Working with an Autonomous Interface: Exploring the Output Space of an Interactive Desktop Lamp

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ABSTRACT
Increasing sophistication and ubiquity of digital devices is creating potential for the development of new kinds of actuated interfaces. In this paper, we explore the design space around movement as a form of gestural communication for information output, in simple actuated desktop devices. We were curious as to how people might envision interacting with autonomous technology in the office. Accordingly, we focused our attentions on one prevalent desktop object, an interactive lamp, with three actuated joints, which allowed us to explore the interaction space of such devices. We invited 13 participants to design and enact movements with the lamp to communicate 20 simple messages. We explored a subset of these generated gestures, using the lamp as a personal cueing device in an office setting with 14 new participants. We present our qualitative findings from both studies that let users imagine the usage of an interactive desktop lamp through actuation.

Author Keywords
Actuated Interfaces; Interactive Desktop Lamp; Autonomous Technology; Qualitative Evaluation.

INTRODUCTION
The decreasing costs of embedded sensors, processors and actuators enable the design of actuated artefacts for everyday use. Interactive objects are merging with our environments [36] and interfaces can now be 'brought to life' through such technology [24]. This phenomenon of ubiquitous computing has proved to be useful in many different application areas, such as domestic, health and office spaces [2, 3]. Commercial products, such as small personal robots (jibo.com), just started to occupy this space and are in great demand. In this paper, we seek to understand how users perceive and interact with everyday objects that 'come to life' through actuators.

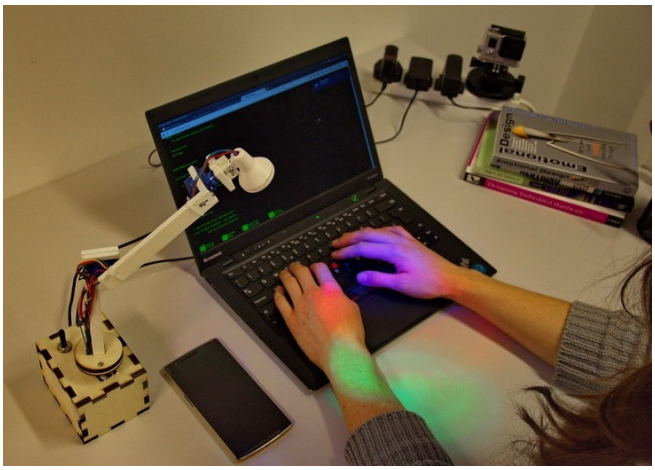

Figure 1. The actuated desktop lamp.

There is an underlying similarity in interaction when we compare devices producing actuation (e.g. light, sound, movement). Research has shown that - consciously [8] but also unconsciously [28] - people react socially towards these interfaces. Interface design is also commonly used to create an illusion of systems being alive and having a personality [13, 26]. To explore these areas, we developed an interactive desk lamp for the office (pictured in Fig. 1). Our interest lies in the limits and edges of intelligence and autonomy in interaction design. Within this inquiry, we are particularly aiming at creating a tangible autonomous interface [25], a device which is less complex than a robot, but a tangible user interface that exhibits autonomous behaviours. But how do people actually feel about such interfaces in an everyday setting? Which consequences does this have for designing technology?

We envision a scenario where the lamp could be a personal device, reacting to input provided through a digital calendar or also through physiologically monitoring the user. In this paper, through exploratorily imagining a scenario in the office with

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participants, we want to research how to design an autonomous desktop lamp as a notification device. Our key interest lies in understanding the space between humans and autonomous interfaces.

We report on two studies that are built around a smart desktop lamp, functioning as an autonomous interface to support office work. In the first study, we let participants actively explore how an interactive lamp might display a range of messages related to a work scenario through enacting various motions with a passive lamp. The ideas collected in the first study helped to design potential interactions for an interactive desktop lamp for the office desk. But how acceptable and usable would our generated design be in real life? In the second study, we tested a subset of the generated movements with a new set of participants in a semi-realistic, exploratory office setting. We invited the participants to sit at a desk and work for 30 minutes. In a Wizard-of-Oz setup, the lamp provided output to the participants. We then followed up with a semi-structured interview to investigate the functionality and practicability of the lamp. We focused on social reactions to technology to qualitatively understand how users would like such a lamp to function and how they would feel about interacting with it.

RELATED WORK

Research previously explored technological augmentation of desks to support the user with daily tasks [4, 33]. Here, we want to focus on actuated objects and interactive desktop lamps and how these influenced our work.

Actuated Objects

Product Movement is a design field focusing on using actuation to deliver information to the user. Jung et al. [19] created an abstract robotic torso, which can move and rotate. They found that most users interpret messages differently, as plain movement might not be distinct enough to communicate something that all people can agree on. Context is needed to make messages more explicit and movement should be seen as an additional modality that can be used along with other outputs. Building on their work, they further evaluated three actuated prototypes [18] in the shape of everyday objects (shaking water bottle, moving assignment box, rotating recycle bin). Although some movements were confusing, the devices quickly caught attention. They observed that people treated the devices as life-like and showed affection and empathy, speculating that in the future humans may build relationships with such technology. However, they also mentioned that some movements were frightening or annoying. *Breakaway* [16] is a small paper strip on the desktop that slouches when the user is sitting for too long, to foster behaviour change. An initial study with one participant over two weeks revealed that *Breakaway* indeed motivated movement and was not intrusive.

These prototypes serve as great examples to show the feasibility of actuated products to communicate through movement. However, such design needs to be carefully balanced between the actual movement, the context, and the purpose of the device. Otherwise, abstract actuation might not bring any benefit and lead to confusion or annoyance. We were interested in how people would react to an actuated desk lamp and which emotions people would convey towards such a device. Especially, we wanted to find a suitable design for the context of a work environment and how to avoid annoying movements.

Camy [30] is a dog-shaped web camera covered in fabric (used as an electronic assistant), which can move next to the screen and also has a digital counterpart on the screen. The authors explored how animal analogies (especially to pets) could be used in ubicomp product design. The study indicated that the users personified *Camy* and associated a character with it. The authors conclude that due to its social presence, *Camy* might achieve a higher acceptability as a product, as users at times seemed more forgiving towards certain otherwise distracting functions. Research on the perception of insect behaviour identified new design opportunities for notification cues, leveraging knowledge from lifelong experience and building on associations with living beings [23, 22]. However, interfaces with zoomorphic appearance are, at the moment, still challenging to implement and far from being able to behave like the model they resemble. Therefore it is advisable to not evoke expectations through visual resemblances (e.g. make an interface look like an animal) that may be broken and lead to disappointment [7, 5]. To avoid these pitfalls, we lay high importance on functional and plain appearance and focus on machine-like technology. Therefore we chose a lamp.

In related work on actuated interfaces, may it be helium balloons [24], quadcopters [20], kitchen bowls with morse output [35], bespoke radio devices [10]; researchers always seem to report the same two phenomena: people perceive these actuated devices as animals or even pets and participants tend to perceive them as social beings. Remarkably, the devices only have the actuation in common, visually their designs are diverse. What is it about the design of these interfaces that makes people react in that way? Conventional autonomous technologies in the office environment, like Clippy, proved to be distracting and annoying and were not well received [37]. Research also showed that reminder technology needs to show a degree of 'politeness' to be acceptable [6]. Hence, we are asking: How could we leverage the fact that people react socially towards actuated technology to create autonomous devices that are acceptable? Ultimately, we are interested in aspects that make autonomous technology suitable at work. Against this background of work, we wanted to research how the lamp could establish itself as an embodied, social desktop companion and therefore enable a more enjoyable interaction.

Interactive Desktop Lamps

DeVito et al. [9] created an actuated desk lamp and used a user-centred approach to design hand gestures for different control tasks, such as switching the light on or off and shining at a certain object. A more playful prototype is *disco lamp* [21], which tracks a hand to provide light at that area and also dances to music. The most sophisticated robotic lamp was presented by Hoffman [14]. In a workspace setting, users directed a lamp's head and therefore guided the light with their hands as well as changed the light's colour. Participants were impressed with the robot's performance and collaboration worked well. Some even stated a feeling of inferiority when making mistakes, while the prototype solved its tasks. These

studies focus on gestures for the user and their interaction to control the light. Our aim was to understand the possible movements for more expressive output of an actuated lamp. *Gertie* [12] is a desk lamp with five degrees of freedom (DOF). In an online survey, four different emotions (fear, joy, sadness, surprise) that the lamp was intended to convey were evaluated. Participants reliably identified joy and sadness, but not fear and surprise, which oftentimes were confused with surprise and disgust. Whereas this work focused on the display of emotions, we are exploring how a lamp could display various cues to support the user with their tasks in the office and how this opens up an interaction space.

In summary, more research is needed in autonomous desktop interfaces to understand which kind of interactive object behaviours users would accept and want. We aim to do this using a lamp as an exemplary object in a user-centred approach. Instead of focusing on user's gestures, we explore to which extent it is possible to communicate certain messages through movements in the context of a working environment and how these movements affect a user's perception of a device.

In the following we describe the first study, consisting of the gesture collection, its evaluation and findings. Following on that, we describe the second study, a follow-up, exploring the designed movements in a semi-realistic setting.

STUDY ONE - GESTURE COLLECTION

Prototype

The appearance of the lamp is aimed to look like a regular lamp. As already mentioned, we want to avoid deception and possibly frustration with the device. Various designs and different degrees of freedom were explored. In the end, we decided on two actuators as this does not make the device overly complex and allows for a fair amount of output movements. Therefore, the lamp consists of two segments; the cone as the top (holding the LED), which can rotate, and the middle joint, which can bend forwards and backwards (see Fig. 2). To not bias the participants, we did not give the lamp a name.

Setup

We recruited 13 participants, aged 22-53 (6 females and 7 males, mean age 30). The setup of our first experiment was an office room with a desk (audio and video recorded). We created a realistic setting by cluttering the desk with various objects; laptop, books, a mobile phone, some pens and a water bottle. Although this still presents a lab setup as the participants were not sitting at their own desks, such a setup surely does not represent an unusual configuration as it resembles a modern hot-desking situation in various workspaces [15].

Figure 2. The lamp prototype for the first study with a potentiometer to control the light intensity.

Procedure

To discover possible lamp movements, we chose the approach of user-defined lamp actions (which is quite common for other technologies such as surface computing [38]). We asked our participants to use the lamp like a puppet and let the lamp display messages to a person at the desk (in this case themselves). We gave 20 tasks to the participants (in random order, each task was printed on a card) and they could change the lamp's pose, position, and light intensity. They were invited to talk along and explain their thoughts and ideas. To explore a wide range of possible task types, we chose specific tasks (e.g. new email arrived) as well as more ambiguous and open ones (e.g. catch user's attention). The tasks consisted of drawing the attention of the user to something (e.g. a person / something on the desk / outside the room), notifying the user of incoming messages or events coming up (from a calendar, mobile phone, email client, to go for lunch), changing the user's behaviour (drink water, motivate the user to stand up, calm them down because their heartbeat is too fast) and two social messages: say hello and goodbye. The sessions lasted 15-45 mins.

Analysis and Findings

For analysis, we looked at the lamp output that users created, but also carefully observed any behaviour and comments that were made towards the lamp. We transcribed all comments that point at an envisioned usage or subtle utterances that describe the relationship the users might form or imagine with such a device. Using these snippets, we conducted a thematic analysis. There are two elements to our findings. First, we describe the physical movements, which our participants generated. Second, we report on people's expectations of how the lamp should behave that we retrieved from their statements.

Generated Lamp Movements

Essentially, there were two different ways in which the participants manipulated the lamp to communicate with the user. They either let the lamp *point* at something / someone / somewhere by directing the top to orient towards the desired target; or changed the *posture* of the lamp to resemble a (human) posture, movement or gesture (leaning back to relax, bend over to sleep, wave to greet). Each participant stated that it is difficult to create a unique movement for each task. Therefore, to convey a certain message, participants tried to place the lamp in a certain context related to the message.

Overall, for more than half of the tasks (12 out of 20), the majority of the participants found it easiest for the lamp to point at something. Especially for catching attention or draw attention to something, participants used the lamp to point (70%). To remind the user of something, the participants again mostly pointed to the object of interest (66%) and flashed the light (45%). These reminder tasks were similar to the tasks attracting the attention, as for the participants they followed a

similar agenda: find the object of interest and direct the user's attention towards it. For the behaviour change tasks (engage in physical activity, calm down), most participants saw the lamp as a physical role model, mimicking what a human should be doing, e.g. getting up or breath slowly. To remind the participant to drink water, all 13 participants pointed to the water bottle. Typical responses for the 'social' tasks were to point or 'look' at the user's face and then change the posture (58%) by e.g. waving as 'hello' or 'bye'.

We also observed a number of unusual interactions. One participant let the lamp nudge it's mouth (to indicate it's time for lunch), another his wrist to get attention or knock against the wall (to point to another room). One person placed the lamp between himself and his laptop for the case that the lamp urgently needs to attract attention. Participants also mentioned that the light could blink in a certain pattern (e.g. morse) and therefore encode more information (although they acknowledged that they would not understand it).

Behavioural Expectations and Guidelines

It was interesting to us how diversely each participant imagined the lamp to function. Each person had their own interpretation to start with, their own way of approaching the device. Some saw it as a companion, others as a mirror of oneself, a teacher or parent (a device that dictates its use), others just as a light. We compiled the following recommendations from the participant's feedback: *The lamp needs to be polite* - unsurprisingly the lamp should act in a way that is appropriate in an office. Although its movements are highly mechanical, the device should still 'behave' like a polite human. Some form of eye-contact could be a means of respectfully checking in with the user and initiating contact. *The lamp needs to be aware* - the lamp should be able to recognise when a cue has been detected by the user and stop giving hints. It should also be aware about a task being urgent and demand the user to act as this would make the lamp useful and help to not miss out on important tasks. Furthermore, it would be helpful if the lamp knows about its environment, the things that are laying around, the room it is located in. *The lamp needs to change over time* - the longer the interaction, the more a user gets used to the lamp's cues. Therefore, with time, shortcuts can be made. After having interacted with the lamp for longer, the lamp can decrease the magnitude of its movements. It may only need to make small movements which the user would be able to understand because they got familiar with the lamp's movements. *The lamp needs to be customisable* - different people need different cues. It should be possible to adjust the messages (and their frequency) or add new functions.

STUDY TWO - GESTURE EXPLORATION

Prototype

During the first study, the users frequently turned the lamp around. Therefore the lamp was slightly altered for the second study and one additional motor was added to the bottom (see Fig. 1), which allows the lamp to rotate around its centre (approx. 200 deg). The second lamp comprises an Arduino Yun board, its movements and light are controlled remotely through a python program via Wifi. The prototype's hardware and software are open-source [1].

To make robots appear more life-like, roboticists explored principles of animation to create more natural forms of movement [34, 29]. Decades ago, animators established a set of practices which enhance cartoon character's motions to realistically convey their emotions and attitudes [32, 27]. For our prototype, we aimed at a more simple and functional design and therefore we designed the movement in a mechanistic way without applying the animator's guidelines. The lamp initiates its movement and it stays at the same speed until the movement stops. We do this to explore human responses to machine-like interfaces, which don't aim to copy human movement but are expressive in their own, technical way.

Setup

We chose to run a follow-up study in a semi-realistic office setting with 14 new participants and a study setup similar to the first study. Again, we set up a desk in a small meeting room with a laptop, books, a glass of water and pens and placed the desk lamp on it (see Fig. 1). We were curious about the appropriateness of the prompts and how people would react to a little desktop device. Participants were aged 23-39 years, 7 females and 7 males took part with a mean age of 30.

We based our selection of the prompts, which the lamp would display during the study, on the participants' statements about the most useful and/or desired cues: (1) Say Hi, (2) a text message arrived, (3) an email arrived, (4) drink some water, (5) look outside the room, (6) say bye. To create these cues, we looked at the corresponding, proposed movements from the first study. We made sketches of the proposed gestures and identified the most common occurrences as the movements for our study. Based on the majority, when more than half of the participants performed the same gesture, we adapted this choreography for the according cue. For (2), (3), (4), (5) this meant that the lamp would move from the default position (see Fig. 1) and point at the phone, laptop, glass of water, door and flash three times. For 'saying hi' the lamp waved the upper part up and down for a few seconds. For 'goodbye' the lamp also waved and then folded down.

Based on key issues identified by the participants in the first study, we made two further design decisions. To be *aware*, the lamp registers a message as 'received' or noticed by the user, when the user makes eye contact. If the user does not react, the lamp repeats the cue after 10 seconds. As identified in study one, the lamp could get annoying quite quickly. Therefore, to be *polite*, the lamp only repeats a cue up to three times.

Procedure

In the first study, 'gaze', so the lamp pointing at a user's face, was often identified as more polite, 'friendly' and engaging. We wanted to explore how 'gaze' impacts on interaction and if people prefer it to rather functional behaviour. Therefore, for the second study, we split the session in half. Each session lasted about 30 minutes in total and consisted of two conditions. The prompts were presented twice to the participants, in counterbalanced order. In the first 15 minutes, the lamp would provide the cue directly, in the other half the cue was preceded by 'gaze'. This means the lamp established 'eye-contact' by turning the top part (containing the LED) and therefore facing

the participant for a few seconds (with the LED turned off) before displaying a cue.

We created a protocol to make sure the lamp shows the same behaviour for each participant, leaving no room for ambiguity for the experimenter. We used Wizard-of-Oz, the conductor of the study hid in the back of the next room in a way that she could look through the glass door, see the participant, and remotely trigger the movements without being seen. Every 3-4 minutes the lamp would provide a cue to the user. A random email or text message was sent to the participant before the lamp would point towards one of these devices. To resemble a more typical hot-desking situation, we asked our participants to bring their laptop, phone and something to read. While the participant read and signed the consent form, we placed their laptop and phone next to the lamp on the desk in the room. Then the participants were asked to go into the room. As soon as the participant sat down by the desk, the first cue ('Say hello') was given. To explore how easily understandable the movements are, we didn't tell the participants the movement's meanings. We merely mentioned that this study evaluates autonomous technologies, and we told them that they should go into the room, sit down and work or read.

Data Collection

The sessions were audio and video recorded. Right after the study, we conducted a semi-structured interview lasting 20-30 minutes. The interview explored the understanding of the lamp's functioning, preferences, acceptability of its behaviour and participant's general perception of such a device. In the interview, we also explicitly asked the participants if they noticed a difference between the two different conditions and about their interpretation of each gesture. This involved replaying the cues during the interview. We further questioned whether the lamp was perceived as a social actor. Participants were also asked to clarify or reflect on specific behaviours which were noticed by the experimenter during the study.

Analysis and Findings

Our interests lied in how people make sense of the lamp's actions and how this can be seen in their behaviour. Furthermore, we wanted to understand how the design of the lamp leads people to react in certain ways and if these situations can be seen as opportunities for design. The data was analysed in two ways. First, we conducted a thematic analysis on the interview data and identified four overarching themes (presented below). Second, we picked up unusual, surprising or accidental situations from the video data. We analysed people's reactions, facial expressions and behaviours through performing an interaction analysis [17], which are marked as **Vignettes** below. We placed the vignettes within the themes. To develop a broader understanding of the potential of autonomous office technology, we unpacked these specific behaviours that occurred during the study. That is, to understand how people perceive and react to certain actions of our prototype and how a social situation with technology is constructed.

A lamp as a thinking entity

During the study a number of participants stated that they were wondering what the lamp might be 'thinking'. One participant explained that the lamp came across like an intentional entity:

"I thought it was looking off into the distance, and I was like 'what is it looking at'? It looked past the screen so my impression was that it was just looking by itself, at stuff that it was interested in." (P14)

It is fascinating that in the study this participant tried to figure out what drives the lamp, and he does it by trying to understand the lamp's 'thought process'. Almost as if the lamp would be a living being with thoughts. Consequently, he is worried about his actions on the desk and how this might be perceived by the lamp, e.g. picking up his phone. He continued reflecting:

"You do get the sense it's looking at stuff, I know that doesn't really make a lot of sense, well I guess it does, but you're just making that up, it's not looking, it's doing the opposite, it's projecting." (P14)

This all happens despite the fact that the participant knows that the lamp is only a piece of technology, a desktop lamp, and he is realising that he is making analogies that are a bit odd, such as interpreting the shining as looking. Still, the lamp seems alive. Other participants felt similar and when talking about the lamp, it sounded like they were talking about a person:

"Yes it seemed that it was observing what I was doing. It really seemed that it has a life on its own. Like an assistant remind you of things that you forget when you are drawn too much into what you're doing." (P5)

"It's a bit alive, I didn't interact with it, it interacted with me. We do understand each other though, but I'll have to teach it, if it would live with me. The movements, it has its own style. But the actions. I don't know if I would be creative enough [to customise it], it would need to be crowdsourced like 'oh other people teached their lamp to do this trick' or suddenly my lamp started doing things it has seen other people do." (P4)

For this participant it would be important to have a 'library of actions' to choose from so he can make more use of the lamp. In his descriptions it seems like he is referring to a living being, a pet or something similar, that can 'see' and 'learn'. In some cases, interpreting too much into the use of such words, i.e. describing object actions using terms, which would only be used for humans or animals, is problematic as it might just be a lingual artifact. We refer to tables having legs without actually anthropomorphising them and thinking of them as being alive. In such dissections, we have to be careful and aware of this fact. Our participants are however making explicit comments about the lamp 'thinking' and 'caring', which strongly indicates that this artefact can be dismissed in our case. They directly refer to the lamp as a conscious entity.

Vignette: The pet lamp

The lamp indicated that a new email arrived. P13 didn't react to the cue at first, but chose to stroke the top of the lamp after it returned to the default position (Fig.3(a)). In the interview she explains her action:

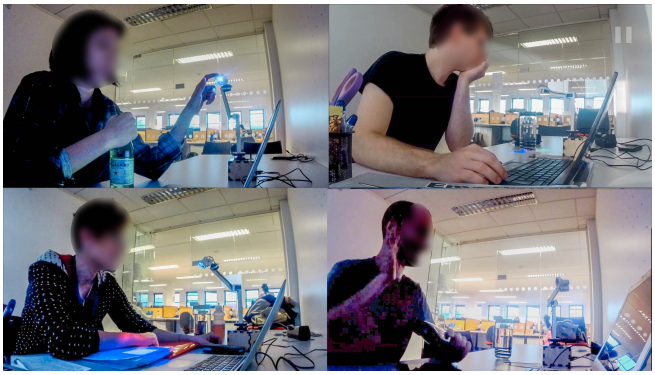

Figure 3. Four snapshots of interesting situations that emerged during the study, left to right, (a)-(d).

"It looked at me and it felt like it was acting like it was a pet. It was just moving [...] and I thought it needed some reassurance that I was aware of it, that it knows I am aware of it doing something. I have a pet, that might be why, my cat does that. [...] I am used to having something that moves around, he sometimes even goes on my keyboard. Because the lamp was here it reminded me of that, because the cat would poke its head out at the same spot. I liked it!"

Although our prototype shows no visual resemblance to a cat, the participant felt reminded of her experiences with her pet at home and therefore reacted the same way she does at home to show approval and compliancy. This situation illustrates how the lamps mechanical behaviour triggers some association with routine domestic behaviours.

A lamp that cares

People felt sympathy towards the lamp and interpreted it as good willing, as if it would actually care for them. The perceptions went far beyond the intended functions:

"It kind of made me feel like I had a little companion and like I should be sat here working rather than checking facebook and things, so I went on twitter, but very quickly, because there was this little thing that was kind of trying to make me more productive." (P8)

We received quotes that demonstrated that some people felt the lamp would motivate them to work, keep up a schedule and live more balanced. Others thought that it acts like an aid and it wants them to live healthier: *"Seemed benevolent, good willing, it was suggesting that I stayed healthy, [...] I think I made a new friend." (P4)*

One participant was not sure about the lamp's intention and the thought came up that it only wanted to distract him:

"It was weird, sometimes I just thought 'oh, it sort of cares about me, it tries to help me by pointing at my phone and stuff', but then other times it was just felt like it was just trying to distract, [...] at times I ended up to me like 'what was I doing again? Can't remember. So he's troubled that one!" (P14)

The actions of the lamp, e.g. pointing at water or the phone were interpreted as support but at times as a distraction as well. Pointing to things in this scenario meant caring for the user and their health or inviting to act or respond. The lamp observing the user and its purpose to keep the user up to date was interpreted as a friendly aid. Ambiguity in the lamp's purpose helped the people to make their own interpretation of the lamp's behaviour. This shows that purposeful autonomous technology is perceived as positive, friendly assistance.

Vignette: The persuasive lamp

In the middle of the second session, the lamp pointed at the water. P4 didn't show any reaction, he ignored the cue and kept typing. The researcher couldn't observe a reaction so ten seconds later she repeated the cue. After the second prompt, the participant followed the lamp's suggestion and took a sip of water (Fig. 3(b)).

"I was just finishing off some code and it flashed at the water and I was like 'yeah, good idea, but I'm gonna ignore you, because I am doing code, maybe next time'. But then it did it again immediately, so I said, 'fine, ok, I'll have a drink'. Then it didn't prompt me a third time so I guess that was me responding to it and it responding to me by stopping."

This situation nicely illustrates the lamp succeeding at persuading the user to do something.

A lamp that fosters a relationship

In general, the responses towards the lamp were positive. When analysing the video, we noticed that the first reaction of most participants, when they sat down and saw the lamp greet them for the first time, was to smile or even laugh. People perceived the lamp as a "little desk companion" (P3, P4, P8, P13), that supports them in everyday tasks. They saw it as their friend (P3), assistant (P5), co-worker (P12): *"I felt like the chemistry was right between us."* (P14) Participants also noticed that they were acting socially towards the lamp: *"I think we kind of teamed up after a while, I also noticed that I was kind of moving a little bit closer to the lamp." (P11)*

The participant continues to explain how her perception changed during the course of the study:

"I perceived it after a while as, you know, it's my team partner in this room and we are working together on something somehow. So even when it pointed out 'ok take a drink', I was like 'oh thank you'. [...], so actually now it's partner in crime." (P11)

This quote indicated that the user, in the short period of the study, engaged in some kind of relationship with the lamp, almost feeling closeness and togetherness. Earlier comments already indicated how participants saw the lamp as a kind of friendly and well-intentioned assistant.

"It is a nice company to working I think when you're alone, when you're kind of in an isolated mode of working, it's quite cheerful. The gestures they are quite unusual for me, I don't have anything like this in my home or so." (P13)

Vignette: The greeting lamp

The situation depicted in (d) occurred at the start of the session with P9. As soon as he sat down, the lamp faced the participant (gaze mode) and then performed the movement 'Say hello'. He was struck by the this movement and felt then compelled to wave directly to the lamp. Afterwards, he remembered this moment in the interview:

"It seemed like it had a vivid character to it. Little bit playful I think, how it's started, I don't know if I did it or not but I tempted to wave to say hello. It's not like it's a cold device, it felt like it had some warmth and it's colourful as well. The first time the motors suddenly kicked in made me jump though."

The participant's first reaction to the greeting is to greet back. He explains that the lamp made a friendly impression on him and therefore he reacted in that way. This shows how autonomous technology can make a friendly first impression and quickly initiate social reactions.

A lamp that is misunderstood

Three participants had trouble understanding the lamp's purpose at all and its behaviour was not apparent to them. They struggled to understand the movement and the functionality in a meaningful way: *"I: Did it seem like it had an intention? P12: No it didn't, not to me, but that may well be because I didn't make the connection between the different things."*

This shows that throwing the participants in at the deep end doesn't work for everyone and some people couldn't make sense of the lamp without an explanation.

To our surprise, 10 out of our 14 participants preferred the version with the lamp not facing them before providing prompts. Eye contact demands immediate response, which seems unnecessary for autonomous desktop technology. Participants stated that it would be distracting. Although participants in our first study identified eye contact between the lamp and the user as something that could help to bond, in practice it is rather irritating and disruptive. However, the four participants that did choose the gaze explained that it felt personal and nice to them. However, these participants also acknowledged that 'gaze' would make the lamp less functional for that reason: *"I don't really think that the facing you is necessary but it would add a bit of personality or something." (P10)*

"When it points into the face I thought it was more cute, like I feel like I can just look at it, smile, and look back, it didn't feel like it was asking me to do anything. It felt like it was just checking I was there, like a pet." (P7)

Vignette: The reprimanding lamp

For participant 12, due to a transmission error, a delay of about 10 seconds occurred before the first cue. The participant sat down and examined the lamp. She wanted to turn the light up and touched the rotor, when the lamp started its movement to 'Say hello'. She immediately went backwards and said "sorry" out loud. Then she looked at the lamp, waiting for a reaction to her apology (c). In the interview she recollected the event:

"I wondered if I could make it brighter, so I touched the control there and it span round and did it, whatever it does, so I was like "oh" better not touch that again. I: Did the lamp seem alive to you? P12: Not really, well that's funny cause I did say sorry to it so that kind of implies that I was treating it as a sentient being. [...] I could tell it was doing something, I just didn't know what that something meant." (P12)

The 'reaction' of the lamp to her trying to change the light was interpreted as reprimanding and the lamp not allowing her to do it. This situation illustrates how the participant showed a spontaneous social reaction to the lamp despite the disaccord.

Summary

Overall, our participants behaved socially towards the lamp and this happened because they felt they interacted with an intentional character. They saw a purpose in the lamp's actions. The presence of the lamp made them feel observed and therefore more aware of their own actions. Despite its mechanical appearance and movement, the participants perceived the lamp as a cute little assistant that helped them with their tasks.

An interesting finding was that the difference in behaviour - so the difference between session one and session two, which was the additional gaze - was not so apparent to the participants. When being asked if they noticed a difference between the two sessions, only four participants noted that the gaze of the lamp was different in each session. Four more recollected the difference after they have been told about it. This confirms related work stating that relative small changes in autonomous behaviour (for short interactions) are hard to notice for users [24]. Interestingly, the participants preference towards not using gaze turned out to be oppositional to the recommendation from the first study. Although having a 'gaze' helped the participant to understand where the lamp was pointing towards, making eye-contact through gaze was not wanted and felt weird to the majority of participants.

Comparing our findings to literature, it is striking to notice that from our study we find that conveying simple messages is less ambiguous than conveying emotions (reported on in related work). From 84 gestures that were shown to participants, only 24 gestures were not identified correctly. This is due to 10 participants not understanding the cue for 'email arrived', as pointing at the computer was too ambiguous. Furthermore, another pattern that emerged was that participants either understood most of the cues or hardly any. This again underlines the need for customisation.

DISCUSSION

Understanding the broader social consequences of machine autonomy has been identified as a key challenge [13]. To address this, we studied an application scenario in an exploratory way. Our aim is to push the scope for technology innovation in this space. Our contributions further include the following design implications derived from our observations, with the description of what worked well and what didn't.

The situations presented above make visible why and how participants might treat (mechanical) technology as a social actor. Each behaviour describes the people's perception of the lamp but also how they expected to treat the lamp and react to it. This analysis presents a snapshot of situations around autonomous objects giving us deeper insights into human-machine interaction. The vignettes show how participants resolve uncertain situations and otherwise unknown interaction with machines. In throwing our participants into these uncharted situations and leaving them to themselves to figure out the situation and the meaning of the setup, we were able to capture a number of fascinating occurrences and illustrate the

richness of social interactions expressed towards mechanical, autonomous technology.

Generally, participants can imagine such a lamp on their desktop, which however requires careful design. Our first study revealed that there are mainly two different ways users imagine desktop devices to convey messages, either by pointing at something or by mimicking basic human postures and movements. We found that users attached great importance to customisation, as the same movement evoked different feelings in users, and therefore movement needs personal adjustment. Unlike most traditional computers and devices that have the same output convention for each user, interactive objects with pro-active behaviour should act with respect to the preferences of the user. In the second study, we showed that it is possible to create a functional and plain looking interface that lets people get emotionally attached and even makes them feel cared for. We explain this by the fact that they saw a purpose in the lamp's actions, which was to assist and support them in their daily tasks. Leaving the purpose of the device open and letting the participants discover it for themselves, while still giving the lamp a function [11], proved successful in our case. We want to close this paper with a discussion on implications for autonomous interface design.

Is anthropomorphism unavoidable?

Our second study showed that an actuated device might be much more acceptable than we thought. When we put our lamp on a desk next to a person working, most participants felt positive about it. As already discussed, previous literature proved that bio-metaphoric resemblances carry pitfalls. However, resort to human or animal like appearance and behaviour can help in understanding cues. For autonomous interfaces this happens quite naturally and is hard to avoid [24]. Therefore, it needs to be carefully balanced. For example, our lamp was interpreted as having an 'eye' to point at things, being able to 'wave an arm' like a human or 'bow' to rest. To communicate different messages, the lamp was treated as a proxy to imitate human behaviour, like 'dancing' or 'sleeping'. Using these 'anthropomorphic affordances' [31] proved successful for communication between the autonomous interface and the user. There is a fine line between borrowing social metaphors which are pleasant, e.g. using gaze to point versus using gaze to make eye contact, which may feel unpleasant.

Social behaviour and norms of technology

In the end, it turned out that the lamp, although being mechanical and its movements functional, was perceived as a social actor and led to rich social behaviour in users. This confirms the literature, an interface doesn't need to resemble animals or other living entities to seem alive and evoke social reactions. The effect that people can't help but treat actuated interfaces, even highly mechanical ones, as social actors has an important implication. Even functional technology needs to contain some knowledge about social norms and retain an awareness of social behaviour (e.g. respect personal space, acknowledge requests with some form of response). This knowledge would make interacting with the lamp pleasant and make sense to the user. People have a socialised understanding of the world, which also extends to autonomous technology. In other words, as soon as we design autonomous behaviour into an interface, we also need to provide a socialised understanding, as there will always be a social response from people.

Transmitting social signals

A great amount of work is put into lamps following a user's face[1]. Interestingly, our study revealed that users might not accept 'mechanical eye-contact' and prefer a more salient and subtle style, which nevertheless seems friendly and inviting. Our participants stated that in a practical setting, not relying on eye contact made it easier to use or ignore the lamp if they want to. Eye contact is a strong social means of communication that doesn't seem to work with mechanical interfaces. It makes the interaction weird as people are not able to understand why the device is 'looking' at them. This is grounded in the fact that human eyes are much more expressive, allowing for more explicit signals, which is not the case with the lamp's top. Because the lamp is constrained, the only sensible output for it is to use its gaze to point, which did work well in the study. Users could confirm to the lamp that they received a cue by simply looking at the device, and this seemed to work well as participants reported this as a convenient way to interact. There were a few more downsides when people interpreted the lamp's actions in a social way. The 'gaze' of the lamp was felt as a form of monitoring, the repeated cues were seen as insisting and not letting the user alone. When the lamp stopped moving, it was seen as 'dead'. We however suspect that careful design could circumvent these, by for example adding slow 'breathing' gestures to keep the lamp alive [39].

CONCLUSION

In this paper, we presented our findings from a study that lets users imagine the usage of an interactive desktop lamp in short encounters to explore first impressions, perceptions and how people start to get familiar with autonomous devices. We discussed the participants' outputs, presented ways in which an interactive lamp can communicate, and explored these in a semi-realistic setting. We closed with insights and design implications for interactive lamps. Users' expectations of smart objects around them that are proactively behaving were gathered, and we showed that a quasi-social behaviour, politeness, and a learning curve in understanding each other are desirable. Interestingly, the finding from the first study, that gaze would make the lamp more interesting, turned out not to be suitable when tested. We further found that people have socialised understandings of mechanical movement and therefore interactive technology needs to include knowledge about social norms. With this work, we aim to open up design spaces, and inspire and generate new ideas for actuated interfaces.

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[1]Pinokio (ben-dror.com/pinokio), Anados (anodos.co.jp/ral), Junior (trieuvyluu.nl/living-lamps)

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