple remote users to connect to the same site. To some extent, these issues may be addressed through further design. For instance, one possibility is to avoid moving a camera at all, and instead to produce a shifting view on remote scenes by undistorting changing sections of the view from a fish-eye lens. Nonetheless, such a strategy is likely to be computationally demanding.

In any case, it may be misguided to design technologies that slavishly follow existing patterns at the expense of their own affordances. For example, once participants in our study had achieved good views of remote spaces, they often seemed reluctant to move for fear of losing them. This problem is partially an effect of the current system's limitations, but it seems desirable to maintain the dissociation. A foot pedal could be added to the system, for instance, allowing people to stop the Virtual Window so that local movement would not disturb a good view of the remote site. In general, good design seems to demand a balance between providing the sorts of affordances originally suggested by the everyday world with those more inherent to given technologies.

AN ECOLOGICAL APPROACH TO SOCIAL INTERACTION

The ecological approach is useful in the design process because it describes perception and interaction in terms of the properties of the environment, as well as those of people, and design is fundamentally about manipulating the environment for people. Moreover, design work can both take from and give to the ecological approach, by guiding design, and—when difficulties are encountered—by highlighting subtle factors of behaviour that might otherwise go unnoticed. From this perspective, designing systems to support collaboration requires instantiating (sometimes implicit) theories about affordances for collaboration. These theories are often too simple, which means that the systems don't lead to the sorts of social interaction expected. This then leads both to a clarification of social behaviour and a refinement of the systems – theory leads to design, which leads in turn to new theory.

Although I have focused on design in this discussion, however, an ecological approach to social behaviour can extend far beyond this. Examples of affordances for social behaviour are innumerable. The ways people communicate using voice, gesture, and gaze are shaped by the information light and sound conveys at various distances (c.f. Hall, 1982). Interior decoration relies on designing affordances: The ways tables are laid out in restaurants, for instance—whether they are small and well-spaced, or arranged in long rows—will determine whether the space offers an intimate encounter or a convivial celebration. Community architecture is another example: In Paris, for instance, major boulevards meet in a star, forming thriving social centres that exist near quieter local neighbourhoods in a way that grid patterns do not encourage. Social behaviour of all sorts—whether in the natural world or mediated by human invention—may be usefully approached from an ecological point of view.

Trying to eliminate the need for social convention as an explanatory concept may be a quixotic endeavour. Many of our social behaviours do not seem to have any clear basis in the constraints of our physical environment. The side of the road on which we drive, the utensils we use to eat, the graphical and textual symbols we use to organise public spaces—all seem the result of relatively arbitrary cultural choices. These customs could be different, and in different societies they are. But even if it is not clear whether or how physical constraints led to us driving on the left or right side of the road, for instance, it is clear how the physical consequences of deviation (e.g., car crashes) help to maintain the choice once made. Similarly, it may be that given one way of doing things, others evolve to fill leftover niches (e.g., knives may imply forks; c.f. Petroski, 1992). Finally, even such paragons of convention as symbol systems are shaped by the physical constraints on differentiation, recognisability, and legibility (e.g., WORDS in all capital letters are more difficult to read than words in a mixture of upper- and lower-case). In general, it seems possible to push an ecological approach further than might be obvious in dealing with such phenomena, even if a complete explanation may not be immediately forthcoming.

There is a parallel between the challenge offered by the ecological approach to traditional psychologists and the one I suggest it could offer traditional social theorists. The ecological approach to perception highlights the tendency for traditional psychologists to describe perceptual phenomena in terms of cognitive structures such as memory and problem-solving rather than seeking an explanation in the physical energies that surround us. From the ecological view, memory provides such a convenient explanatory principle for traditional accounts that it is usually invoked when the physical basis for perception is not immediately obvious. This may not reflect inadequate information for perception, however, but inadequate analyses of the environment to be perceived. Thus the ecological approach challenges researchers to avoid the temptation of using memory and inference in explanations of perception, and encourages them instead to discover the possibly high-level physical attributes that serve as information about the world.

In this article, I have raised an analogous situation in accounts of social behaviour. In these accounts, there is a tendency to invoke sociological and anthropological constructs such as “communities of practice” or “social convention” rather than recognising the degree to which social activities are embedded in and shaped by the material environment. I have suggested that, just as an ecological account sees the use of cognitive constructs such as memory and inference as signs of inadequate analyses of perceptual information, so might explanations that rely on social conventions be taken as signs of incomplete analyses of the environments in which interactions take place. In the end, this should challenge researchers to avoid the temptation of ascribing social behaviour to arbitrary customs and practices, and to focus instead on discovering the possibly complex environmental factors shaping social interaction.

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REFERENCES

Bly, S., Harrison, S. and Irwin, S. (1993). Media spaces: Bringing people together in a video, audio, and computing environment. *Communications of the ACM*, 36(1).

Brown, J. S., and Duguid, P. (1994). Borderline issues: Social and material aspects of design. *Human-Computer Interaction* (9) 1, 3 - 36.

Carroll, J. M, & Kellogg, W. A. (1989). Artifact as theory-nexus: Hermeneutics meets theory-based design. *Proceedings of the CHI'89 Conference on Computer and Human Interaction*. 1989 April; Austin, Texas. ACM, New York, 7-14.

Dourish, P., Adler, A., Bellotti, V. and Henderson, A. (1994). Your place or mine? Learning from long-term use of video communication. Working Paper, Rank Xerox Research Centre, Cambridge Laboratory.

Fish, R., Kraut, R., Root, R., and Rice, R. Evaluating video as a technology for informal communication. *Proceedings of CHI'92.* ACM, New York, 37 - 48.

Gaver, W. W. (1991). Technology affordances. *Proceedings of CHI'91* (New Orleans, April 28 - May 2, 1991). ACM, New York, 79 - 84.

Gaver, W. W. (1992). The affordances of media spaces for collaboration. *Proceedings of CSCW'92* (Toronto, 1 - 4 November, 1992). ACM, New York..

Gaver, W. W., Moran, T., MacLean, A., Lovstrand, L., Dourish, P., Carter, K., and Buxton, B. (1992). Realizing a video environment: EuroPARC's RAVE system. Proceedings of CHI'92 . (Monterey, CA).

Gaver, W., Smets, G., and Overbeeke, K. (1995). A virtual window on media space. Proceedings of CHI'95 (Denver, Colorado, May 7 - 11). NY: ACM.

Goldring, P. (1991). Early steps towards language: How social affordances educate attention. Proceedings of the Sixth International Conference on Perception and Action (Amsterdam, 25-30 August). International Society for Ecological Psychology: Amsterdam.

Hall, E. T. (1982). *The hidden dimension.* London: Anchor Books.

Heath, C., and Luff, P. (1991). Disembodied conduct: Communication through video in a multimedia office environment. Proceedings of CHI'91 (New Orleans, Louisiana, 28 April - 2 May, 1991), ACM, New York.

Gibson, J. J. (1979). *The ecological approach to visual perception.* Boston: Houghton Mifflin..

Overbeeke, C., Smets, G., and Stratmann, M. (1987). Depth on a flat screen II. *Perceptual & Motor Skills, 65*.

Petroski, H. (1992). *The evolution of useful things*. New York: Random House.

Smets, G., Overbeeke, C., and Blankendaal (1995, submitted). Movement induced visual perception and resolution for product design. Submitted to *Automatica.*

Smets, G., Overbeeke, C., and Stratmann, M. (1987). Depth on a flat screen. *Perceptual & Motor Skills 64,* 1023 - 1034.

Still, A. W., and Good, J. M. M. (1991). Beyond social affordances: The flow of information in social kinesthesis. Proceedings of the Sixth International Conference on Perception and Action (Amsterdam, 25-30 August). International Society for Ecological Psychology: Amsterdam.

Warren, W. H. (1982). Perceiving affordances: The visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance.*

Warren, W. H., & Whang, S. (1987). Visual guidance of walking through apertures: Body-scaled information for affordances. *Journal of Experimental Psychology.* 13 (3) 371-383.