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The Design of Implicit Interactions

Wendy Ju

Synthesis Lectures on Human-Centered Informatics

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The Design of Implicit Interactions

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ABSTRACT

People rely on implicit interaction in their everyday interactions with one another to exchange queries, offers, responses, and feedback without explicit communication. A look with the eyes, a wave of the hand, the lift of the door handle—small moves can do a lot to enable joint action with elegance and economy. This work puts forward a theory that these implicit patterns of interaction with one another drive our expectations of how we should interact with devices. I introduce the Implicit Interaction Framework as a tool to map out interaction trajectories, and we use these trajectories to better understand the interactions transpiring around us. By analyzing everyday implicit interactions for patterns and tactics, designers of interactive devices can better understand how to design interactions that work or to remedy interactions that fail.

This book looks at the "smart," "automatic," and "interactive" devices that increasingly permeate our everyday lives—doors, switches, whiteboards—and provides a close reading of how we interact with them. These vignettes add to the growing body of research targeted at teasing out the factors at play in our interactions. I take a look at current research, which indicates that our reactions to interactions are social, even if the entities we are interacting with are not human. These research insights are applied to allow us to refine and improve interactive devices so that they work better in the context of our day-to-day lives. Finally this book looks to the future, and outlines considerations that need to be taken into account in prototyping and validating devices that employ implicit interaction.

KEYWORDS

machine, communication, technology, computers, interface, automation

Contents

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I wish to thank my family, particularly my parents, my husband Justin Olson, and sons Case Olson and Simon Olson for their support throughout this project.

CHAPTER 1

Introduction

Imagine, for a second, a doorman that behaves like an automatic door does. 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 six feet of the door, whereupon he flings the door wide. If you arrive after hours, you might stand in front of the doors for a while before you understand 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 continue to ring even when we are obviously trying to stifle them. Our smartphone alarm clocks go off in the morning even if we are already awake, staring right at the screen and poking at the device. Our computers only know to ring every so many minutes before an important meeting, jerking us in and out of distraction rather than easing us out of our task and toward our next activity. The infiltration of computer technologies into everyday life has brought these interaction crises to a head, to the point that many feel it is necessary to take a digital Sabbath.

Everyday Interactives, Pervasive and Mundane

While the lion's share of attention around interaction design is given to new devices and platforms that introduce new interaction paradigms—computers, webpages, smart phones, tablets—more mundane interactive devices surround us as well in our everyday lives: vending machines, ticket turnstiles at a train station, information kiosks at a museum, GPS-enabled navigation systems, auto-flush toilets, motion-triggered room-lights, and automatic automobile door locks. More and more passive mechanical devices are making a significant transition to become electronic and computationally enhanced digital machines. Our cars and coffee machines are acquiring screens and buttons where they once had dials and knobs, embedded chips and sensors where they once had springs and gears. In this transition, there are novel possibilities for old genres of devices, but there are also new snags for their users.

While we might be willing to dedicate a lot of time to the newest and whizziest gadgets we have acquired, the demand for our attention will not scale if explicit intearction is required by every new computer-enabled device. As we design interactions for multitudes of devices distributed throughout our world, we need an approach for interaction that is different than the one used for traditional computer user interfaces. Many in the research world believe that it is possible for us to make smart machines that are context-aware and autonomous, so that they won't need the input

of the user at all. Implicit interactions represent another view: they suggest that people are critical to interactions, but that the engagements can be designed to be far less jarring or disruptive than what we experience now.

Interactions Require Social Savvy

It is for these everyday devices and in-the-world contexts that an understanding of the rules that govern human interaction is really critical. Many have suggested that more sophisticated artificial intelligence or elaborate networks of sensors may be the solution to the problem of obnoxious and overbearing machines. However, this book considers another complementary perspective: that sensing and computation need to be augmented with an understanding of the unstated expectations we people have from our interactive counterparts. We have protocols that govern when and how we engage one another, when and how we transact, when and how we take leave, how much attention is demanded, and how much attention is given. Our lack of sophistication in designing interactive devices that do not constantly demand input or attention can be remedied through increased awareness and understanding of the implicit protocols that govern our everyday interactions with one another.

This foray into implicit interactions represents a major departure from traditional human-interaction design. Traditional human-computer interactions and human-machine interactions have focused on the realm of explicit interactions, where the use of computers and interactive products rely on the overt input and output common in command-based or graphical user interface-based interfaces. In these interfaces, the agency lies wholly with the user or machine: You use a mouse to select the file you'd like to open. You order a robot to fetch you a drink. The alarm clock tells you to wake. The GPS tells you where to go. In implicit interactions, agency and initiative are less clearly assigned. Implicit interactions are based on inputs and outputs that are negotiated and jointly performed—perhaps the computer desktop makes some file icons slightly larger and easier to click on based on what else you're working on; perhaps a robot offers you a drink because it thinks you look thirsty. No party is clearly in charge; actions do not equate to agency if they take place in the context of implied demands or offers. These types of implicit interactions are an inevitable part of what some call "smart" products, products whose actions contain some degree of agency or of activity that occurs without the explicit behest or awareness of the user.

These interactions are becoming more prevalent as interactive technologies begin to be applied to situations where people are not able to exercise full agency and control—when users are novices, or in arenas such as the automobile, the meeting room, or the home, where the person is physically, socially, or cognitively engaged.

Developing Intuitions for New Interactions

In some ways, designers of interactive devices are in new territory, and cannot know what to expect from users. In other ways, though, the answers lie within us. We humans have an abundance of experience employing implicit interactions in our day-to-day interactions with one another. Over the course of their lives, people learn behavioral patterns and codes that enable them to negotiate their interactions with one another. We often employ them 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 do much to smooth our day-to-day interactions with one another and yet are made without explicit command. The success of these interactions relies less on extraordinary intelligence and more on sophisticated negotiation of changing contexts and subsequent behaviors.

1.1 BACKGROUND

In my years working at the intersection of research and design on interactive devices ranging from kitchen counters that guide people to cook to chairs that rearrange themselves when guests come over, I've often been struck by how the difference between the right interaction and the wrong one was often subtle and difficult to talk about. The more complex the devices, the more difficult the problem. Today, devices are designed by interdisciplinary teams who often do not speak the same professional language or follow a common practice. Debating, sketching, and discussing designs has grown more challenging as interaction design grows as a field because interaction designers do not have established norms or tools for conversing about interaction. It does not help that the most successful interactions are often somewhat invisible, as we cannot attribute functionality to mechanisms we do not discern.

1.2 THE THEORY OF IMPLICIT INTERACTIONS

The Implicit Interaction Framework supports *The Theory of Implicit Interactions*, which posits that people rely on *conventions of interaction* to communicate queries, offers, responses, and feedback to one another. These everyday implicit interaction patterns with one another drive our expectations of interactive device behavior. Thus, designers can learn to make better interactive devices by honing their ability to recognize and dissect day-to-day interactions to understand how they work. By understanding how people cue attention, indicate potential for action, signal agreement or refusal, interaction designers can develop an intuition for successful interaction patterns. This will help designers to create more effective and comprehensible products and services.

1.2.1 POINT OF VIEW

This book is written from a juxtaposition of design and research perspectives. It has two goals. The first is to help researchers to analyze interactions, discern patterns, and characterize user responses. At the same time, this book is intended to empower designers working on designing implicit interactions, specifically to give them a stronger intuition to draw upon as they design products and services that have an interactive or behavior component to them.

1.3 BOOK OVERVIEW

In this book, I outline the Implicit Interaction Framework as a tool, which maps the trajectories of interactions by looking at the interplay of initiative and the dynamics of attentional demand over the course of simple transactions. By mapping these activities and patterns on this framework, we designers are better able to analyze the pragmatics of interactions, to understand specific interactive practices at play, to communicate and share their intuitions with clients and collaborators, and to develop successful interaction analogs. Chapter 2 explores the Implicit Interaction Framework in detail, looking at how the framework interaction essentializes interactions to make it easier to apply the method of designing through interaction analogues. In Chapter 3, we closely examine interactions with doormen and automatic doors, to understand in detail how interactions are initiated, the elaborate dance and negotiation that precedes every engagement. Chapter 4 looks at the transition from automation to interaction through the example of light-switching. In Chapter 5, we look at an example of how implicit interactions perform in contexts where people and interactive devices are working together to get somewhere by looking at interactions with vehicles. Finally, in Chapter 6, we revisit the question of how to design and evaluate interactions with the implicit interaction perspective in mind. This design-based approach has two main objectives: to be generative—that is, to guide designers in a constructive fashion in designing implicit interactions—and to be generalizable—that is, to suggest techniques and methods that are applicable to interaction designers working on a wide array of ubiquitous computing scenarios.

This book is written for designers and researchers of interactive systems. It does not assume a lot of technical knowledge about how such systems are operationalized on a technological level. Instead, I focus on aspects of timing, behavior, attention, and initiative that everyday people should understand. That said, because it is written for designers and researchers, the perspective taken throughout this work is that of the designer. When I speak of "users" or "people," I do not mean ourselves, but rather the other people who will be interacting with the devices we create.

By shining a light on implicit interactions, my intent is to help designers notice these implicit communicative activities taking place in their everyday life, to illuminate key interaction techniques and patterns using the Implicit Interaction Framework, and to illustrate how these techniques and patterns can be used by designers to develop novel ways of engaging people with interactive devices.

By using a framework, the design process can be more systematic and less ad-hoc; designers still have important work to do, they will just be able to mine known territory instead of having to dig around in the dark. It is my hope that, when these social mechanisms that help us engage with one another in everyday life are made clearer, we can come to expect elegance and economy in our day-to-day interactions with machines.

CHAPTER 2

The Theory and Framework for Implicit Interaction

To help us better understand and design implicit interactions, I introduce the *Implicit Interaction Framework*. This framework helps us to understand the dynamics of interactions as they unfold, and to identify common patterns in interactions that can assist us when we are analyzing interactive activity or designing novel interactions. It is meant to be used in the translation between observations of human-human interactions and the design of human-device interactions.

This framework is premised on a theory that implicit interactions function through regular patterns of communication; hence, it hypothesizes that interactions designed in accordance with these patterns will be recognizable and effective. Lucy Suchman posited, in fact, that human-computer communication was a special case of human communication in which the resources available to the participants is limited (Suchman, 1987). Following Brenda Laurel's metaphor of "the computer as theatre" (Laurel, 1993), we speak of the person and the interactive systems as being actors on the stage of our framework. The interactions are communications, but they are also performances that we are watching, directing, scripting (Field, 1994), and evaluating.

2.1 ACTORS IN THE FRAMEWORK

This framework models interactions as the exchange between two entities. One of the key premises in this work is that people engage interactive objects or media *socially*, as if they were other people, even if there is no mistaking the object for a person (Reeves and Nass, 1996). In the diagrams in this chapter, we assume one entity is a person and the other is an interactive object. The interactive object is commonly a computer, robot, or interactive device, but it could also be something larger or more systemic (like the voice interface for the computer on the Starship Enterprise in *Star Trek*.) The framework provides a useful basis for understanding elementary interactions between two interactants. In everyday practice, interactions can be far more complex, involving more people or objects that work in concert or in an uncoordinated fashion.

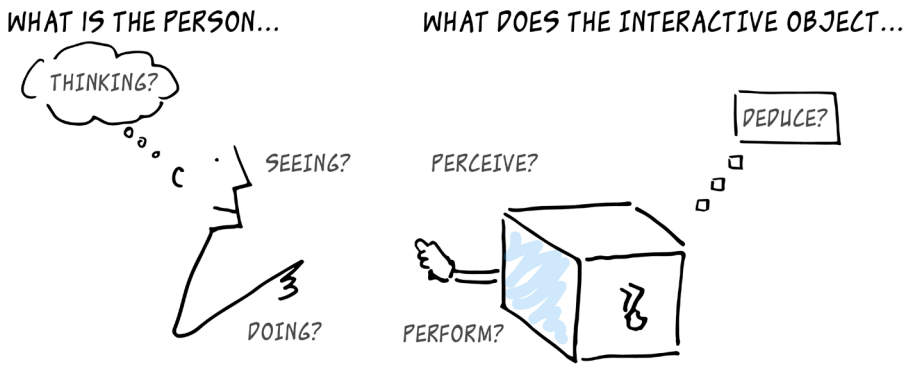

Figure 2.1: We are interested in the interplay between what people see, think, and do in an interaction, and what objects perceive, deduce, and perform.

Bill Verplank says, "Interaction Designers answer three qustions: How do you do? How do you feel? How do you know?" (Verplank, 2003) As designers of interactive systems, we also need to think about what the interactive object can perceive, deduce, and what actions it can perform. More importantly, we need to understand how what one entity sees, does, and deduces affects the other.

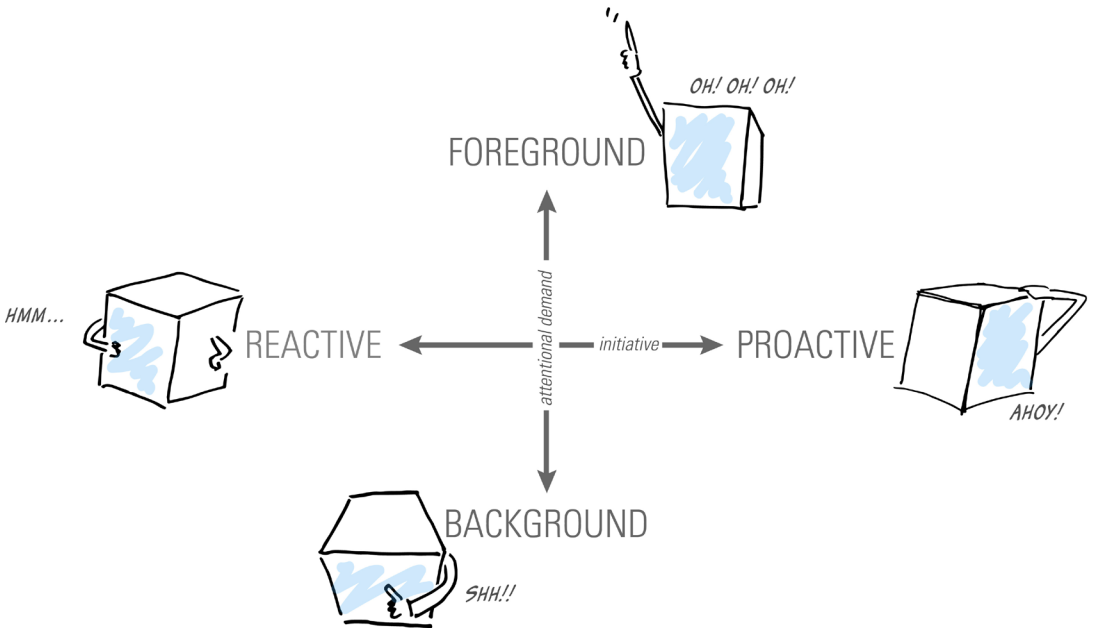

Figure 2.2: The Implicit Interaction Framework shows the dimensions of interactive system behavior.

2.2 IMPLICIT INTERACTION FRAMEWORK

The Implicit Interaction Framework (Figure 2.2) divides the space of possible interactions between our two actors along the axes of attentional demand and initiative. Attentional demand is the attention demanded of the user by the computer system. It is generally described by the degree of cognitive or perceptual *focus*, *concentration*, and *consciousness* required of the user. Interactions that demand the user's attention are *foreground interactions,* and interactions that evade the user's attention, and in fact, may elude notice, are *background interactions*.

Initiative encompasses who initiates an interaction and to what degree. The framework presumes the perspective of interactive system designers, so interactions initiated by the user are *reactive interactions,* and interactions initiated by the system are *proactive interactions*. By characterizing interactions in this way, we are able to generalize about the capabilities and features of whole classes of interactions in a domain-independent fashion.

Early on in human-computer interactions, researchers associated attentional demand and initiative with one another. Bill Buxton, for instance, defined attentional ground this way: "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. By Background, we mean tasks that take place in the periphery—'behind' those in the foreground. Examples would include being aware of someone in the next office typing, or the light in your kitchen going on automatically when you enter it, as opposed to you manually flicking the switch" (Buxton, 1995).

What the Implicit Interaction Framework helps to illustrate is that attention and initiative do not always go hand-in-hand. Buxton's examples contrast deliberate user-initiated interactions—typing into a keyboard or switching on a light—to device-initiated interactions that users scarcely notice. However, device-initiated interactions can demand attention—a cell phone ringing, for example, gets a person's attention even though the device initiates the interaction. Also, user-initiated interactions can occur in the attentional background—for example, if the lights go out when I leave a room.

2.2.1 ATTENTIONAL DEMAND

Attentional demand can be manipulated by adjusting the perceptual prominence of objects. This may be done through visual organization techniques, such as contrast, hierarchy, and weight (Lupton, 2004), as well as more dynamic means, such as pointing or placing (Clark, 2003). This type of visual display formatting has been most notably used to improve situation awareness in airplane cockpits (Andre et al., 1991). Interaction design research on the use of such techniques to present ambient information to users engaged in some other task has been pursued at the MIT Media Lab (Wisneski et al., 1998) and Berkeley's Group for User Interface Research (Matthews et al., 2004)

among others. Saskia Bakker has pointed out that tangible and handheld objects in particular can enable peripheral interactions that do not require major attentional effort (Bakker, 2010).

Another way to affect the degree of attention demanded is through *abstraction*. By combining elements into a larger whole, the user is presented with less detail. *Chunking* is an example of an abstraction technique 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 (Chase and Simon, 1973). Gestalt laws suggest that chunking leads to 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 (Polanyi, 1967).

2.2.2 INITIATIVE

Initiative is salient in situations where actors work together to accomplish a task. "Every day we engage in activities in which we have to coordinate with others to succeed," says Clark. "Face to face, we have systematic, economical and robust techniques of arranging for joint activities" (Clark, 1996). The distinction of who initiates an interaction is a critical one in human-human communication.

Device-initiated interactions (where the device does more than merely react to a user's immediate command) have existed for quite some time—alarm clocks, for example, or tutorial systems. However, the range of device-initiated interaction has grown a great deal with the advent of inexpensive computation, sensing, and networking technology. Thus, the factor of initiative is becoming increasingly important as more and more interactive devices are able to perform autonomous action. Autonomous action enables devices to take action without engaging a user's explicit attention.

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 (Tennenhouse, 2000). This explains why most forays into proactivity, such as the research performed at Microsoft Research (Czerwinski et al., 2000), University of Karlsruhe (Schmidt, 2000), and Georgia Tech (Salber et al., 1999), have been oriented to the technological issues of sensing, aggregating data, developing user and task models, and performing inference (Pantic and Patras, 2006). The importance of both attention and initiative in human-machine communication have been recurring themes in the research of Eric Horvitz (Horvitz, 1999; Horvitz et al., 2003), but interestingly his work does not look at these factors together as a way to map interaction.

2.3 INTERACTION PARADIGMS

Figure 2.3 shows the Implicit Interaction Framework, with descriptions of interactions typified by each quadrant.

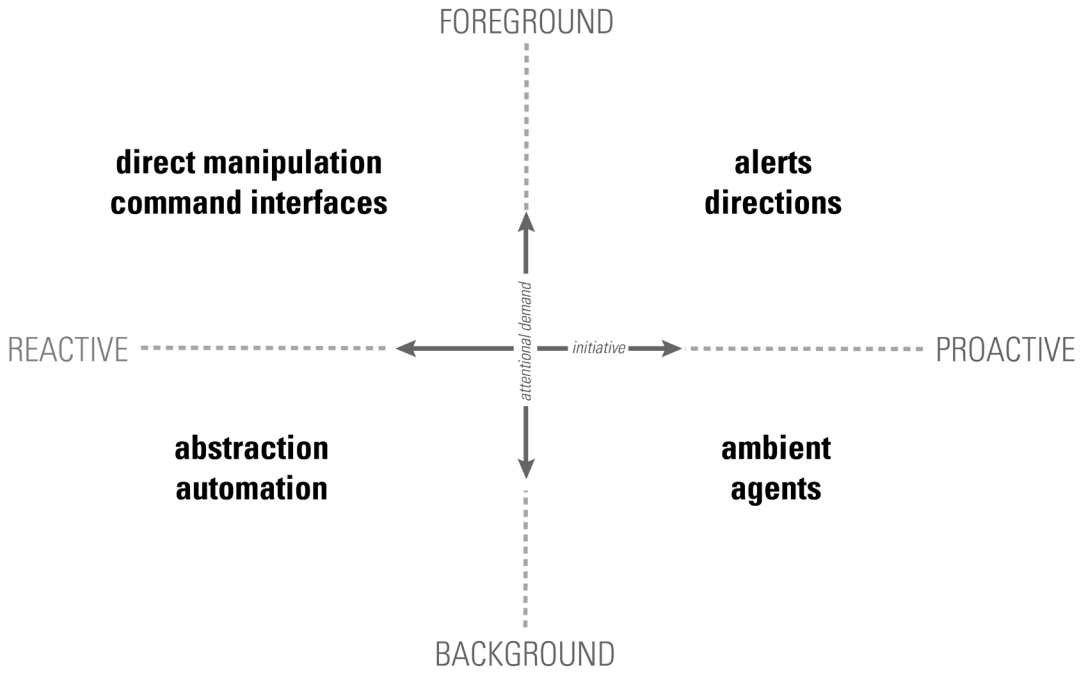

Figure 2.3: Characteristic interactions for each quadrant of the Implicit Interaction Framework.

2.3.1 FOREGROUND REACTIVE

Interaction paradigms tend to belong primarily in one quadrant or another of the Implicit Interaction Framework. For example, "direct manipulation," which is what we call the interaction paradigm associated with windows, icons, mouse and pointers, typically takes place in a person's attentional foreground, and the computer reacts and responds to control maneuvers made by the person on the computer desktop. The previously dominant "command-line" paradigm was similarly foreground-reactive.

2.3.2 FOREGROUND PROACTIVE

Interactions that alert people about things they don't know about, or which guide people through an interaction are foreground-proactive. That is to say, these are interactions where the device takes initiative in the interaction. This is common with clocks, timers, and alarms, and also is used in direction-based applications, such as automotive navigation or online tutorial interactions.

The same device might incorporate modes that lie in all four quadrants. Take, for example, digital video recorders, such as the genre-creating TIVO. DVRs can act much as a videocassette re-

corder does, recording shows when you command (foreground reactive), or recording shows you've pre-programmed (background reactive). In addition, the device can suggest shows it thinks you might want to watch (foreground proactive) or even pre-record shows it is pretty sure you want to watch (background proactive).

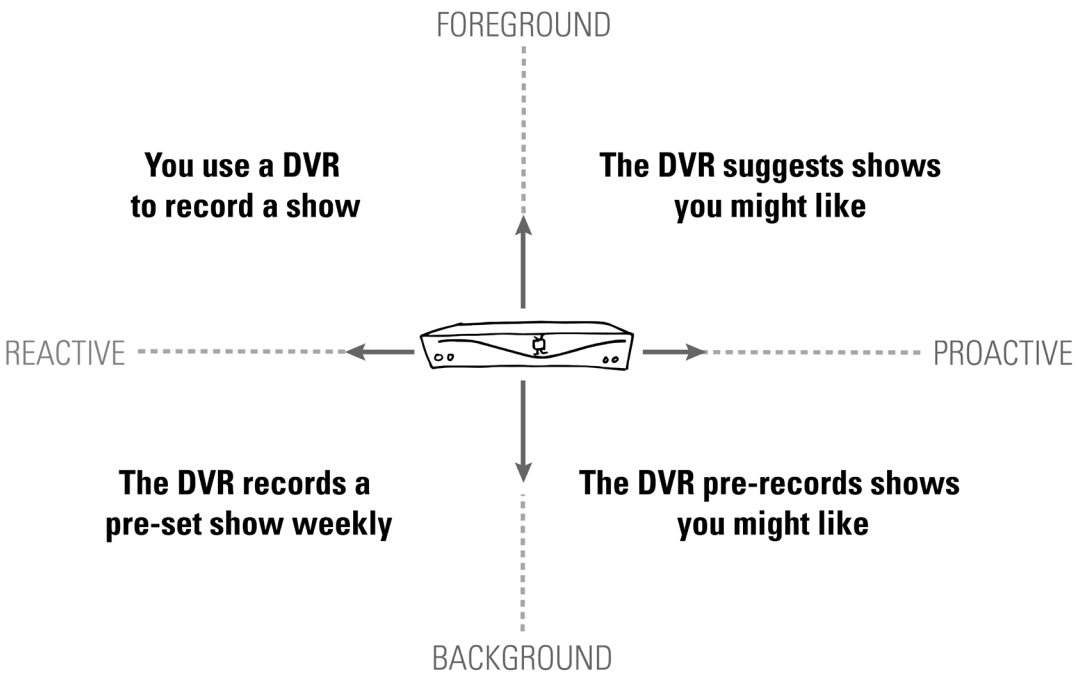

Figure 2.4: The DVR's different record functions on the Implicit Interaction Framework.

2.4 INTERACTION TRAJECTORIES

Although it is useful to characterize basic interactions paradigms based on attention demanded and initiative, the most useful aspect of the Implicit Interaction Framework is its ability to map the dynamic changes in attentional demand and initiative that take place throughout an interaction. For example, let us consider how a snooze alarm works.

The alarm is initially set through some foreground-reactive task where the user picks a time in the future that the alarm will go off.

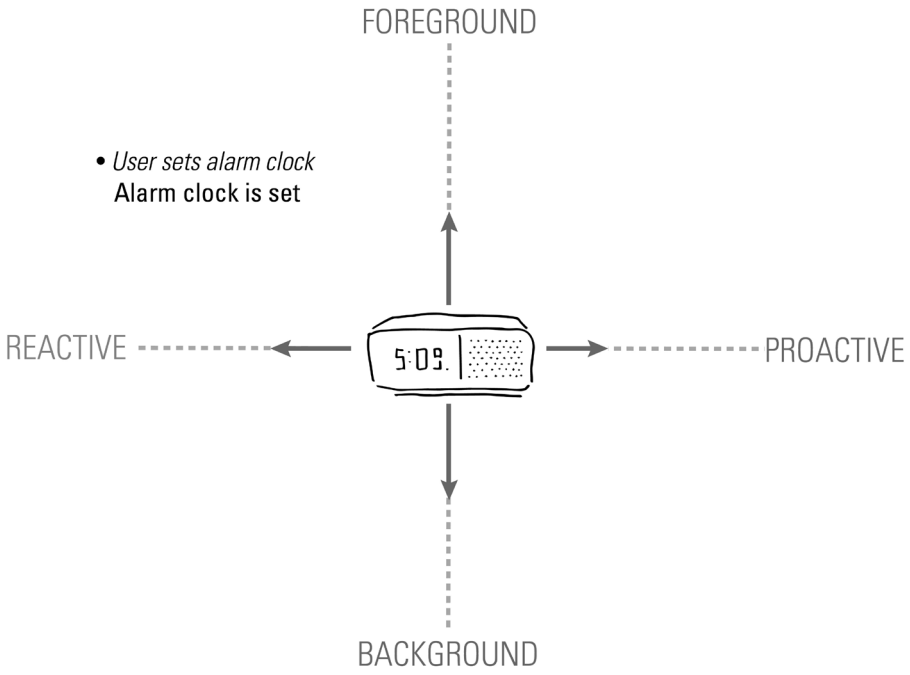

Figure 2.5: User setting alarm clock is a foreground reactive task.

For situations where the alarm is recurring, it is a good idea for the alarm clock to show some indicator that an alarm is set as feedback, both to avoid the user forgetting that an alarm is set, and to more clearly indicate when an alarm is not set. Presumably because users know when they've just set the alarm, the alarm set displays are always pretty subtle.

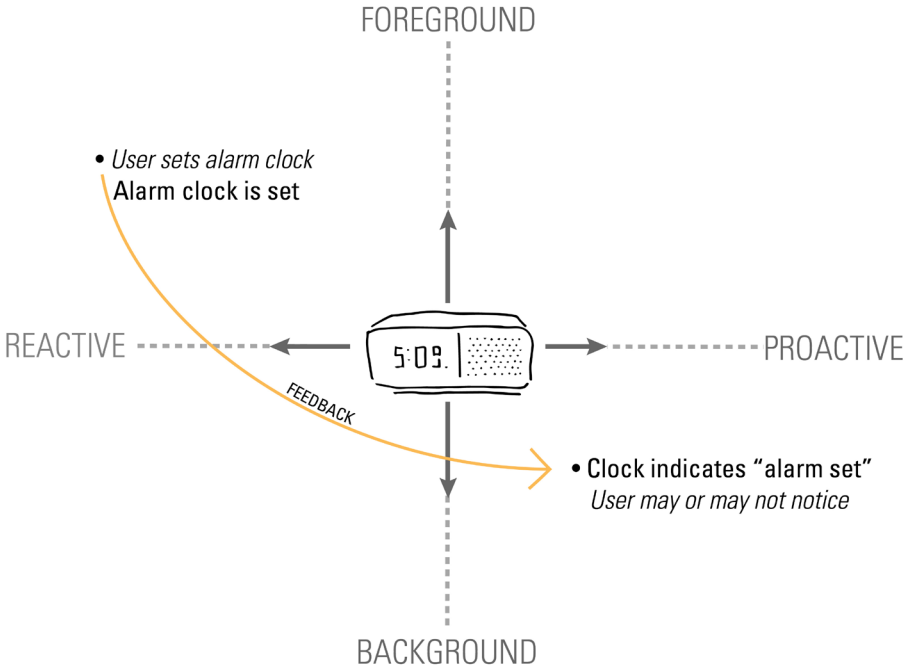

Figure 2.6: Next step: the clock may indicate whether the alarm is set or not.

Alarms, like all alerts, are proactive—if the intended audience for the alarm were aware enough to initiate an alarm, then the alarm would not be required. When the set time arrives, the alarm goes from proactive-background to proactive-foreground to get the user's attention and wake them up!

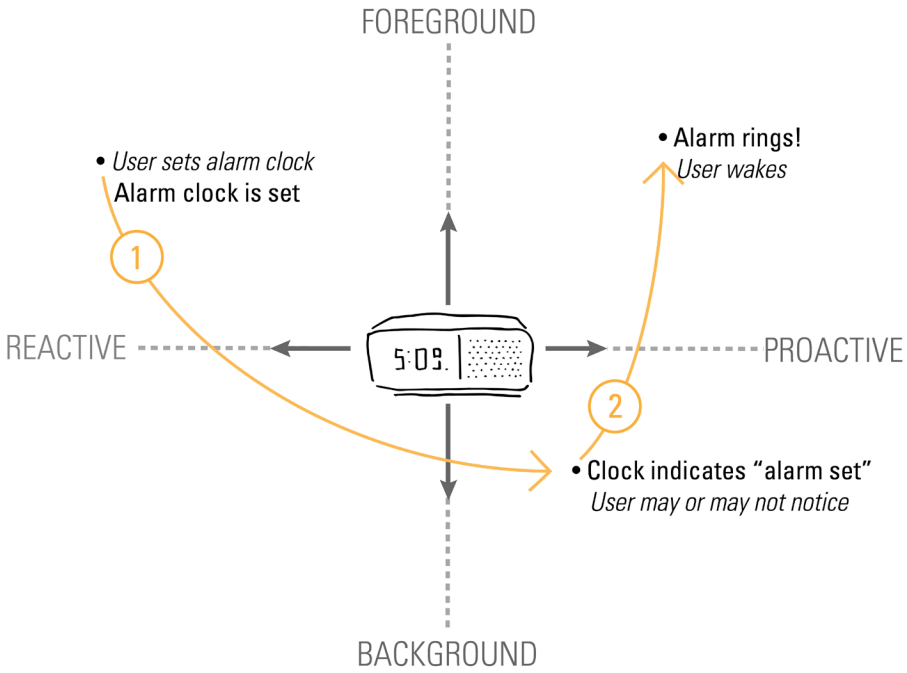

Figure 2.7: Next step: alarm ringing moves the trajectory of the interaction into the foreground proactive space.

The snooze function is a foreground-reactive interaction, but it only works as a snooze if snoozing the alarm takes less attention than setting an alarm from scratch.