The Design of Implicit Interactions

Making Interactive Objects Less Obnoxious

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Abstract

Implicit interactions represent an important research frontier in interaction design. Whereas traditional interaction design has focused on explicit interactions, where the use of computers and interactive products rely on explicit input and output, implicit interactions occur without the behest or awareness of the user.

This article outlines implicit interactions as an emerging area of applied design research and provides guidance to designers of interactive objects and systems. We provide a framework that characterizes interactions by attentional demand and initiative, and present a methodology for generalizing implicit interaction techniques through the development and use of interaction patterns and analogues.

Introduction

Imagine, for a second, a doorman that behaves as automatic doors do. He does not acknowledge you when you pass by or approach. He gives no hint which door can or will open—until you wander within 6 feet of the door, whereupon he flings the door wide. If you arrived after hours, you might stand in front of the doors for a while before you understood that the doors are locked, because the doorman's blank stare gives no clue.

If you met such a doorman, you might suspect psychosis. And yet this behavior is typical of our day-to-day interactions not only with automatic doors, but any number of interactive devices. Our cell phones ring loudly even though we are clearly in a movie theatre. Our alarm clocks forget to go off if we do not set them to, even if we've been getting up at the same time for years. Our computers interrupt presentations to let everyone know that a software update is available. These problematic interactions are symptoms of our as-yet lack of social sophistication in designing *implicit interactions*.

Implicit interactions represent an important research frontier in interaction design. Whereas traditional interaction design has focused on *explicit interactions*, where the use of computers and interactive products rely on explicit input and output, implicit interactions occur without the explicit behest or awareness of the user. Such interactions are employed when the user is focused on something other than trying to get an interactive device to do what they want, perhaps because the user is physically, socially or cognitively engaged, or because he or she is not cognizant of what direction the interaction should take.

The infiltration of computer technologies into everyday life has brought the need for implicit interaction techniques to a head. As Neil Gershenfeld observes, "There's a very real sense in which the things around us are infringing a new kind of right that has not needed protection until now. We're spending more and more time responding to the demands of machines."[1] It is clear that we cannot interact with computer devices in a car the way that we do with our desktop computer—but how should we interact with the device while we are driving? We all recognize that the computer need to be less needy of our attention when we are in a meeting, or on the phone, but how do we make these less-needy interfaces?

This article outlines an emerging area of applied design research[2] and provides guidance to early designers of implicit interactions. To this end, we provide a framework by which to better understand implicit interactions, and present a methodology for designing implicit interactions. Because different kinds of implicit interactions share commonality across different domains and scenarios, we posit that it is possible to generalize implicit interaction techniques through the development and use of interaction patterns and analogues.

Approach

Ironically, implicit interactions are challenging to design in large part because we humans are so adept at using them. We successfully employ them in our daily interactions with each other without conscious thought: We modulate our speaking volume based on ambient noise level, use smaller words when explaining things to children and hold the door open for others when we see that their arms are full. These accommodations help to manage attention, govern expectations, and decrease cognitive load. They do much to smooth our day-to-day interactions with one another, and yet, are made without explicit command. [3]

One goal in our approach to the design of implicit interactions is to leverage this know-how that humans have about interacting with one another—and to enable designers to share this knowledge with one another. Just as toolkits provide a common architecture and library for software developers working on similar classes of applications[4], we provide a common framework and methodology for designers to use in designing implicit interactions. By outlining a design method that is useful in creating a broad class of interactions, we seek to complement technology-based approaches (which focus, for instance, on sensors and architectures that enable implicit interaction), or analysis-based approaches (which would investigate implicit interaction through studies and controlled experiments) towards implicit interaction design.

Many researchers working in the areas of ubiquitous computing and pervasive computing are focused on how to solve these problems by making devices "smarter." But these approaches give short shrift to the richness of human interactions. They focus on being "logical" rather than "courteous." What if our true talent as human interactants is less a wealth of intelligence so much as a measure of suave?

A Framework for Characterizing Implicit Interactions

For the most part, interaction designers have come to rely on a variety of design principles and heuristics to design implicit interactions. Cooper and Reimann's About Face 2.0, for example, provides the following guidance for designing considerate software: "Considerate software takes an interest. Considerate software is deferential. Considerate software is forthcoming. Considerate software anticipates needs. Considerate software is conscientious. Considerate software doesn't burden you with its personal problems. Considerate software keeps you informed. Considerate software is perceptive. Considerate software is self-confident. Considerate software doesn't ask a lot of questions. Considerate software takes responsibility. Considerate software knows when to bend the rules."[5] This is not bad advice, but these guidelines do not actually instruct designers when an interactive object should take an interest, and when it should not ask a lot of questions. It is more useful to have a map characterizing interactions so that designers can more easily reason about what degree of implicitness or explicitness is desired in the situation they are designing, and how they might create the appropriate experience.

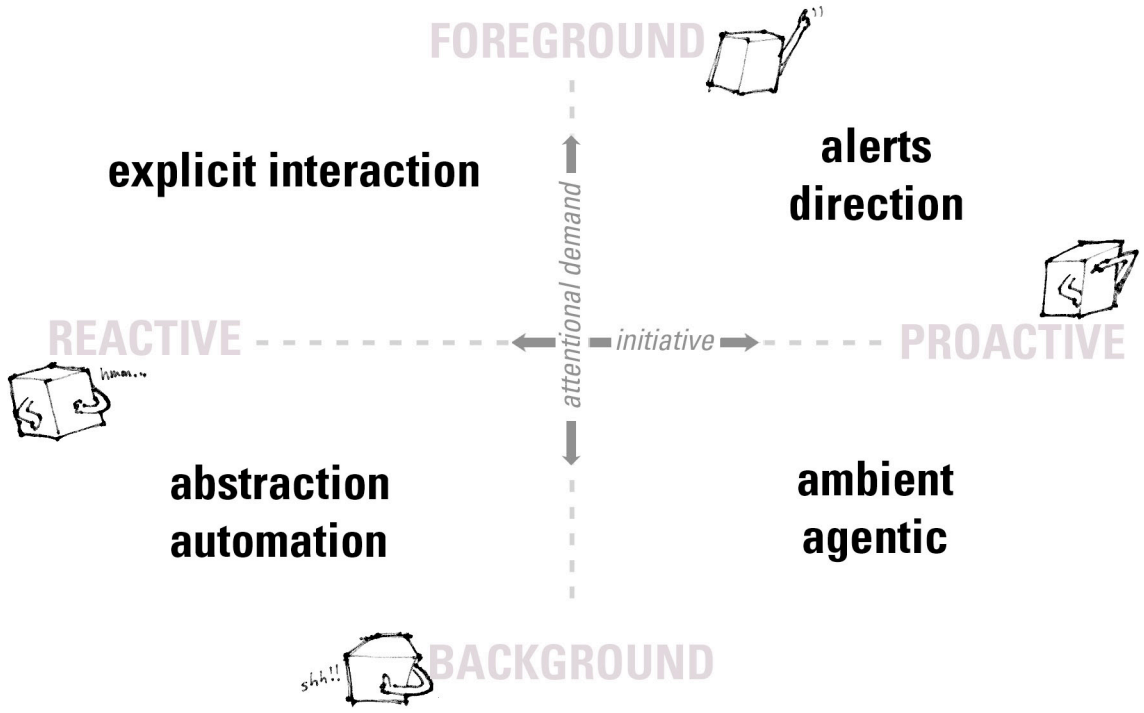
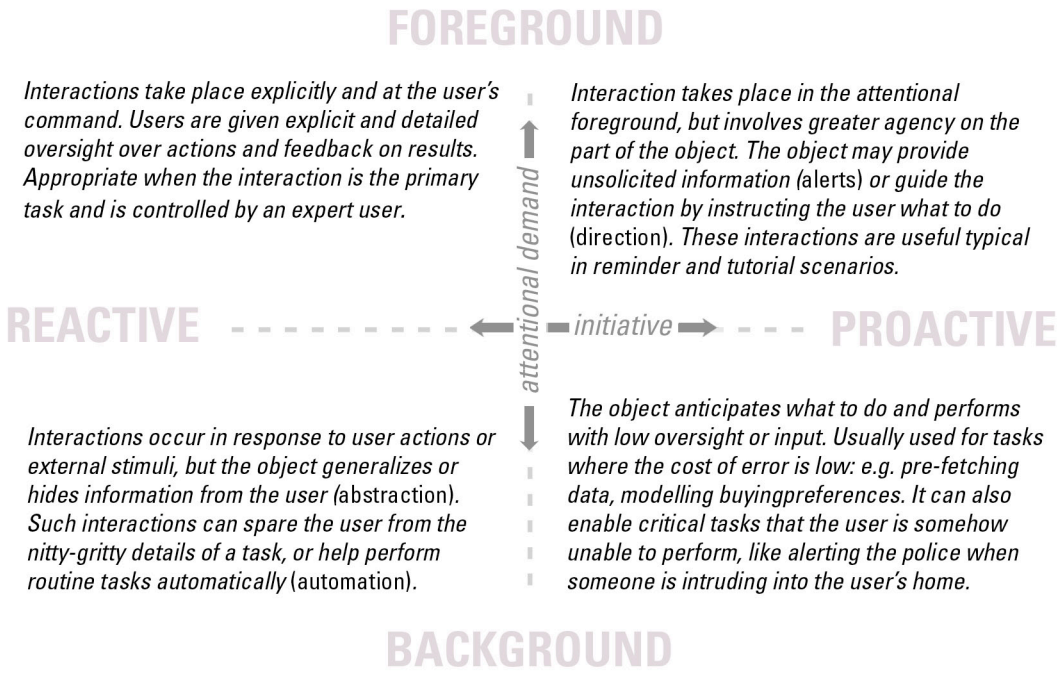


Figure 1. The Implicit Interaction Framework shows a range of interactive object behavior

Figure 1 shows an implicit interaction framework that characterizes different types of interactions based on two dimensions: attentional demand and initiative. By characterizing implicit interactions by the initiative shown by the actor and the attention demanded of the other interactant, we are able to generalize about the capabilities and features of whole classes of interactions in a domain-independent fashion.

It can be come confusing, in discussing the transactions between two actors, to determine whose attention and initiative we are speaking of in this framework. Therefore, let us define our interactions as occurring between object and user. In this case, the object may actually be a human, a computer, a door, or a voice on the phone. The object represents the thing whose actions we can design. As designers, we adopt the object's perspective on the interaction. The user is presumed to be the object's partner in interaction, who the designer has no direct control over. The user is usually a human, but could as easily be a dog, cat or any other autonomous being. When we speak of attentional demand in Figure 1, we actually mean the attention demanded by the object from the user. When we speak of initiative, we speak of actions or presumptions made by the object toward, about or around the user.

The following are descriptions of interactions typified by each quadrant. The intent is to characterize rather than to define categories:



The Framework, Applied

To better understand the range of implicit interactions, let us consider this example: Our friend Terry sends us a link to a funny animation that can be found online. To play the animation, we need a Macromedia® Flash plug-in installed on our computer. The following cases show different ways that the plug-in can come to be installed:

> **CASE 1**: We see that the animation does not work. We deduce that we need the plug-in. We find, download and install the plug-in.

This is a classic example of explicit interaction. This is far from a unilateral activity on our part, for the computer is involved throughout this process, but we are actively engaged in diagnosing, deciding and performing each step along the way.

> **CASE 2:** We see that the animation does not work. We deduce that we need the plug-in, and ask the web browser to find, download and install the plug-in.
> **CASE 3:** Our web browser shows that our animation does not work because we are missing a plug-in. We find, download and install the plug-in.

The second and third cases highlight the different ways interactions can be implicit. In case 2, we actively perform the task of problem observation and diagnosis, but the individual steps of getting the plug-in installed are abstracted away so we don't have to attend to each step. In case 3, the browser proactively identifies the problem and suggests a solution, although we have to go through the steps to implement it.

Case 2 is an example of *abstraction;* the plug-in installation occurs in the background, so that we don't have to actively and explicitly perform each step. Case 3 is an example of *alert*, where the interaction is implicit in that the system proactively diagnosed and informed me of the need for the plug-in. These cases illustrate how attentional demand and initiative affect the implicitness of the interaction.

> **CASE 4:** Our web browser shows us that our animation does not work and offers to find, download and install the plug-in. We accept the offer, and the plug-in is installed.
> **CASE 5:** Our web browser sees that we are trying to play an animation that we do not have the plug-in for, and lets us know that it is automatically finding, downloading and installing the plug-in.
> **CASE 6:** Our web browser sees that we are trying to play an animation that we do not have the plug-in for, and automatically finds, downloads and installs the plug-in as a background process.

These three cases show increasing degrees of proactivity and *presumption* on the part of the web browser, and decreasing degrees of attentional demand. In case 4, there is a fair amount of demand on our attention because we need to actively accept an offer. In cases 5 and 6, the plug-in is installed without any activity on our part, but the last case is more implicit because no feedback is offered. Although our actions in both cases are the same, the case 6 is more presumptuous because we do not have the opportunity to oversee and possibly cancel the task.

> **CASE 7:** Our web browser anticipated that we might want to play a Flash animation someday, and has already downloaded and installed the plug-in.

This last case is the most implicit interaction; in fact, with so much presumption and so little visibility, this last interaction may hardly be considered an interaction at all, since there is no activity or awareness on our part.

There is a range of ways to accomplish the task of installing the Flash plug-in with different degrees of attentional demand and proactivity. Which is the best? It depends a lot on the situation: How capable is the user of installing this plug-in? How much control does the user want over disk space or network bandwidth? How concerned is the user about security? Just how funny is this animation Terry sent, anyway? Most plug-ins employ a design like the one in case 4 because it provides a happy medium.

As this example shows, although we speak of "implicit interactions," it is more accurate to speak of interactions being more and less implicit. Within the course of a task, different aspects of the interaction—the diagnosis, the action, the feedback—may be more or less implicit. Even though this example reflects a human-computer interaction, the issues that we raised around the implicitness are reflective of the style of the transaction rather than the characteristics of the computer, and hence transcend human-computer interaction to interaction in general.

Now, let us examine the two dimensional variables in greater depth:

Attentional Demand

On face value, attentional demand is easy to understand. *Foreground interactions* require cognitive or perceptual "focalization, concentration and consciousness."[6] *Background interactions* do not make such demands, and in fact, elude notice.

Upon deeper scrutiny, the simplicity of the definition breaks down. We also need account for spatiality (as Goffman did in drawing a distinction between "frontstage" and "backstage" interactions), breadth (with many stimuli or just one), or intensity, among other things. This complexity occurs in large part because our understanding of attention itself is still fairly limited. Cognitive neuroscientists are coming to feel that what we call attention is actually a catch-all grouping of widely diverse mental functions and phenomena.[7] However, since a broad, commonsense understanding of attention allows us sufficiently to reason about and plan our interactions with other humans, it is reasonable to assume that it is operationally sufficient to design with.

Interaction designers commonly manipulate attentional demand by adjusting the perceptual prominence of objects. This may be done through visual organization techniques, such as contrast, hierarchy, and weight.[8] It may also be done through more dynamic means, such as pointing, or placing.[9] Interaction design research on the use of such techniques to present data calmly to users engaged in some other task has been pursued at the MIT Media Lab[10] and Berkeley's Group for User Interface Research,[11] among others.

Another way to affect the degree of attention demanded is through *abstraction*. With abstraction, atomic interactions are combined into a larger whole, so that the user is presented with less detail. Abstraction is related to *chunking*, wherein experts are able to comprehend complex situations (such as the state of a chessboard) with greater ease because they are able to parse the scene into familiar subcomponents.[12] Gestalt psychology has demonstrated that this process of chunking leads an "integrating of

awareness" where people are able to identify a whole (say, a particular person's face) without being able to identify the details that make up the whole.[13] Whereas abstraction implies an extrinsic manipulation of representation, the phenomenon of chunking is intrinsic to the user.

One final and often overlooked aspect of attentional demand is *expectation*. Since what people tend to notice most are discrepant objects and events, it is possible to demand attention by deviating from expectation, and to relinquish attention by conforming to *convention*. This introduces the problem of having to understand what the " prevailing standards of decorum"[14] are in any situation we are designing for. This also explains one of the most challenging aspects of introducing innovative objects that are meant to be "invisible"; they are new and unexpected, and so people tend to focus on them.

This discussion of attentional demand may resonate with those familiar with Bill Buxton's concept of attentional ground[15]: "What we mean by Foreground are activities which are in the fore of human consciousness - intentional activities. Speaking on the telephone, or typing into a computer are just two examples." Buxton's definition of foreground only overlaps with the left half of the implicit interaction framework; because he only considers the realm of user-initiated interactions—typing into a keyboard, or switching on a light—Buxton's definition conflates attention with intention. This definition is inadequate for describing device-initiated interactions—a cell phone ringing, or an automatic door opening. These interactions clearly take place in the foreground but are not at all intentional on the part of the user. Decoupling attention from intention gives us a separate dimension, initiative.

Initiative

The distinction of who initiates an interaction is important one in defining its implicitness. If a waiter refills your coffee because you ask him to, that is a *reactive* response to your explicit request. However, if the waiter refills your cup because he sees that it is empty, this interaction becomes implicit; even if the *proactive* act of pouring the coffee might be in your attentional foreground, the waiter is responding to a projected request for more coffee.

This range of initiative from reactivity to proactivity exists within a larger spectrum. On the one end is *direct manipulation*, where the object is a tool with the potential to be an extension of the user. On the other end is *autonomy* where the object acts on its own without input or intervention. Both extremes have been presented as ideal goal states; interestingly enough, neither are salient to this discussion. Autonomous objects are not pertinent to interaction design because there is no interaction to speak of. In direct manipulation, when the object is ready to hand, there exists a one-to-one mapping between what the user intends and the action that ensues. As Winograd and Flores observe, "You do not think 'How far should I turn the steering wheel to go around that curve?' In fact, you are not even aware (unless something intrudes) of using a steering wheel. Phenomenologically, you are driving down the road, not operating controls."[16] This type of ready-to-handness has steep requirements, however, as the user needs to be

fully engaged, often mentally and physically; it does not scale well beyond expert users, or to control of multiple objects or background tasks.

Initiative is salient in situations where actors are working together to accomplish a task. From the perspective of those championing direct manipulation or autonomy, joint action is suboptimal because it requires negotiation and coordination. However, it is far easier to think of successful examples of joint actions than terrific tools or perfectly autonomous objects. "Every day we engage in activities in which we have to coordinate with others to succeed," says Herb Clark. "Face to face, we have systematic, economical and robust techniques of arranging for joint activities."[17] One can even argue that we can experience readiness-to-hand in interaction with others; certainly we can contrast the ease and transparency with which we can buy a shirt at Macy's with the tortuous process of buying things in a foreign country with a different language and customs. In fact, it is possible to imagine optimal interactions at every point along the initiative continuum; the challenge is knowing what interaction is appropriate for the situation at hand.

The concept of initiative was introduced to interaction design by Eric Horvitz, who may have borrowed the variable from the realms of linguistics and explicit dialogue systems. Horvitz terms the interplays between proactive and reactive actions *mixed-initiative*: "In mixed-initiative interaction, both users and computers take turns in contributing to a project or an understanding."[18] Proactive objects operate in a realm of greater presumption, and so it is common that they need ways of seeing, discerning and reasoning about the world.[19] This explains why most forays into proactivity, such as the research performed at Microsoft Research, [20] University of Karlsruhe[21], and Georgia Tech[22], have been oriented on the technological issues of sensing, aggregating data, developing user and task models, and performing inference.

And yet the solution for proactivity cannot lie in technology alone. People, for all their vaunted intelligence, make inference mistakes all the time, and are usually forgiven. Why is it, then that interactive products such as the Microsoft Office Helper are so roundly criticized for guessing incorrectly what users are trying to do? It is probably because Clippy is untrained in the art of what Erving Goffman calls "facework", sometimes called social graces, *savoir-faire*, diplomacy or social skill.[23] When people go out on a limb, taking initiative in the face of uncertainty, they engage in compensating measures, hedging their actions with techniques such as overt subtlety (where actors make a show of how unobtrusive they are trying to be) or pre-emptive apology (where actors may bow their head, scrunch up their faces or raise their shoulders as they execute an action to indicate an apology if their initiative is unwelcome). One could easily imagine, for instance, that recent research on interruptions at Carnegie Mellon[24] and Microsoft Research,[25] which have focused primarily on *when* to interrupt could be complimented by research on *how* to interrupt. There are conventional ways to act proactively, even in the face of uncertainty, and these are a matter of sociable design rather than technological intelligence.

Implicit Interaction Design Methodology

Our design methodology for implicit interactions is for people to base the design of interactive objects on the habitual and standardized practice of day-to-day interactions.[26] To formalize the methodology, we present two important tools: first, the interaction pattern, which is a representation of standard interactions shared between participants, and second, the interaction analogue, which enables designers to borrow the techniques found in one interaction pattern to use in another.

Interaction Patterns

To understand the role of interaction patterns in implicit interaction design, it is first critical to appreciate the importance of convention to both dimensions of implicit interaction. Conventional statements and actions draw far less attention than do unconventional ones: The routine "How do you do?" is a lot less provocative than the semantically equivalent "What is the state of your general well-being?" Similarly, following convention when exerting initiative or accepting an initiated interaction is necessary to prevent interactional "break-down."

The patterns of day-to-day activity which we seek to represent have been studied before, by those in other disciplines. Sociologists, for instance, represent what Goffman calls the "strips of activity" as detailed narratives, setting the general context and describing specific behaviors.[27] Artificial intelligence researchers, such as Roger Schank and Robert Abelson, choose to use "scripts"—predetermined, stereotyped sequences of actions that define well-known situations. Hoping for something more detailed and prescriptive than the description offered by Goffman, and something more human-legible than the scripts created by Schank and Abelson, we have opted instead to use conventions from the realm of theatrical performance.

These interaction patterns differ from pattern languages used in interaction design. They share some common ground in that they aim to provide templates for solutions that designers can share with one another. However, design patterns suggest fairly high-level approaches to specific classes of design problems and are based on previous successful designs. Our interaction patterns provide detailed instructions for the oft-implicit communications between actors, and can be derived from observations in the world.

This section examines the key components of our interaction patterns—settings, roles, and sequences—in detail.

SETTINGS

The setting is the context in which in interaction will occur. The setting is important because it determine how we act, and how we interpret the actions of others. In addition to providing context, the setting is also an environment that may have structures or props intended to support the interactions that are expected there.

At a grocery store, for example, I put the groceries I wish to buy on the checkout counter, and keep the things I purchased before entering the store in my handbag; this draws attention to the items I wish to interact with the grocery clerk about, and draws attention

away from the items that might otherwise confuse the situation. The checkout counter has a line, and I know that I cannot engage in barter until I reach the front of the line; the physical structure of the counter helps to define who is the GROCERY CLERK, who is the PAYER, and who is a WAIT-ER.

As designers, we can create settings, defining the physical, visual or spatial environment in a fashion so as to disambiguate what is to be interpreted from presence, location or orientation. We give important actions prominence so that they are more easily perceived, and dim unimportant ones so they do not distract. We privilege certain locations with the ability to determine the roles of the actors. And of course, we provide ample room for the interaction to play out.

ROLES

In the previous example, the GROCERY CLERK, PAYER, and WAIT-ER are all roles. A role represents the relationship actors have in the interaction. As Goffman noted, "whenever an individual participates in an episode of activity, a distinction will be drawn between what is called the person, individual or player, namely, he who participates, and the particular role, capacity and function he makes during that participation."[28]

Sometimes, the roles have goals and states associated with them. For example, if we cast the roles in the grocery store example as CLERK and CUSTOMERS, then both CUSTOMERS would have the goal of obtaining goods, and the CLERK would have the goal of obtaining money. The CUSTOMER at the head of the line is in the state of Paying. The next CUSTOMER is in the state of Waiting.

Roles are often communicated implicitly, through behavior, location and dress. In human-computer interactions, the roles are so often COMPUTER and USER that we lose sight of the fact that in other contexts, roles need to be clearly communicated to help quickly and efficiently set up expectations about the nature of the interaction to come. Other examples of familiar role pairs are DRIVER/NAVIGATOR, and STUDENT/TEACHER. Roles need not be filled by agentic characters—a compass can be a navigator, and a vending machine can act as a server—but they do need to fulfill the tasks that are their raison d'etre.

SEQUENCE

The sequence is the order of events that occurs in the course of the interactions. For implicit interactions, it is important that the sequence be very detailed, capturing not only words but also gestures and looks of the actors

For a interaction sequence model, we borrow the pattern suggested by Henning Nelms for performing an illusion in *Magic and Showmanship: A Handbook for Conjurers:*[29]

1. Interest-catcher: This commands attention and directs it into the routine.
2. Introduction. Once attention has been gained, you must definitely establish the proper atmosphere and fix both your role and that of your audience.

3. Statement of Theme. The statement should be a summary in one or two sentences of ideas already explained in the introduction.
4. Kickoff point. There is always a point where the performer stops dealing in generalities and commits himself to some positive action.
5. Preliminaries. The apparatus is introduced, explained and rigged during this stage.
6. Instructions. Spare no effort to make them brief, clear and foolproof.
7. Action. This is the exhibition proper.
8. Effect. Ideally this should be short and come as a climax.
9. Ending. This covers the period form the end of the effect of the point where some completely new subject is introduced.

What is interesting about this sequence is that the trick at the heart of the illusion—the action—is sandwiched between many steps that a less conscientious magician might overlook. The early steps of the illusion serve to "ground" the interaction by garnering attention, defining roles, and establishing expectations for the action to come. The late steps help the performer to establish what the outcome was.

A full-length interaction sequence will often transition between]different quadrants of the implicit interaction framework. A cell phone might alert you to a call (foreground/proactive), which you then answer (foreground/reactive, a.k.a. explicit). When the call is done, you hang up (foreground/reactive) and the phone automatically logs the time, source and the duration of the call (background/reactive). Sequences through the space of the interaction framework constitute a major portion of the interaction pattern.

Example

Here is an example of the exchange between a doorman and a person presented as an interaction pattern. We have numbered each action to enable ease of comparison later on, and included stage notes to clarify the intent of the actions:

> SETTING: On a street sidewalk with a entrance to building in middle of the block
> ROLES: DOORMAN, PASSERBY
>
> (1) DOORMAN: [stands in front of door, wearing red uniform]
> (2) PASSERBY: [walks down street, in a path that will pass door]
> *These steps represent interest-catching and introduction. The red uniform of the DOORMAN and the motion of the* PASSERBY *both serve as interest catchers.*
> (3) DOORMAN: [spots person walking down street]
> (4) PASSERBY: [notices doorman with red refinery in front of door, keeps walking]
> *The doorman's location helps set the theme, as does the behavior of the PASSERBY, establishing ground.*
> (5) DOORMAN: [puts gloved hand on door handle]
> *This is the kickoff, and also acts as a preliminary, introducing the door.*
> (6) PASSERBY: [slows down a little, looks into doorway]
> (7) DOORMAN: [opens door slightly]

This is the main action. It is an offer framed as a demonstration.
(8) PASSERBY: [keeps walking past door, turns to look down street]
This is the effect, a refusal.
(9) DOORMAN: [lets door shut, takes hand away from door handle]

This interaction analogue provides a specific and detailed illustration of how an implicit interaction can be functionally modeled as a performance. In the implicit doorman example, the doorman employs proactive, low-attention techniques to signal his capability for opening doors. He did this both through *overt preparation*, when he put his gloved hand on the door handle, and through an *enactment technique*, pulling the door open a little as a suggestion. By classifying the actions of the doorman by their general form, we are able to change domains and look for actions which perform the same function in a similar manner.

Interaction Analogues

Convention is a major obstacle to designing new interactions with novel devices; there is no established convention for such objects, and so interaction designers tend to invent new ones from scratch and hope users will catch on. Our design methodology turns the problem of convention into an advantage. We've argued that the reason to use implicit interaction techniques is because people interact implicitly with one another everyday. If each interaction was spontaneous and original, it would be hopeless to speak of designing implicit interactions without Turing-complete artificial intelligence. However, because the interactions are conventional, and follow patterns that we can script, it is possible to borrow the underlying structure of existing implicit interactions to design new interactions that fulfill many of the interactional requirements of the new situation.

The implicit interaction framework provides a good way of identifying analogous interactions. Here is an example of an interaction sequence with an automatic door which is analogous to the interaction with the previously discussed doorman:

SETTING: On a street sidewalk with a entrance to building in middle of the block
ROLES: DOORMAN, PASSERBY

(1) DOORMAN: [stands in front of door, wearing red uniform]
(2) PASSERBY: [walks down street, in a path that will pass door]
(3) DOORMAN: [spots person walking down street]
(4) PASSERBY: [notices doorman with red refinery in front of door, keeps walking]
(5) DOORMAN: [puts gloved hand on door handle]

SETTING: On a street sidewalk with a entrance to building in middle of the block
ROLES: DOOR, PASSERBY

(1) DOOR: [exists, with sign that says "automatic door"]
(2) PASSERBY: [walks down street, in a path that will pass door]
(3) DOOR: [sensors notice motion down the street]
(4) PASSERBY: [notices door frame, keeps walking]
(5) DOOR: [makes a soft motor hum noise, as if preparing to open]
(6) PASSERBY: [slows down a little,

(6) PASSERBY: [slows down a little, looks into doorway]
(7) DOORMAN: [opens door slightly]
(8) PASSERBY: [keeps walking past door, turns to look down street]
(9) DOORMAN: [lets door shut, takes hand away from door handle]

looks into doorway]
(7) DOOR: [opens a little, jiggling its handle]
(8) PASSERBY: [keeps walking past door, turns to look down street]
(9) DOOR: [lets door shut]

This example actually shows two stages of analogic leap: from Nelms' instructions on the structure of illusions, to the behavior of doormen, and onto the designed behavior of an automatic door. An interaction designer designing an automatic door can use Nelms' suggestions to magicians to consider how the door draws attention to itself, how it communicates its role as a portal, how it introduces its affordance. Such steps can sometimes be accomplished implicitly; the door's mere physical form serves to draw attention and communicate its door-ness. The designer can also look for clever ways to achieve the effects of each step: by opening a little when a person walks by, for example, the automatic door can simultaneously draw attention, define its role as a door and introduces its ability to open automatically. The interaction analogues allow the designer of the automatic door to consider how to accomplish the same tasks as the doorman, softly humming in overt preparation or jiggling its handle as enactment, without slavishly replicating his actions with a doorman robot.

ISSUES FOR IMPLICIT INTERACTIONS

Problem selection vs. problem representation

At this point, it seems logical to revisit the question, what types of design problems are implicit interaction problems? We introduced implicit interactions by stating that they may be employed when the user is focused on something other than trying to get an interactive device to do what they want, perhaps because the user is physically, socially or cognitively engaged, or because he or she is not cognizant of what direction that the interaction should take. These are instances where the design requires some degree of agency on the part of the interactive object.

That said, whether a design requires agency is a matter of the designer's point of view. A car, for example, may be said to be driven through the direct manipulation of the steering wheel, gas, brake and clutch pedals. However, one can also view the interaction between car and driver as a series of sometimes overlapping transactions—that the driver requests greater speed by pressing on the gas pedal, or a change in direction by turning the steering wheel. This second view grows more apt as steer-by-wire technology for automobile operation becomes prevalent. Using the second perspective, the designer is able to break away from one-to-one mappings between the driver's inputs and mechanical action, and attempt to make good on the perceived intent of the driver, pulsing the brakes when the driver slams on the brake pedal, or braking one wheel and revving the other when the driver makes a sudden, hard turn of the steering wheel. It may be senseless, from a design standpoint, to speak of which view is right or wrong but it is

evident that adoption of different points of view suggests very different types of solutions.[30]

For this reason, it is useful to view the implicit interaction framework less as a hammer, and more as a lens. From the design research perspective, the implicit interaction framework is a type of problem representation, a means of representing interaction problems so as to make the solution apparent.[31] The central goal of this paper is not to advocate the design of a class of interactive products ("Make implicit interactions!"), but rather, to champion particular approach to designing interactions ("Consider your design as an implicit interaction!"). As Tom Erickson suggests, "There are multiple perspectives from which interaction designers can analyze the sites or situations with which they are confronted, and that designers will fare best when they are able to pick up one lens, then another, and then a third."[32] It is up to the designer to employ the framework and methodology in a mindful manner.

Interdisciplinarity & Appropriation

Part of the challenge of implicit interaction design is making explicit that which is invisible in day-to-day life. One way to do this is for interaction designers to employ sociological methods to understand human-human interactions, and translate those interactions to novel human-product interactions. The application of sociology to human-product interactions is nothing new. Bruno Latour, for instance, enjoyed anthropomorphizing doorsprings to argue that sociologists need to address the role of nonhumans in their accounts of society:

> "For sure, springs do the job of replacing grooms, but they play the role of a very rude, uneducated, and dumb porter who obviously prefers the wall version of the door to its hole version. They simply slam the door shut."[33]

In this paper, we have reversed Latour's approach, objectifying the role of human actors to make products that are less obnoxious, making doors that act not as wall or hole, but as a courteous groom. Designers have broadly employed ethnographically informed practices for decades to inform the user needs or context of the design; this work simply extends the use of ethnography to the generation of positive models for product behavior. We also drew on methods from communications, psychology or linguistics. For instance, this approach can also be seen as the interactive extension of Reeves and Nass' Media Equation: we expect people to interact most successfully with interactive products in the same manner they interact with other people.[34]

As these techniques are appropriated for design, they are necessarily transformed: the value structures behind the social science methods we use cannot but change when the intended outcome shifts from production of knowledge or performance to production of new interactive systems.[35] We are not claiming that this work is the same as, or a substitute for, the practice of social science by social scientists or the practice of art by artists within these same domains. At the same time, it is important to recognize that designers *need* to appropriate these techniques and make them their own in order to meet their aims. For instance, in his discussion on studying doormen in New York City,

sociologist Peter Bearman notes that "For the founding fathers of sociology, […] the city posed special problems for the generation of social order. In contrast to the thick, multivalent and sustained interactive world of the country, urban interactions were seen as thin, episodic, instrumental and univalent."[36] (Bearman goes on to argue that urban environments are in fact as rich and thick as any other environment.) For designers of interactive systems, however, the desire may very well be to study thin, episodic, instrumental and univalent interactions, because the very lack of rich humanity that makes these uninteresting transactions for social scientists makes them the most promising targets for interactive design. Thus, the use of interdisciplinary techniques by designers can offer something original to the world of interaction design.

Conclusion

As interactive devices continue to permeate their way into our world, it is up to the interaction designers to correct their obnoxious habits, to make them more usable and useful. Designed well, implicitly interactive devices can allow us to reap the benefits of computation and communication away from the desktop, assisting us when we are physically, socially or cognitively engaged, or when we ourselves do not know what should happen next. Designed poorly, these same devices can wreck havoc on our productivity and performance, creating irritation and frustration in their wake. By taking stock of what it is we humans do when we work with one another, and using a bit of creativity in applying those lessons to the machine world, we can help make this next generation of interactive devices welcome in our world.

Perhaps the most exciting consequence of this is that it brings design research into the realm of designing behaviors for interactive objects. Implicit interactions have convergent features due to the constraints imposed by the human in the loop. By relating interactions in disparate domains by their attentional demand and initiative, designers can perform analogical transforms to enable them to reason intuitively about the problem, or to borrow solutions from other domains. This transmissibility of solutions from one domain to another also enables design solutions to be passed from one designer to another, enabling designers of interactive objects to develop generalized interaction patterns for different classes of interactions.

It is our hope that the approach presented here enables other interaction designers to effectively convert their own intuition about appropriate social behavior through analogical leap to the design of implicit interactions. In addition, we expect that this will bring newfound excitement to the social sciences which are focused on understanding the nature of human convention. The wealth of literature on these topics provide a valuable resource for interaction designers looking to design socially savvy interactive devices.

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