Animate Objects:
How Physical Motion Encourages Public Interaction

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Abstract. The primary challenge for information terminals, kiosks, and incidental use systems of all sorts, is that of getting the "first click" from busy passersby. This paper presents two studies that investigate the role of motion and physicality in drawing people to look and actively interact with generic information kiosks. The first study was designed as a 2x2 factorial design, physical v. on-screen gesturing and hand v. arrow motion, on a kiosk deployed in two locations, a bookstore and a computer science building lobby. The second study examined the effect of physical v. projected gesturing, and included a follow-up survey. Over twice as many passersby interacted in the physical v. on-screen condition in the first study and 60% more interacted in the second. These studies, in concert, indicate that physical gesturing does indeed significantly attract more looks and use for the information kiosk, and that form affects people's impression and interpretation of these gestures.

Keywords: kiosk; physicality; gesturing; public; field study.

1 Introduction

Pity the poor information kiosk. Information terminals the world over are going untouched—unloved—because people do not really understand how to interact with them. This sad state extends beyond the underuse of myriad kiosks, for, after all, kiosks have no feelings. No, the true tragedy is all the people who have gone uninformed, undirected, unguided, because they didn't receive the information they needed when they needed it.

The conundrum of the information kiosk embodies the challenges of what Alan Dix termed "incidental interactions." [1] Technologically, kiosks may be no different from the personal computers we use for hours each day, but their use pattern is distinctly different: they are single purpose; every user is a novice; there is scant opportunity for training or orientation; each transaction is fleeting. Human-kiosk interactions are like "engagements among the unacquainted" [2] rather than engagements between familiar parties. For many such incidental use systems, the big challenge is to overcome people's reluctance to engage with the unknown for an indefinite payoff [1]. Understanding how to overcome such obstacles will improve the use and usefulness of public information and communication technologies.

In the project described in this paper, we seek to improve the engagement and approachability of public computer systems, like the lowly information kiosk, by using motion and physicality. After all, people implicitly signal their willingness to engage with others in all sorts of ways; might some of these techniques work for initiating interaction with a machine? These questions will become increasingly important as information technologies become more ubiquitous in our daily lives.

2 Related Work

2.1 The First Click Problem

Kiosk designers have traditionally focused on the issue of usability. Because kiosks are used incidentally, designers of such systems seek to ensure that no orientation or training is required for use [3]. However, deployments of these research kiosks usually show that lack of approachability renders the issue of usability moot. For example, in evaluating MINNELLI [4], Stieger and Suter note how the conventional wisdom that kiosks can draw users by using “attract loops” fell short. The flashy, animated attract loop actually kept people from using their bank kiosk system, because they adopted the role of passive observers: “This was in fact the central hurdle in the system’s usage, as the great majority of users had no trouble at all handling MINNELLI after they had mastered the first click.” Absent this first click, however, none of the other niceties of the system design really mattered.

Some kiosk systems, such as MACK [5] or MIKI [6], employ embodied conversational agents and natural language processing for the purpose of creating more natural “usability,” but even in these systems, the kiosk remains idle until a person has engaged the system—by sitting on a pressure-sensitive chair mat, for MACK, or by issuing a command to the system, in the case of MIKI. For all their interactive sophistication, these systems also have documented “first click” or “first contact” problems, where people do not approach, or where they approach but seem not to know how they are to engage with the system. MIKI’s designers identified this as the primary limitation of their system, “namely that there are not enough cues provided to the casual observer as to what the kiosk is and how to interact with it.”

Part of the problem with applying a usability approach towards the first click problem is that usability is usually evaluated in the lab, rather than in the wild. Consequently, the question of whether a usable system will actually get used often doesn’t really get evaluated until the system is in full deployment. By looking at approachability—the problem of how to get the first click—as an independent issue, one that requires insight about users and how they behave in real public settings, we can address the challenges of engaging users from the outset of a kiosk’s design.

2.2 Social Actor Theory in Information Displays

Because people respond socially to computer and media technologies [7], designers often employ embodied avatars to make kiosk systems easy for newcomers to use. However, such systems set up high expectations on the part of the user about the “intelligence” of the kiosk. It can be prohibitively expensive, in cost, time and effort, to develop the vision, speech, and language processing systems that can perform in a way that people assume a seemingly intelligent system would. While such investments may be worthwhile if the goal of the system is to interact socially and emotionally with passersby, as in the case of Valerie the Robo-receptionist [8], they can actually be overkill—even counterproductive—if the ultimate goal is to present users with written information or maps. In their paper on their experiments with intelligent kiosks, for example, Christian and Avery note that their talking embodied avatar heads attracted a lot of curious passersby, but that the moving head subsequently competed with the content of the kiosk screen for the user's attention [9].

By moving beyond human-likeness as a design strategy, it may be possible to make displays approachable without having to achieve AI-completeness. In their study of public displays in the wild, Huang, Koster and Bochers noted that the physical orientation and positioning of public displays often had influence on whether people looked at or interacted with displays than catchiness of the on-screen content [10]. Otherwise, they found, people seldom glance at even bright and dynamic displays for more than a second. This finding is consistent with Reeve and Nass' social actor theory, for, as Erving Goffman pointed out in Behavior in Public Places, unacquainted persons generally actively avoid face engagement—even if the other person looks to be friendly or in a good mood [2]. This "civil inattention" is not rude, but rather, polite behavior. For receptionists and sales clerks—or other people in similar roles—certain physical orientations or locations "expose" them, thereby providing permission for unacquainted engagement. Thus, it should be unsurprising that people are far more willing to engage a public display if it is properly exposed.

Part of the challenge of looking at public information systems as social actors is designing the right sorts of experiments to test how people interact with such systems in public; this is fundamentally different from how people interact with systems in a more intimate or familiar setting. To this end, we take a page from Paulos' Urban Probes [11] and Ju and Takayama's gesturing door studies [12], where potential technologies are inserted into a public context with the knowledge that they may provoke behaviors and responses that otherwise are difficult to predict or access.

2.3 Motion and Physicality in Social Interaction

In The Social Life of Small Urban Spaces [13], William H. Whyte writes about two blind beggars he observed:

"The first beggar, while staying in the same spot, kept making a shuffling motion and moving his cup. The other remained stationary. The moving beggar received roughly three times as many contributions from passerby as the other."

While many bodily movements are emblematic—interpreted by members of a culture to have direct verbal translations—many more simply draw attention to the self and convey what sociologists call "openness", or availability: a willingness to engage in social interaction [14]. Unlike more static traits like friendliness or attractiveness, availability is a dynamic trait. Because of this, we are accustomed to seeing motion as part of demonstrations of current availability: train passengers wave their open palms to indicate the availability of the seat next to them, promoters wave handbills at you as pass, the doorman opens the door a little as you walk down the street. These motions invite engagement without actually crossing the threshold into explicit interaction.

While it as has been noted by [7] [12] and [15] that human-likeness is not a prerequisite for having people interpret computers, robots, and even automatic doors as social actors, most interactive information interfaces that employ physical motion have incorporated humanoid facial features [8][16][17]. In the following experiments, we investigate whether motion and physicality might function independent of facial form to encourage public interaction.

3 Experiments

The following experiments are, in the parlance of non-verbal communications research, decoding studies. They are structured to investigate how interactants perceive, interpret or react to non-verbal signals. They take place "in the field" so as to understand how people interact with systems in true public settings.

We tested several hypotheses with these studies:

H1. The Physical Hypothesis. That physical motion is better for indicating availability and encouraging engagement and interaction than mere visible motion.

H2. The Anthropomorphic Hypothesis. That human-like gesturing is more readily understandable and familiar than non-humanoid gesturing.

H3. The Uncanny Valley Hypothesis. That human-like gesturing is perceived to be stranger and less natural than non-humanoid gesturing.

3.1 Study 1: Physically embodied vs. on-screen gesturing

In this first study, we sought to test our idea that physical motion and gesturing might do a better job of attracting attention and encouraging interaction with an interactive touchscreen kiosk than equivalent on-screen motion and gesturing.

System. We created a basic touchscreen kiosk with a gesturing apparatus attached. We were careful to design the kiosk so that it presented a neutral visual appearance in the non-physical gesturing conditions (see Figure 1). The kiosk most closely resembles a speaker's lectern or podium: it is 35 inches tall, 15 inches wide and 15 inches deep, and is clad in oak wood with a clear satin polyurethane finish. A 15-inch ELO 1515L touchscreen LCD rests inside on an upper shelf. A Dell laptop PC rests inside on a lower shelf and drives the touchscreen.

This laptop runs a JavaScript program that presents webpages within custom-designed browser window that features forward, backward and home navigation buttons, where the "home" location is the homepage for the study site. When the kiosk has been idle for 30 seconds, the browser program automatically resets the

Figure 1. The kiosk in *(left to right)* a) Study 1 On-screen condition, b) Study 1 Physical Hand condition, c) Study 2 Projected Hand condition, and d) Study 2 Physical Arrow condition

display to the home location, blacks out the page content, and presents a large round "**i**" information button in the foreground. Touching the screen removes the information button and brings the content back to the foreground. We performed preliminary tests to validate that the touchscreen-operated webpages functioned as a plausible kiosk.

The kiosk also houses a HiTec 8815B sail servo and an Arduino Decimila microcontroller board. In the physical gesturing conditions, the servo motor winds and unwinds a transparent monofilament to pull on the gesturing arm of the kiosk, causing it to move forward and backward.

The physical gesturing apparatus is constructed of a flexible steel strip. It is sheathed in black cloth and, depending on the condition being run, terminates either in white-gloved hand or a similarly-sized white foamcore arrow that points downward toward the kiosk. (See Figure 1b) and 1d). An infrared rangefinder mounted to the front of the kiosk detects the proximity of on-comers and sends an analog signal to the microcontroller, which stops the arm from waving when someone is standing in front of the kiosk.

For the on-screen conditions, the physical arm was removed and similar gestures were instead shown on the touchscreen display. In these cases, after the kiosk has been idle for 30 seconds, the "**i**" and black background of the kiosk are accompanied by an animated gesturing hand or arrow whose motion mirrors the speed and motion of the physical hand and arrow.

Sites. This field experiment was conducted at three locations: a design department lobby, the campus bookstore and a computer science department lobby. These locations were selected because they are natural sites for an information kiosk, have reasonable amounts of foot traffic, and have distinctly different traffic patterns and demographics: the bookstore is frequented by newcomers, whereas the computer science building has the same people coming in and out each day.

One of the most salient differences between these locations is that the arrangement of furnishings and objects at the design department and the bookstore change often, so even if a person visited everyday, he or she might not consider the addition of a kiosk on one day to be out of the ordinary. The kiosk is certainly novel, but its relative novelty in that context is low. In contrast, the computer science lobby is sparsely decorated, and the objects in the space rarely change. In addition, office dwellers may

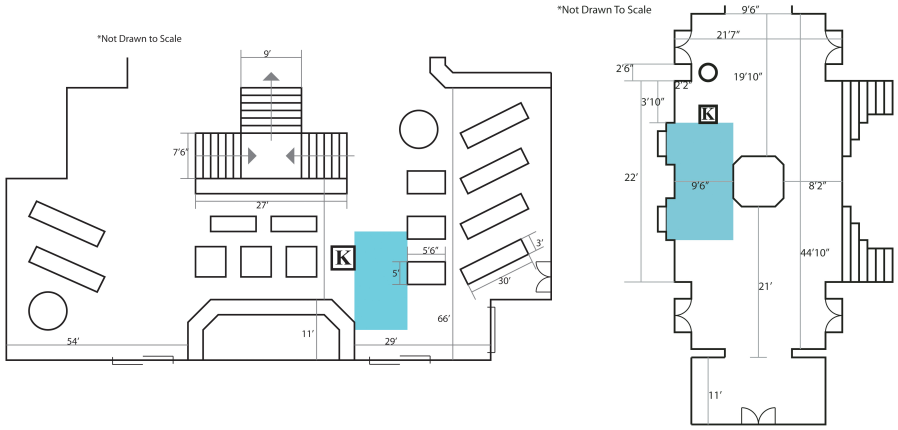

Figure 2. Schematic maps showing layout of bookstore *(left)* and computer science building lobby *(right)*. The entryways are along the lower edge of the maps. The kiosk is labeled with a K, and the runway is highlighted in blue.

pass through it several times per day. As a result, they are likely to recognize the presence of a kiosk as a novel addition to a familiar setting.

The design department has one primary entrance with two large double doors, with a reception desk 20 feet from the entry. The kiosk was set up to the left of the entry, 10 feet inside of the doorway. The bookstore has two entrances with a checkout counter between them, and has books and accessories that fill many tables and shelves spread around the remainder of the floor. The kiosk was positioned 20 feet inside of the right entrance, along the right side of the main foot-traffic flow through that entrance. The computer science building lobby has one entrance with two elevators on the left side, a 6 foot wide octagonal information kiosk at the center (currently not functional) and a staircase on the right. The kiosk was positioned just beyond the two elevators, along to the left of the central information kiosk. Site maps of the bookstore and the computer science lobby are shown in Figure 2. The layout of the design department lobby is similar to the bookstore.

Experimental protocol. We employed a 2x2 factorial design for our studies. The two independent variables were the type of motion (physical vs. on-screen) and form (hand vs. arrow). We then measured the ratio of passersby who looked at and interacted with the kiosk. In addition, we asked people who interacted with the kiosk for brief informal interviews about their experience. Questions were open-ended, but included, as examples: What did you first notice about the kiosk? How does the kiosk design make you feel? and, Where else would this design work well?

To ensure that all of the people in our study were seeing the kiosk from the same angle, we were very strict about the people who we counted. We outlined a “runway” roughly 15 feet in front of the kiosk, and only counted people who approached the kiosk from the forward direction along that runway. People were determined to have “looked” at the kiosk only if their gaze was sustained for more than 3 seconds—for instance, if they had to turn their head to keep looking at the kiosk as they walked on by. People were determined to have interacted with the kiosk if they touched the touchscreen so that the kiosk’s home webpage was fully visible. All people who interacted with the kiosk were also counted as having looked at the kiosk. People who stopped and played with the gesturing hand or arrow but did not touch the kiosk screen were counted as having looked but not touched the kiosk. Because groups of people tended to act in concert, pairs or clusters of people were treated as a single opportunity for interaction, regardless of whether they passed by, looked, or interacted with the kiosk.

The study ran over three days, with each condition set up for half an hour in the morning and another half an hour in the afternoon in each location. Because of natural variations in the traffic patterns, we did not have an even number of participants in each condition.

Study 1 Results. To explore the impact of physicality and form of kiosk gesturing motion on the behaviors of passersby, subjects were exposed to one of four conditions: Physical Hand, Physical Arrow, On-screen Hand, and On-screen Arrow. A chi-square test was then conducted on the observed frequencies of interaction within each nominal condition. Twenty-eight out of 179 people—roughly 16% of all the passersby—interacted with the kiosk, and 56 out of 179—roughly 31% of all the passersby—looked at the screen. There was a statistically significant main effect for physicality on looking, with a Pearson $\chi^2(1, N{=}179) = 8.39$, $p{=}0.04$, as well as for touching the kiosk screen, with a Pearson $\chi^2(1, N{=}179) = 4.24$, $p{=}0.04$. Nearly 44% of the people in the physical condition looked at the kiosk, whereas only 23% in the on-screen condition did. 22.5% of the people in the physical condition interacted with the kiosk, compared to 11.1% in the on-screen condition. The main effects for form on looking, $\chi^2(1, N{=}179) = 0.65$, $p{=}0.42$, and interaction, $\chi^2(1, N{=}179) = 0.28$, $p{=}0.60$, were not significant. A cross-check on the effect of location on the variables found no significant effect: the conversion rates for looking at the design department, the bookstore and the computer science department were 20%, 29% and 37%, respectively, and the rates for touching were 15%, 14% and 17%.

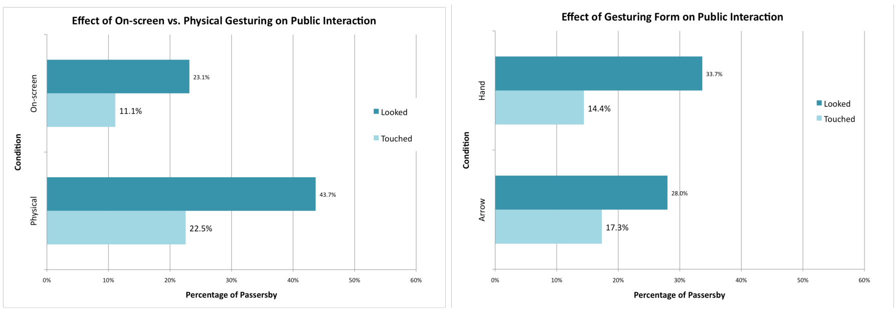

Figure 3. Charts showing the percentage of passersby who looked and touched the kiosk in Study 1. Significant effect on looking and touching was found for on-screen vs. physical gesturing *(left)*, but not for form *(right)*.

Study 1 Notes and Observations. In the post-interaction interviews, people who saw a physical pointer recounted that the moving arrow or hand drew them to the kiosk, at which time their curiosity led to an interaction. People who saw an onscreen pointer described only novelty (a new device in a familiar location) or curiosity as inspiring their approach. People who were new to place were more likely to indicate curiosity as their reasons for drawing near to interact with the kiosk, whereas regulars were more likely to state that they that they came because the kiosk was something new, but, regardless of the stated reasons for interacting with the kiosk, the conversion ratios at all three locations were remarkably similar.

3.2 Study 2: Physically embodied vs. visually embodied gesturing

Following our initial study, we sought to further investigate the effects of form and physicality on interactive engagement. Because surveyed participants in the initial study never mentioned the on-screen hand or arrow as having motivated their approach, we sought to make the non-physical condition compete more evenly with the physical condition by projecting a “life size” video of a waving hand or arrow on a vertical backplane. We also changed the kiosk’s on-screen image during idle mode to display a transparent gray backdrop rather than a solid backdrop, so that inquisitive passersby could see what they would be interacting with if they touched the touchscreen. Finally, we incorporated a short survey for people who had interacted with the kiosk.

System. Our kiosk setup in this second study was nearly identical to the initial study. We added a frosted acrylic backplane to the kiosk to act as a display surface. The display on the backplane was projected from a portable projector stationed waist-height approximately a yard behind the kiosk. This display was connected to a MacBook Pro running video loops of a waving hand or waving arrow on a blue background (for the visually embodied conditions) or a plain blue background (for the physically embodied condition) using iTunes player. The height of the projected hand and arrow was calibrated to be the same size as the physical hand and arrow.

For the visually embodied conditions, when the kiosk has been idle for thirty seconds, the program resets the touchscreen content to the home location, then dims the content rather than hiding it behind a black background, and presents the same information button from Study 1 in the foreground. No animated gesturing hand or arrow appears on the touchscreen display in this study.

Sites. This study was performed in the campus bookstore and the computer science department. We chose these two sites because they had higher non-repeat traffic than the design department did in Study 1, and because the conversion rates for interaction were fairly similar for all three sites. Due to changes in the bookstore layout, our kiosk location in this study was located across the main entrance pathway from the site used in the initial study.

1. What did you first notice about the kiosk?
2. What prompted you to approach the kiosk?
3. On a scale of 1-10, how approachable is the kiosk?
   Unapproachable 1 2 3 4 5 6 7 8 9 10 Approachable
4. On a scale of 1-10, how natural is the kiosk?
   Artificial 1 2 3 4 5 6 7 8 9 10 Natural
5. On a scale of 1-10, how strange is the kiosk?
   Familiar 1 2 3 4 5 6 7 8 9 10 Strange
6. On a scale of 1-10, how understandable is the kiosk?
   Incomprehensible 1 2 3 4 5 6 7 8 9 10 Understandable
7. How frequently do you visit [the bookstore/computer science building]?
   ___ first time ever ___a few times a week
   ___ a few times a month ___a few times a year

Figure 4. Questions from the Study 2 interview questionnaire. Questions were asked verbally and answers were subsequently recorded by the researcher.

Experimental protocol. As in the previous study, we employed a 2x2 factorial study design. The independent variables were physicality (physical vs. projected) and form (hand vs. arrow). We employed the same standards for counting looks, touches and interaction opportunities as we used in the initial study. After people interacted with the kiosk, a researcher approached and asked if they would be willing to answer a few short questions about their interaction with the kiosk. The questions on the survey (shown in Figure 4) were asked verbally, although the participants were also shown the questions in writing as the researcher recorded their responses in front of them. Ten-point Likert scales were used because of the verbal format of the survey.

This study was run four months after the initial study. The study ran over four days, with an hour for each condition at each site.

Study 2 Results. As with Study 1, subjects were exposed to one of four conditions: Physical Hand, Physical Arrow, On-screen Hand, and On-screen Arrow, and a chi-square test was conducted on the observed frequencies of interaction. Overall, more people looked at and used the kiosk; 86 out of 457 people—18.8% of all the passersby—interacted with the kiosk, and 217 out of 457 people—47.5% of all the passersby—looked at the screen.

There was a statistically significant main effect for physicality on looking and touching. For looking, the Pearson $\chi^2(1, N=457) = 8.18, p=0.1$. For touching the touchscreen, the Pearson $\chi^2(1, N=457) = 5.62, p=0.02$. 51.4% of the people in the physical condition looked at the kiosk, compared to 40.8% in the projected condition. 23.1% of the people in the physical condition interacted with the kiosk, compared to 14.5% in the projected condition. The main effects for form on looking and touching were not significant. A cross-check on the effect of location on the variables found no significant effect: the conversion rates for looking at the bookstore and the computer science department were 41% and 56%, respectively, and the rates for touching were 18% and 19%. Overall, the rates of conversion were remarkably consistent; for example, the touch conversion rate for the physical condition at both the bookstore and computer science building in Study 1 was 21%, and in Study 2 was 22% and 26%, respectively.

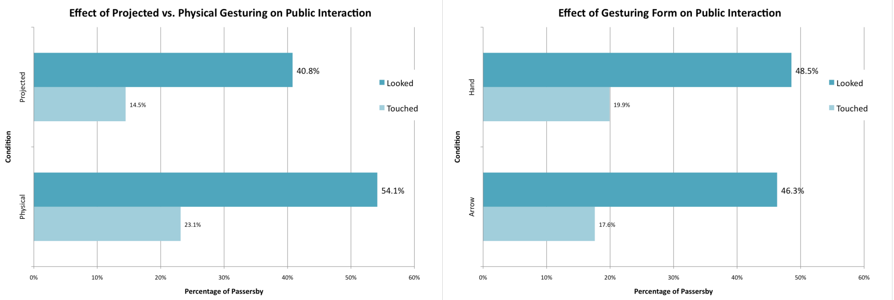

Figure 5. Charts showing the percentage of passersby who looked and touched the kiosk in Study 2. Significant effect on looking and touching was found for projected vs. physical gesturing *(left)*, but not for form *(right)*.

A two-way between-groups analysis conducted on the Likert scale variables in the survey (Approachable, Natural, Strange, Understandable) yielded a statistically significant main effect for form on understandability, [F(1,3)=41.95, p=0.02] where the arrow was rated to be more understandable than the hand (*M*=8.02, SD=2.41) vs. (*M*=6.08, SD=2.77).

Study 2 Notes and Observations. The survey results confirmed several assumptions made in our experimental design. First, the respondents always indicated that the thing that they first noticed, and the thing that caused them to approach, was the waving hand or arrow. Interviewees generally expressed incredulity at our asking of the question. Hence, we were assured that our manipulations worked, and were the operating factors behind the difference in observed behaviors. Next, we confirmed our assumptions about the demographics at our two field sites: The vast majority surveyed in the computer science building indicated that they were in the building a few days a week, where as most in the bookstore indicated that they came, at most, a few times a year, or that it was their first time to the bookstore.

At the same time, the survey may have suffered from closely following the kiosk interactions. At the time of the interview, people were mindful of their recent interaction—for instance, we fielded lots of requests for an on-screen keyboard to make search easier—and so the degree to which their ratings on the Likert scales pertained to the gesturing mechanism varied based on how long they had interacted with the kiosk. This issue may be inherent to our field study design, for it is impossible to constrain all our experimental participants to having the same experience without sacrificing the naturalism of the scenario. It may be desirable, however, to follow up this study with a more tightly controlled laboratory experiment.

4 Discussion

Taken together, the results of these two studies suggest a robust effect on public interaction for physical gesturing over on-screen or even large projections of gesturing. This is consistent with the Physical Hypothesis (H1) posed earlier. Although the specific rate of public interaction with an information system would vary based on the site, the placement of the system relative to the environment, the demographics of those passing by, and the value of the kiosk content, among other things, the consistency of our findings across different times and locations leads us to believe that it is possible to infer as a general design heuristic (a) that physical gesturing encourages public interaction, and therefore (b) that motion and physicality are significant influences on approachability and social engagement.

The importance of form for garnering attention or even drawing interaction seems less important than the actual physical presence of a gesturing object. However, the form does seem to affect the user's perception of the interactive system; there is the suggestion, from our second study, that non-anthropomorphic forms may be less confusing to users than anthropomorphic forms. This causes us to believe more in the Uncanny Valley Hypothesis (H3) than the Anthro-pomorphic Hypothesis (H2), at least when the goal is to get the first click. The similarity between conversion rates for the human-like hand and non-humanoid arrow conditions implies that effective public systems do not have to be anthropomorphic to invoke social responses from passersby. This understanding frees designers from focusing exclusively on emotional expressivity; they can, alternatively or additionally, explore social and communicative expressivity through means such as availability or approachability.

The findings from this research also underscore the importance of addressing the "first click" problem. The same informational content, staged in the same location, to the same people, can have dramatically different rates of impact depending on how approachable the staging of that content is. It is not sufficient or even desirable to generate a "greatest hits" preview of the content within an information system; this shortcut doesn't actually fulfill the need of demonstrating openness. Instead, our results suggest that for public systems, the actions and content that come before the first click—whether physical, on-screen or projected—need to be designed as much as the actions and content that come after.

Designers of physically interactive systems, such as robots and motorized machines, should be particularly aware that they could employ capabilities for physical motion to signal availability or unavailability. This method of soliciting attention can be a valuable design alternative to using voice or words on a display to engage people. Designers must also be equally mindful that physical motions have social connotations even if sent inadvertently; it may be important to assess whether the device's actions "expose" them in ways that are undesirable. Most of all, the results of this study point to the potential for sensing and actuation technologies in myriad settings. Indeed, this research points the way to employing interactive technologies in a wide variety of animate objects that need to signal their intermittent availability or unavailability.

5 Future Work

Animate objects have great potential to save us from the present, where we sail blithely unaware of all the information we need and are missing, and from a future where every product with a chip talks, beeps or rings an alarm to get our attention. They offer some possibility for a middle ground, for communication without cacophony. At the same time, random incoherent motions from objects can be highly disorienting and distracting as well; it is important not to heedlessly incorporate motion into products before fully understanding how they really function.

In future work, we intend to investigate the longer-term implications of gesture and motion for information systems—might gesture's ability to garner attention wear off as the novelty faded, or does motion have lasting power to engage social interest and engagement? We are also interested in studying the factors that affect the interpretation and impact of non-anthropomorphic physical gesturing, including the form of the object being gestured, the gesture speed, and the motion trajectory. In addition, we plan to expand our range of studied gestures by looking into the role of non-anthropomorphic gaze, orientation and targeted address on interaction. Finally, we plan to see if these findings generalize to ubiquitous computing applications at large by expanding our gesturing repertoire beyond kiosks to a wider variety of incidental use systems.

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