Animate Mobiles: Proxemically Reactive Posture Actuation as a Means of Relational Interaction with Mobile Phones

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ABSTRACT
In this paper, we explore body language in mobile phones as a means of relational interaction. We describe a prototype that allows the simulation of proxemic reactions to the nearing hand of a user, ranging from affection to aversion, based on nearness-based input and shape change-based output. A user study is reported, which indicates that users were able to interpret the prototype's behavior drawing on animal parallels. It is concluded that proxemically reactive actuation may be a viable means of actively integrating the relationship between the user and the device into the interaction.

Author Keywords
Animation, mobile phone, proxemics, relationship.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Experimentation, Human Factors.

INTRODUCTION

"What matters is not technology itself,
but its relationship to us."
– Mark Weiser & John Seely Brown [29]

The increasing inclusion of computers into our everyday lives is accompanied by a shift in the way we perceive the interaction with them. While this interaction was conceptualized as *tool usage* for a long time, recent proposals are increasingly conceptualizing HCI as our *experience of* and our *relationship to computers*. Such models have, for instance, been proposed by McCarthy and Wright [18], Shneiderman [24] and Fällman [5].

TEI 2013, Feb 10-13, 2013, Barcelona, Spain.

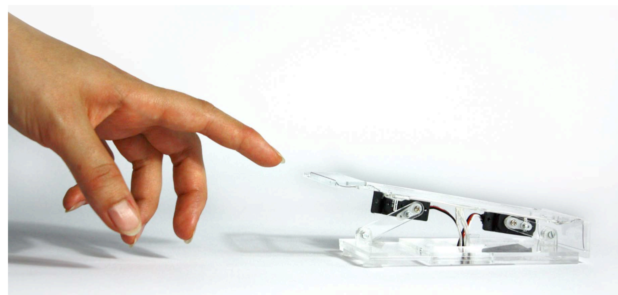

Fig. 1: Prototype, reacting to user's nearing hand.

Relational approaches to interaction seem of particular interest to the field of *mobile phones*, given the increasingly close relationship that users have to their devices [20]. Such research also stands in a context of research concerned with the attribution of human- and animal-like properties to inanimate objects, which has been explored, for instance, by Heider and Simmel [11]. However, proxemic interactions with mobile phones have been researched only marginally. This is surprising, as the rise of internet-enabled smartphones has spawned discussions about *information overload,* and, more recently, about *information addiction*. Researching *relational aspects of these interactions* appears worthwhile as such efforts could, for instance, make users aware of their information consumption behavior. Recently, increasingly *socio-spatial* interactions with technology have brought *proxemics*, 'the study of microspace as a system of bio-communication' [8] to the attention of HCI researchers; *proxemic interactions* have been proposed as a general model for HCI [6]. The perhaps most well-known aspect of proxemics is the structuring of experienced space into 'intimate space', 'private space', 'personal space' and 'public space' [7]. Interestingly, Hall's original notation system for proxemic behavior provides more, containing eight dimensions: *posture and sex*; *relative body orientation* (ranging from 'sociofugal' to 'sociopetal'); *kinesthetic factors*, *touch*, *retinal combinations* (intensity of looking at each other), *heat, olfaction* and *voice loudness* [8].

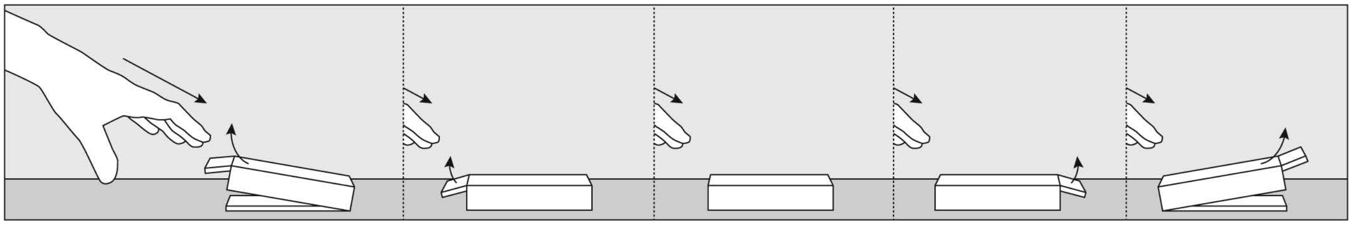

Fig. 2: Reaction schemes: a) affection b) attention c) ignorance d) anxiousness e) aversion

While exploring all of these aspects is beyond its scope, this paper focuses on *posture*. Actuating the phone's posture in reaction to the user's nearing hand could be a helpful means to make mobile phone users aware of their information consumption behavior. Timed just before the grasping of the phone, it can provide direct feedback for the user, nonetheless maintaining a continuous style of interaction. This is supported by posture's continuous nature, in comparison to other, less continuously experienced dimensions proposed by Hall, e.g. heat or olfaction. Postural actuation in mobile phones is also hypothesized to be easily interpretable, due to a rich set of parallels to animal and human postures.

RELATED WORK

Nearness-based input, shape- and movement-based output and human-robot proxemics have been investigated before. An overview over these fields will be given in this section.

Nearness-based Input

Nearness is employed as a means of user input in various applications, ranging from explicit manipulation to the detection of implicit actions. Work in this area includes manipulation in mid-air (e. g. in the iSphere [16] system) and continuous interaction in the airspace over tabletop [17] systems (e. g. in the Z-Touch system [26]). In mobile devices, the integration of distance sensors into mobile phones has also inspired works in the field of around-the-device interaction (e. g. HoverFlow [15] and SideSight [4]), which is often concerned with an enlargement of the available interaction space. In most of the works on nearness as a means of user input, the output modality is visual or acoustic. Shape and movement actuation, in turn, have been a separate research field.

Shape- and Movement-based Output

A recent overview by Rasmussen [23] provides a detailed overview over the emerging field of shape- and movement-based output. Work in this field ranges from thickness as an indicator of digital content [13], deformability-based output (e. g. in the BubbleWrap [2] and MudPad [14] systems), the physical creation of buttons on an interactive surface [10] to the actuation of objects' positions on a table [30]. Hemmert et al.'s Ambient Life [12] prototype, being based on shape-based life-like actuation, is an important reference project for the prototype in this paper. It articulates missed calls through an 'excited' heartbeat and breathing, but does not react to the user's hand, and remains stable in its posture. Other works have made use of shape- and movement-based systems as social proxies, as to allow for a richer experience of telepresence (e. g. in the MeBot [1] and Cally [31] systems, as well as in Paulos et al.'s work on tele-embodiment [22]). In most existing works on shape- and movement-based output, what was symbolized by the output was either an internal state of the device or a telepresent user.

Human-Robot Proxemics

A considerable amount of research has investigated proxemic behavior with robots [19]. Interestingly, most research focuses on *human* proxemic behavior [28]; proxemic action on the *robot's* side has received less attention. Work in this field has investigated robots' eye gaze [19] and position [25, 27]. Robot posture has been investigated mainly for the robotic display of *emotional cues* [3, 9]. One model that has found particular interest in human-robot proxemics is that of Patterson [21]. It is of particular interest here because it is based on the *relationship* between two subjects in proxemic interactions. It maps the *likability* of person A to person B's reaction to person A's nearing (and withdrawal) – if users like the robot, they would rather react to nearing also with nearing (i.e. *mirror* the robot's behavior), if they dislike the robot, they would rather react to nearing with withdrawal (i.e. *avoid* the robot). Generally, this model is used to measure the likability of the robot – combined with nearness-based input and shape- and movement-based output, it could, however, be also employed to signalize a *likability of the user*, from the device's perspective. This, in the case of mobile phones, could be used to make users aware of their information consumption behavior – 'over-checking' the phone could lead to the phone being 'annoyed', while checking it after a prolonged period of time could make the phone react affectionately to the user's nearing hand.

PROTOTYPE

Our prototype (Fig. 1) consists of an acrylic mobile-phone sized box (120x65x20mm) with a segmented, motorized surface (max. height increase: 18mm). The box is located on a semi-transparent mirror, under which a distance sensor is mounted, in order to measure the distance to the user's hand (within a range of 30-300mm). The prototype features no indication of 'top' or 'bottom', all wires are led through a channel in the ground plate of the box, through a hole in the semi-transparent mirror. The motorization is achieved through servo motors in the prototype's body, and through shape-memory alloy 'muscle wires' in the front and back plates. A GUI on a nearby computer allows adjustment to the prototype's nearness thresholds, delay times (reaction and calm-down), and other animation properties. The prototype is able to react to the user's approaching hand through different postures, ranging from 'affection' (Fig. 2a) to 'ignorance' (Fig. 2c) and 'avoidance' (Fig. 2e). The general posture is achieved through a tilt of the surface, additional expressivity is added through the muscle-wire-driven tilting of the prototype's front and back plates.

USER STUDY

In order to find out about user's interaction with the prototype, a small user study was conducted. It was hypothesized that the prototype's reactions to the user's nearing hand would be interpreted in a proxemic sense, according to Patterson's model: If the prototype *mirrored* the approach (taking a posture 'towards' the user), they would, hypothetically, interpret this behavior as affection – as being *liked by the prototype*. If the prototype *avoided* the hand, they would, according to our hypothesis, interpret this as *being disliked by the prototype*. It was also hypothesized that users would draw upon previous knowledge from interacting with pets, e.g. explaining their interpretations through *animal metaphors*.

Subjects and Task

In a user study, 14 subjects (8f, 6m, Ø30yrs.) were asked to approach the prototype, which was placed on a table in front of them, and extend their hand to it. Users had not previously been informed about the project or its expected outcomes. Different posture reaction schemes (*affection, attention, anxiousness, aversion*) were, in balanced order between subjects, exhibited by the prototype in reaction to the approaching hand. After each approach, users were asked to describe their interpretation of the prototype's behavior. Then, they were asked to approach the prototype again, in order to see its next reaction.

Results

Most users interpreted the prototype's reactions through animal metaphors ('It's like a dog!', 'It behaves like a cat that wants to be stroked.', 'It wants me to scratch it.') and expressions of relationships ('It knows me.', 'I am disturbing it.').

The *affection* reaction scheme was interpreted mostly as *friendly* ('It recognizes me, jumps up and noses my hand.', 'It wants to be picked up.', 'It has been waiting for me.'), whereas two users interpreted the nearing of the prototype as *aggressive* ('It looks excited, so I better not touch it.', 'It does not want to be picked up, but I could tease by doing it anyway.').

The *attention* reaction scheme was mostly interpreted as *calm* ('It's noticing me, but not excited about me.', 'It's tired, stretches itself.', 'It's very friendly, wants to be touched.'), mostly as calm. Here, also technical interpretations were uttered by the users ('It's opening, offering something from inside.', 'It needs to be charged.').

The *anxiousness* reaction scheme led to mixed interpretations, partly *inviting* ('It says hello.', 'It's open-hearted.'), partly *avoiding* ('Something is wrong.', 'It's shy.', 'It winces, because someone wants something from it.'). Also, technical interpretations were expressed ('It has a solar panel.', 'There is something to hear.').

The *aversion* reaction scheme was interpreted mostly as *loath* ('It does not want me to touch it.', 'You back off intuitively.', 'I'm scaring it.'). Five users also interpreted the reactions as *friendly* ('It sits up, so I can pick it up.', 'It's ready.').

DISCUSSION

Even though the prototype contained no animal cues besides its movement, most users interpreted the prototype's behavior by drawing on animal metaphors and in correspondence to Patterson's model: When the prototype took a posture towards their nearing hand, they interpreted this as *friendly*. Conversely, they mostly explained the prototype's avoiding postures with the assumption that the prototype *did not want them to touch it*. In both of these cases, they attributed the prototype's reaction to *a relationship* between themselves and the prototype. In some cases, however, reactions differed from this pattern. Some users interpreted the *aversion* scheme as inviting to pick up the prototype, while other users interpreted the *affection* scheme as an attack. One possible explanation for this could be that they interpreted the prototype as 'upside down' (i.e. where they imagined the prototype's metaphorical head and tail to be), but their explanations did not confirm that. Another explanation might be that in the *affection* scheme, the phone is, ergonomically, harder to grasp, while it is in the *aversion* scheme technically adjusting to the angle of the hand. However, for no user the *affection*/*aversion* interpretations were swapped. Whenever user's interpretations differed from Patterson's model, they were rather interpreted *both* as friendly or averse, so the general attitude of the user towards the prototype might be a more plausible explanation here. The results of the study stand in large correspondence with Patterson's model of proxemic behavior and likability, but they also point to some ambiguity in interpreting the behavior. This may be reasoned in the design of our prototype and its reaction schemes, but it also resembles an aspect of normal social behavior – nearing can indeed be both aggressive and friendly.

CONCLUSION AND OUTLOOK

We have presented a new way of interacting with mobile phones, based on body language and nearness. Our findings suggest that such a style of interaction could be a viable way of integrating the *relationship* between the device and the user into the interaction. Future research may reveal how movement speed, delay times ('forethought' and 'sleepiness') and calm-down time ('forgetfulness'), besides other animation properties and user recognition (i.e. being friendly to one user, and behaving aversely in the presence of another) could affect this style of interaction. The concept of proxemics holds great potential for a 'relational' approach to HCI, for which this study is only a small example. In the long term, it could help us to make our interactions with technology – and our *relation* to it – more rich and intense.

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