Bringing Movement to Digital Tasks at the Office: Designing an Acceptably Active Interface Interaction for Sending Emails

Philip Keller
Eindhoven University of Technology,
Eindhoven, The Netherlands
p.u.g.keller@student.tue.nl

Roy van den Heuvel
Eindhoven University of Technology,
Eindhoven, The Netherlands
r.v.d.heuvel@tue.nl

Carine Lallemand
Eindhoven University of Technology,
Eindhoven, The Netherlands, and
University of Luxembourg,
Esch-sur-Alzette, Luxembourg
carine.lallemand@uni.lu

Figure 1: Illustration of the interaction with A2-I2, a design exemplar of an acceptably active interface interaction

ABSTRACT

While working on a computer typically involves sitting for prolonged periods of time, sedentary work routines are associated with numerous health issues. To address this societal concern, existing solutions trigger physical activity as a break from work, rather than a part of it. In this research, we explore a vision for physically active ways of working, by transforming mundane digital tasks into physically active ones. As a research artifact and design exemplar, we present A2-I2, an innovative tangible system for sending emails. After loading their email onto a physical "letter" token, office workers must walk to a physical mailbox located in the office space. Understanding what design qualities influence the experience and acceptability of such systems is a necessary step toward the design of acceptably active interface interactions. We report on a preliminary user test with 8 participants. With this project, we aim to inspire future tangible and embodied systems addressing the timely issue of sedentary behavior at work.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Interaction techniques; Human computer interaction (HCI); Empirical studies in HCI.

KEYWORDS

Sedentary behavior, physical activity, office work, interaction design, computerized tasks

ACM Reference Format:
Philip Keller, Roy van den Heuvel, and Carine Lallemand. 2023. Bringing Movement to Digital Tasks at the Office: Designing an Acceptably Active Interface Interaction for Sending Emails. In *TEI '23: Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '23), February 26–March 01, 2023, Warsaw, Poland*. ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3569009.3573113

1 INTRODUCTION

A lack of physical activity and high levels of sedentary behavior at work can have severe negative effects on health [3, 16, 33]. The increasingly sedentary lifestyle of a large part of the working population in Western countries can be attributed to the physically inactive nature of most work tasks [19]. Office tasks are typically done on computer interfaces, designed for interactions to be as efficient and effortless as possible. By typing on keyboards, clicking with mouses, and staring at screens, one does not need to move more than our fingers to interact with these devices [28, 32]. The last two decades have witnessed a growing trend in the HCI and design community towards tackling sedentary behaviors and physical inactivity at work [4, 11, 14, 29]. A myriad of interventions has been developed, both spatial or physical [26, 30] and digital [23, 27]. However, a 2020 review [4] on the use of digital workplace health promotion tools revealed that most of these provide limited opportunities for physically active ways of working (as opposed to the common strategy of prompting breaks). Additionally, interventions are usually additional systems or services, rather than integrated into existing office infrastructures. This calls for future research around interactions that go beyond the screen and engage with

TEI '23, February 26–March 01, 2023, Warsaw, Poland

ACM ISBN 978-1-4503-9977-7/23/02.
https://doi.org/10.1145/3569009.3573113

the body, in order to shape a healthier and more stimulating office environment [28]. While tangible and embodied design approaches attempt to break away from screen-centric work routines, there is little work on transforming sedentary office tasks into active ways of working, and even less research on explicitly designing user interfaces and interaction to be physically active. Acknowledging the specific (e.g., social, cultural, physical) challenges inherent to the workplace context, HCI researchers should consider the acceptability of such interventions.

We define an *active interface interaction* as a computerized task requiring the user to perform some form of movement or physical activity to interact with the computer. In this contribution, we explore what an *acceptably active interface interaction* could be, where the "acceptability" of a technology is understood as the user's judgment of the technology prior to use, and "acceptance" refers to the judgement after use [22]. The concepts of acceptability and acceptance have been used in several studies, but often focused on the deployment stage, rather than throughout the design process [25]. We introduce a vision of acceptably active interface interactions in the workplace, addressing the timely issue of sedentary office behavior. We present a novel artefact, A2-I2 (Figure 1), as a design exemplar and research probe investigating how such interactions can be integrated into work routines. We conducted a preliminary user test to understand what factors influence the acceptability of such systems and suggest future steps towards the design of acceptably active interface interactions. Finally, we aim to spark discussion amongst designers to think in new ways and to consider new opportunities to design for workplaces that integrate physical activity with work.

2 RELATED WORK

Sedentary behavior and physical inactivity have a profound impact on workers' health and well-being [3, 16]. Health promotion interventions in the workplace can help address these challenges through interactive technologies [4, 14] that stimulate people to change posture [5], take breaks [20] or track physical activity [18]. Systems that promote physically active ways of working (as compared to very common break prompting interventions) have traditionally been designed as standing desks or treadmill desks [37]. While the latter can be effective in increasing physiological results [21], Tobiasson et al. [36] note that this equipment often goes unused, and that movement feels superficial when not included in the work activities. This is in line with Damen et al. [4], who argue that future research on healthy office environments should focus on the meaningful integration of physical activity into work tasks, and the smooth integration in the existing office infrastructure in order to increase the acceptance and adoption of such new technologies.

To better integrate physical activity into work routines, researchers have explored designs that transform office infrastructures into more active ones. The literature entails examples redesigning work tasks or meeting situations. Probst et al. [28] presented their vision of an *Active Office*, focusing on the design of digital workspaces that support the integration of bodily actions into primarily sedentary work routines. Their designs use tangible interactions such as using your feet to tap or scroll in an interface, or a '3D Active Chair' to control an interface by moving around. Another illustration of embedding physical activity as a core aspect of the design itself is Position Peak [5], a modular meeting room furniture that promote changing sitting postures. Initial empirical insights suggest that the design was effective in triggering more movement and could have side benefits in terms of creativity and social dynamics. But participants also mentioned postural discomfort and expressed worries about the credibility of such a design at the office. Unfortunately, the momentary user evaluations adopted in most studies falls short in documenting the trade-offs between these pros and cons and their influence of the acceptability of such products or systems. Walking meetings, one of the most integrated practice to embed movement into work [1, 8, 11], have led to more longitudinal studies investigating their acceptability. The Workwalk illustrates how existing work routines are made more active by offering a walking route as a 'meeting room' that one can book in the system [8]. The Hubs by Damen et al. [7] extend this concept with a network of stand-up meeting stations that accommodate different work-related tasks during walking meetings. Such physically active ways of working were deemed novel and stimulating in most circumstances [8]. They evoked different social dynamics at the office, and various use cases emerged during testing. Mentioned limitations to the acceptability of walking meetings relate to several contextual factors: task-related (e.g., need for note taking), physical (e.g., weather, walking routes), social (uncertainty if colleagues would be up for a walk), or even organizational (e.g., does it look professional and credible in the company's culture). An approach to overcome some of these barriers by supporting contextualized interventions, is to use existing work software as a delivery mechanism for health promotion suggestions [6]. For instance, Tweak is a cloud-based health promotion system that integrates tailored and context-aware health suggestions into the users' digital work calendar [6]. While the results of such interventions can increase physical activity, the interactions themselves (e.g., digital prompts or software use) seem to disregard physical activity altogether.

Other motivational strategies have been used in the larger literature of break taking interventions. Ren et al. [31] proposed an interactive office chair using elements of gamification to promote movement and stretching during short breaks. While exergames use movement as an interaction mechanism, the numerous interventions that promote physical activity [35] in the exergame literature might not be considered appropriate in the context of work. Users in the study of Cambo et al. [2] for instance did not feel comfortable pursuing a challenge near executives' offices or visitors' areas.

Reflecting on the boundaries of what is acceptable or not, and challenging the status quo of office work, is a key part of more speculative or critical designs addressing sedentary behavior at work [9, 24, 34]. Some examples question sitting time, such as the 'Irritating chair' [36], whose sharp spikes rise after a prolonged period of sitting, or the office chair Ivy that represents employees' sitting time through growing ivy strands, eventually rooting them to their seats [24]. Others adopt a wider view on a healthy office. The bossy Office Agents [34] compete to bring the employee to work in the healthier possible manner. The Office Jungle [9] used bodily experimentations to bring 'wildness' to the office. These types of interventions might not find a place in the everyday work context but are used to question what kind of interactions and design processes can be used towards new designs for workplaces that integrate physical activity with work.

3 DESIGN

Our design process started by multiple explorations around the concept of Acceptably Active Interface Interaction, including first-person perspective and bodystorming sessions, as well as mapping computerized tasks to movement, and reflections around the acceptability of movement at the office.

3.1 A2-I2

A2-I2 (Figure 2) is designed as an exemplar of what could constitute an acceptably active interface interaction. A2-I2 is a novel interface interaction for sending emails, involving a walk to a physical mailbox, located in the office space yet distant from the employee's desk, where a token is scanned. This research artifact aims at exploring how to integrate physical activity within computer interaction. While A2-I2 is functional and could act as a real mailing system, we designed it with the aim to trigger debate and collect insights into the use and acceptability of physically active interfaces. Following our design explorations mapping movement to computer tasks, walking has been selected as the movement modality for both its qualities (involves the whole body without imposing strain on a specific body part) and acceptability in the office environment (e.g., natural movement, not disturbing others, not sweaty). The procedure is as follows (Figure 1): to send an email, the user places a token (in the form of a C7 envelope) into the Editor connected to their computer. Upon insertion, a simple email client appears on screen where the user can type the email along with the recipient address. When the user is ready to send the email, the envelope needs to be removed from the Editor and the email client window disappears. The user can bring their envelope to the Mailbox to post it. The Mailbox is located in the office environment, at some distance from the user's computer. It can be shared with other employees. When the user slides an envelope through the mail slot, they hear the envelope fall in the box and see the slot glow green, which indicates that their email is now sent. If the user would reinsert the same envelope into the Editor before posting it, the email client would still display its content. Inserting a different envelope would open an empty email client, if the user had not written anything on it previously. If the user runs out of envelopes, they can collect the ones that were posted from an opening at the back of the Mailbox.

3.2 Technical Realization

The A2-I2 prototype consists of two modules, the Editor and the Mailbox (Figure 3). Both the Editor and the Mailbox have a MFRC522 Proximity Coupling Device (PCD) to detect the presence of an 'Envelope'. Each Envelope contains a Proximity Inductive Coupling Cards (PICCs). The two microcontrollers communicate wirelessly with each other using the ESP NOW protocol. The Editor uses its Wemos D1 Mini microcontroller to send the Envelope ID via USB serial connection to the connected laptop. A shell script process continuously reads and logs this serial data. A simple email editor opens through Applescript (based on data given by the Editor) for the user to type and address their email. When the Envelope is taken out of the Editor, the email contents are saved to a file

Figure 2: Functional prototype of A2-I2. (Left) The Editor with an envelope being inserted. (Right) The Mailbox.

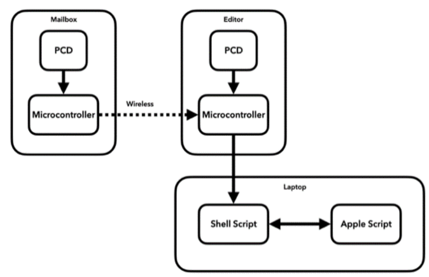

Figure 3: Technical diagram of A2-I2

associated with the Envelope ID. The Mailbox reads and sends the ID of the Envelope to the Editor, which in turn informs the laptop to extract and send contents of the appropriate file. This is done using AppleScript to automate the user's existing email software. The mailbox also contains an RGB LED-strip to illuminate the mail slot when the mail is posted.

4 METHOD

We report insights from a preliminary user study, aimed at testing users' first impressions regarding the interaction, their perceived workload and judgment of acceptability of such a device. The research was approved by the University Ethical Review Board, and informed consent was collected amongst participants. The lab study involved 8 participants (2 men, 6 women), between 20 and 29 years old. Participants were university students, recruited via the authors' professional network.

The individual lab sessions took place in a controlled office environment and lasted about 20 minutes (Figure 4). After filling out a consent form and demographic questions, the participants were invited to think of their email practices (when, how often and to whom they send emails during a typical day). Participants were then told that they were to try a different way of sending emails.

Figure 4: Overview of the exploratory user test procedure (N=8)

Table 1: Descriptive statistics of the NASA-TLX scale (N=8)

Dimension	Definition	Min	Max	Mean	SD
Mental demand	How mentally demanding was the task	25	70	45	13.1
Physical demand	How physically demanding was the task	25	70	53.1	15.1
Temporal demand	How hurried or rushed was the pace of the task	0	60	37.5	20.4
Performance	How successful were you in accomplishing what you were asked to do	0	35	21.3	10.6
Effort	How hard did you have to work to accomplish your level of performance	15	75	39.4	22.4
Frustration	How insecure, discouraged, irritated, stressed, and annoyed were you	0	80	23.1	25.6

The topic of sedentary behavior was not mentioned during the briefing of the session to avoid prompting participants. Participants were instructed to "use the editor and the envelopes to write the email", before "posting it in the physical mailbox" to send the email. Each component was shown during the explanation to clarify which object was the editor and which was the mailbox. The A2-I2 prototype was connected to a laptop and email account provided by the researcher on which the scripts were running. The mailbox was positioned 7 meters from the desk, visible to the participant if they turned their head, but not directly in view. Participants were asked to think out loud during the task.

After the task, participants were prompted to share their impressions of the interaction, and to describe how confident they felt that the email was sent. We used the standardized NASA-TLX scale [12] to evaluate the workload of the task according to 6 dimensions (each leading to a rating from 0 to 100): mental demand, physical demand, temporal demand, performance, effort, and frustration level. As active interface interactions like A2-I2 involve some effort and potentially disrupt the users' workflow (which can cause frustration or hinder the adoption of the technology), the dimensions of the NASA-TLX appear as relevant to understand the intricacies between the level of effort, physical demand, mental demand, or frustration. These factors can also be put into perspective with the perceived acceptability of such a device. A slightly adapted version of a UTAUT2 questionnaire [38, 39] was used to assess the user's acceptability of the concept and support a discussion around these topics. Items were rephrased to refer to A2-I2 as a product. Participants were asked to think out loud while completing the questionnaires. Finally, participants were asked to compare this experience to the way they usually send emails.

5 RESULTS

Descriptive statistics of the standardized scales are presented along with participants quotes. The first impressions shared by participants were rather positive, mostly due to the novelty effect of the interaction. The satisfying physical interaction created an initial enthusiasm: *"[laughs] I love this system! [repeatedly inserts and removes envelope from editor]"* (P6). The device also triggered reflections on how emails are currently handled, e.g., *"currently with my emails the content gets most of the focus, not the sending"* (P1).

5.1 Perceived Workload

The perceived workload of the task was assessed using the NASA-TLX scale (Table 1). The dimensions scoring the highest on average were physical demand (M=53.1, SD= 15.1), mental demand (M=45, SD= 13.1) and effort (M=39.4, SD= 22.4). The level of frustration was the lowest dimension (M=23.1, SD=25.6).

Regarding the physical demand, 5 participants referred to the getting up and walking part of the interaction, while nevertheless highlighting that the physical demand was reasonable: "*I did have to get up, but that's not... very demanding [laughs].*" (P2), "*I didn't mind the action putting the letter in the box and going to the inbox, I thought that was quite cute.*" (P3). Four participants out of 8 attributed the mental demand mainly to interacting with a new system for the first time: "*At first I had to discover how it worked, but later thought it's not that difficult!*" (P5). Sharing this feeling, P1 specified that mental demand also results from the extra steps required by A2-I2 to send the email, *"[the mental demand] might drop a bit as I now know how the system works, but still, it adds a few steps to the sending of the email that one has to remember. By definition, it is slower, I have to do three things instead of one".* Probably due to the controlled situation involving no time limit and only one message to send, none of the participants indicated that the temporal demand was higher than with a regular email. We would expect more effects of the temporal demand in an-situ field test, especially for employees sending emails frequently. All participants positively assessed their performance. About effort, P2 and P7 referred only to physical effort in their verbalizations: *"It was pretty good to do, it wasn't that far away"* (P7), whereas P1 and P4 referred only to mental effort: *"I'm not sure what happened if you put the envelope inside, I had to try it out."* (P4)

Table 2: Descriptive statistics related to the UTAUT2 scale (on 7-point Likert scale items) (N=8)

Dimension	Definition (by Venkatesh et al. [38, 39])	Min	Max	Mean	SD
Performance expectancy	The degree to which an individual believes that using the system will help them to attain gains in job performance	2	7	3.83	1.4
Effort expectancy	Degree of ease associated with the use of the system	3	7	6.32	0.93
Social influence	Degree to which an individual perceives that important others believe they should use the new system	1	6	3.57	1.39
Facilitating conditions	Degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system	2	7	6.03	1.37
Hedonic motivation	Fun or pleasure derived from using a technology	4	7	6.17	0.92
Behavioral intention	Intention to use the system	1	6	4.02	1.44

5.2 Perceived Acceptability

The acceptability of A2-I2 was assessed using the UTAUT2 scale (Table 2) along with participants' verbalizations.

Most participants enjoyed the hedonic aspect of the interaction, which could increase their "performance": "*Email is a task on my to-do list (...), this type of interaction would let me have fun!*" (P8). The physical presence of the device was considered an asset: "*With email it's easier for me to put it apart, do other stuff, then go back again and... I think it is a better reminder for me to finish a task.*" (P6). It was however also perceived as a barrier, "*It is a nice action. It's a cutesy thing, but if I am lazy on my couch and if I want to send this email, I will just take my phone out of my pocket and send it via there.*" (P3). In terms of effort expectancy, participants overall rated A2-I2 as very easy to learn and to use (M=6.38, SD=0.74). Not being able to see the content of the email when sending it triggered opposite experiences, some regretting the lack of control, "*I usually triple check everything (...) Instead of a green light, it gives me less confidence.*" (P1), others seeing it as a benefit: "*just putting it in a letter and replying to it would cause me less anxiety because I don't have to look at it.*" (P2). Participants expressed difficulties to assess the social influence dimension at this stage. In terms of facilitating conditions, P1 was the only participant mentioning incompatibility with other technology: "*It doesn't do Mail Merge.*" (P1). Finally, A2-I2 triggered mixed feeling regarding the intention to use the system. Participants P1, P3, P6 mentioned the lack of portability of A2-I2 as a drawback. P3: "*I don't know if I would because I am so mobile right now. (...) I always work somewhere else, and you need this thing next to your laptop.*" (P3), P1: "*It feels like a novelty item, that soon becomes disused. It's a physical device that needs to connect to another physical device. And what I like about digital technology is that I do it everywhere, and A2-I2 kind of takes that away*" (P1). Throughout testing, participants also commented on the impact of frequency of use on the acceptance of the device: "*I'm curious if it is still nice multiple times a day. If I have to walk a lot of times, I'm not sure how the effect will be, maybe it's okay*" (P5), "*I am scared if I have to do it a lot of time during the day.*" (P8). Interestingly, P7 shared an opposite view: "*I don't send emails often, so when I do it, I want to do it quickly and easy. (...) I imagine that it has added value if you do it more often.*" P8 and P3 envisioned such a use as more likely for personal and ritualized contexts. P8: "*I would use it for something intimate, because I have to use a bit more effort, and it reminds me of something for intimate people, (. . .) of postcards.*" Another consideration was shared attention and multi-tasking: "*Sometimes I reply to emails when watching a movie. I feel like I can't do that when I physically must put something away.*" (P2).

6 DISCUSSION

In this contribution, we presented A2-I2, a design exemplar of our vision of acceptably active interfaces. Through the development and evaluation of A2-I2 (N=8) we provide first insights into what enablers or obstacles designers can face when transforming mundane digital work tasks into tangible interactions, to integrate physical activity into work routines.

6.1 The Acceptability of A2-I2: a Tension between Stimulation, Efficiency and Potential Alternative Benefits

Our initial findings show that people were overall positive about this new interaction. This initial enthusiasm should however be taken cautiously, as a positive novelty effect is commonly observed when users are introduced to a novel design. As shown by Karapanos et al. [15], stimulation and learnability are key design qualities influencing users' evaluative judgments during the first experiences with a product. The mental demand attributed by participants to the fact of using a system for the first time refers to the learnability, which was deemed acceptable with the prototype (which currently does only support basic email sending features). With only a few meters between the device and the physical mailbox, the physical demand was also perceived by our participants as reasonable. As mentioned by P1, A2-I2 however reduces the efficiency of the interaction by adding extra steps in the interaction (literally and figuratively). This tension is indeed embedded into A2-I2 as an exemplar of such active interfaces, which by essence challenge the idea of convenience and productivity as the sole dominant factor in an office environment. As healthy workstyles and wellbeing at work grow in popularity, the exploration of the boundaries between an acceptable decrease in efficiency for the sake of health purposes is necessary. One can wonder for instance what the effect would be when the distance to walk to the mailbox is extended to bring a more significant number of steps? Would the fun component mentioned by participants last beyond first interactions and be sufficient to make the technology acceptable in the long term? Ideally, the redesign of work tasks could be done with additional benefits in mind. In the domain of usable security, the notion of security-enhancing friction by Distler et al. [10] envisions extra steps added to a computer action to provide time for reflection. This can help users in not falling for phishing attempts or manipulative interfaces. Applied to movement at the office, the extra effort requested by A2-I2 might be considered a positive friction, as an energizing micro-break or as a time to reflect on the content of the message sent or on collaboration in general.

Addressing these concerns and designing satisfying interactions that can integrate smoothly in work routines, should be done through a rigorous analysis of email practices. Currently, our findings highlight that the diversity of how people use email can turn A2-I2 into an obstacle, e.g., binding people to one device at their desk. The number of emails, current practices to send them and the need for efficiency at work might collide with such an active interface interaction. Ecosystems of various active interface interactions might adapt to the user context and their digital tasks, such as proposed by [6], in order to offer the right interactions at the right time.

6.2 A Vision for An Ecosystem of Acceptably Active Interface Interactions

The design concept A2-I2 constitutes a design exemplar of a broader vision of an ecosystem of acceptably active interface interactions reshaping the office of the future. Hence, the movement triggered by A2-I2 (to remain acceptable in terms of frequency of sending emails or distance to reach the mailbox) is not sufficient on its own to make a relevant difference in the level of physical activity of office workers. It can break sedentary behaviors and provide a change of posture, but supporting office workers to reach daily recommended amount of physical activity [40] would involve an ecosystem of such interactions. Such ecosystems then also might turn user acceptance into a dynamic, multi-stage process [25]. Building on multiple visions of active office environments in the HCI and design literature [4, 6, 11, 28], including speculative work [9, 24, 34], we extend this view beyond singular systems or interventions. To rethink the work environment holistically, we envision a constellation of services and designs whose components collaborate to provide office workers with a smooth yet active work experience. The integration of physical activity promoting interactions in such an embedded manner echoes ideas on ubiquitous computing, but with a bodily engaged twist. Intelligent ecosystems of small, tangible, and rich interactions might strike the right balance between what is considered to be acceptable in the work environment, and what is engaging and experiential. Imagine a system that detects when all conditions are met to transform a sitting meeting into a walking meeting in one's agenda, and users being then supported during the walk with devices such as the Hubs [7].

Our findings also hinted at the fact that a satisfying physical interaction can be an enabler. Attention should focus on the richness and aesthetics of the interaction with devices such as A2-I2. Design approaches to behavior change, such as the aesthetics of friction [13, 17], might be relevant. Imagine a system that adjusts a meeting room location to one that is further away in the building. Or a more reflective interaction aimed only at meaningful emails. Finally, another source of inspiration can be the exergame field, which uses movements as an interaction modality. While offering complete gaming experiences might not be perceived to be acceptable in a work context (yet), designers can draw inspiration from their use of tangible controls and gamification elements [31].

6.3 Limitations and Future Work

The exploratory study presented in this work-in-progress contribution entail several limitations. Besides the limited sample size (N=8), the profile of student designers is not representative of the population of office workers. The tests focused on a momentary one-time interaction with the device, on the researchers' computer and email account. This setup allowed to assess the acceptability (i.e., prospective judgment towards a technology [22] of this new form of interaction but not really its acceptance (judgement, attitude and behavioral reactions toward a product after use). Many factors in a real-life work situation will influence the experience of use of such a system (e.g., frequency of the emails, distance to the physical mailbox), some of which are hard to reproduce in a controlled situations (e.g., work pressure, social dynamic at work). Follow-up studies should thus involve a broader set of office workers working in different contexts or occupying different job positions in order to explore their experiences with the A2-I2 concept of an acceptably active interface interaction. A baseline measure of workload would be necessary to accurately assess the effect of the intervention. In-situ longitudinal studies are required to better account for context-dependent influencing factors and to understand the experience and engagement of users over time. Beyond a single device, our vision of an ecosystem of acceptably active interface interactions would involve designing and deploying several systems in a long-term study.

We also envision future work on the design concept. First, A2-I2 should be integrated within existing programs (e.g., Outlook) to not disturb the workflow and maintain the richness and functionalities of such software [6]. Second, the boundaries of acceptance should be explored to find a right balance between the physical effort and burden and the perceived benefits or enjoyment of the experience. These insights can inform the redesign of A2-I2, particularly when it comes to the location of the mailbox (distance from the computer, shared use) and design principles (e.g., making it more 'acceptable' by not requiring every mail to be sent via A2-I2, but only a random or customized selection).

7 CONCLUSION

In conclusion, we presented A2-I2 as a design exemplar of an acceptably active interface interaction. Our initial empirical findings suggest the existence of a tension between factors likely to influence the acceptability of such a technology, e.g., stimulation, efficiency, and potential alternative benefits. Contextual factors should be carefully considered to design satisfying interactions that can integrate smoothly in work routines. Used alone, A2-I2 is nevertheless unlikely to decrease the negative effects of sedentary behavior. We envision it as part of a broader ecosystem involving a subtle combination of multiple *acceptably active interactions*. Through this work, we aim to spark discussion amongst designers to think in new ways and to consider new opportunities to design for workplaces that integrate physical activity with work.

ACKNOWLEDGMENTS

The authors would like to thank the students and staff of the Health Squad of the Department of Industrial Design, Eindhoven University of Technology. Thanks to Joanna Rudzińska for the support during the initial explorations.

REFERENCES

[1] Aino Ahtinen, Eeva Andrejeff, and Kaisa Väänänen. 2016. Brainwolk – A Mobile Technology Mediated Walking Meeting Concept for Wellbeing and Creativity at Work. In *Proceedings of the 15th International Conference on Mobile and Ubiquitous Multimedia*, Association for Computing Machinery, New York, NY, USA, 307–309. https://doi.org/10.1145/3012709.3016062

[2] Scott A. Cambo, Daniel Avrahami, and Matthew L. Lee. 2017. BreakSense: Combining Physiological and Location Sensing to Promote Mobility during Work-Breaks. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3025453.3026021

[3] Pieter Coenen, Nicholas Gilson, Genevieve N. Healy, David W. Dunstan, and Leon M. Straker. 2017. A qualitative review of existing national and international occupational safety and health policies relating to occupational sedentary behaviour. *Applied Ergonomics 60*, 320–333. https://doi.org/10.1016/j.apergo.2016.12.010

[4] Ida Damen, Hans Brombacher, Carine Lallemand, Rens Brankaert, Aarnout Brombacher, Pieter van Wesemael, and Steven Vos. 2020. A Scoping Review of Digital Tools to Reduce Sedentary Behavior or Increase Physical Activity in Knowledge Workers. In *International Journal of Environmental Research and Public Health*, 17(2):499. https://doi.org/10.3390/IJERPH17020499

[5] Ida Damen, Lidewij Heerkens, Annabel Van Den Broek, Kimberly Drabbels, Olga Cherepennikova, Hans Brombacher, and Carine Lallemand. 2020. PositionPeak: Stimulating position changes during meetings. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA '20)*. Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/3334480.3383054

[6] Ida Damen, Roy Van Den Heuvel, Rens Brankaert, and Steven Vos. 2021. Advancing Digital Behavior Change Interventions by Exploring a Calendar-Based Suggestion System. In *European Conference on Cognitive Ergonomics 2021 (ECCE 2021), April 26–29, 2021, Siena, Italy.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3452853.3452866

[7] Ida Damen, Anika Kok, Bas Vink, Hans Brombacher, Steven Vos, and Carine Lallemand. 2020. The Hub: Facilitating walking meetings through a network of interactive devices. In *Companion Publication of the 2020 ACM Designing Interactive Systems Conference (DIS'20)*. Association for Computing Machinery, New York, NY, USA, 19–24. https://doi.org/10.1145/3393914.3395876

[8] Ida Damen, Carine Lallemand, Rens Brankaert, Aarnout Brombacher, Pieter Van Wesemael, and Steven Vos. 2020. Understanding Walking Meetings: Drivers and Barriers. *In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3313831.3376141

[9] Ida Damen, Ingmar Nieuweboer, Hans Brombacher, Pieter Van Wesemael, Steven Vos, and Carine Lallemand. 2021. The Office Jungle: Exploring Unusual Ways of Working through Bodily Experimentations. In *Proceedings of the 2021 ACM Designing Interactive Systems Conference (DIS'21)*. Association for Computing Machinery, New York, NY, USA, 466–477. https://doi.org/10.1145/3461778.3462062

[10] Verena Distler, Gabriele Lenzini, Carine Lallemand, and Vincent Koenig. 2020. The Framework of Security-Enhancing Friction: How UX Can Help Users Behave More Securely. In *New Security Paradigms Workshop 2020 (NSPW'20)*. Association for Computing Machinery, New York, NY, USA, 45–58. https://doi.org/10.1145/3442167.3442173

[11] Luke Haliburton and Albrecht Schmidt. 2020. Technologies for Healthy Work. *Interactions*, 64–66.

[12] Sandra Hart and Lowell Staveland. 1988. Development of NASA-TLX (Task Load Index)" Results of Empirical and Theoretical Research. In *Human Mental Workload*, P. A. Hancock and N. Meshkati (eds.). North Holland Press, Amsterdam, 239–250.

[13] Marc Hassenzahl and Matthias Laschke. 2014. Pleasurable Troublemakers. *In S. Walz & S. Deterding (Eds.), The Gameful World.* Cambridge, MA: MIT Press. 167-195. https://doi.org/10.7551/mitpress/9788.003.0011

[14] Yitong Huang, Steve Benford, and Holly Blake. 2019. Digital Interventions to Reduce Sedentary Behaviors of Office Workers: Scoping Review. *Journal of Medical Internet Research* 21, 2. https://doi.org/10.2196/11079

[15] Evangelos Karapanos, John Zimmerman, Jodi Forlizzi, and Jean Bernard Martens. 2009. User experience over time: An initial framework. *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '09)*. Association for Computing Machinery, New York, NY, USA, 729–738. https://doi.org/10.1145/1518701.1518814

[16] Harold Kohl, Cora Lynn Craig, Estelle Victoria Lambert, Shigeru Inoue, Jasem Ramadan Alkandari, Grit Leetongin, and Sonja Kahlmeier. 2012. The pandemic of physical inactivity: global action for public health. *The Lancet* 380, 9838: 294–305. https://doi.org/10.1016/S0140-6736(12)60898-8

[17] Matthias Laschke, Sarah Diefenbach, and Marc Hassenzahl. 2015. "Annoying, but in a nice way": An inquiry into the experience of frictional feedback. *International Journal of Design* 9, 2: 129–140.

[18] Casey Lindberg, Karthik Srinivasan, Brian Gilligan, Javad Razjouyan, Hyoki Lee, Bijan Najafi, Kelli J. Canada, Matthias R. Mehl, Faiz Currim, Sudha Ram, Melissa M. Lunden, Judith H. Heerwagen, Kevin Kampschroer, and Esther M. Sternberg. 2018. Effects of office workstation type on physical activity and stress. *Occupational and Environmental Medicine* 75, 10: 689–695. https://doi.org/10.1136/OEMED-2018-105077

[19] Paul Littlewood, Ignace Glorieux, and Ingrid Jönsson. 2004. *The Future of Work in Europe.* London: Routledge. https://doi.org/10.4324/9781351146609

[20] Yuhan Luo, Bongshin Lee, Donghee Yvette Wohn, Amanda Rebar, David Conroy, and Eun Kyoung Choe. 2018. Time for Break: Understanding Information Workers' Sedentary Behavior Through a Break Prompting System. *In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. Association for Computing Machinery, New York, NY, USA, Paper 127, 1–14. https://doi.org/10.1145/3173574.3173701

[21] Brittany T. MacEwen, Dany J. MacDonald, and Jamie F. Burr. 2015. A systematic review of standing and treadmill desks in the workplace. *Preventive Medicine* 70: 50–58. https://doi.org/10.1016/J.YPMED.2014.11.011

[22] Nicolas Martin, Éric Jamet, Séverine Erhel, and Géraldine Rouxel. 2016. From acceptability to acceptance: Does experience with the product influence user initial representations? *Communications in Computer and Information Science* 617: 128–133. https://doi.org/10.1007/978-3-319-40548-3_21

[23] Akhil Mathur, Marc Van Den Broeck, Geert Vanderhulst, Afra Mashhadi, and Fahim Kawsar. 2015. Tiny habits in the giant enterprise: Understanding the dynamics of a quantified workplace. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp'15)*. Association for Computing Machinery, New York, NY, USA, 577–588. https://doi.org/10.1145/2750858.2807528

[24] Daphne Menheere, Ida Damen, Carine Lallemand, and Steven Vos. 2020. Ivy: A qualitative interface to reduce sedentary behavior in the office context. In *Companion Publication of the 2020 ACM Designing Interactive Systems Conference (DIS'20)*. Association for Computing Machinery, New York, NY, USA, 329–332. https://doi.org/10.1145/3393914.3395822

[25] Camille Nadal, Shane McCully, Kevin Doherty, Corina Sas, and Gavin Doherty. 2022. The TAC Toolkit: Supporting Design for User Acceptance of Health Technologies from a Macro-Temporal Perspective. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (CHI'22)*. Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3491102.3502039

[26] Michel Peeters, Carl Megens, Elise Van Den Hoven, Caroline Hummels, and Aarnout Brombacher. 2013. Social stairs: Taking the piano staircase towards long-term behavioral change. In *Berkovsky, S., Freyne, J. (eds) Persuasive Technology. PERSUASIVE 2013. Lecture Notes in Computer Science*, 174–179. https://doi.org/10.1007/978-3-642-37157-8_21

[27] Meihua Piao, Hyeongju Ryu, Hyeongsuk Lee, and Jeongeun Kim. 2020. Use of the Healthy Lifestyle Coaching Chatbot App to Promote Stair-Climbing Habits Among Office Workers: Exploratory Randomized Controlled Trial. *JMIR Mhealth Uhealth* 8, 5. https://doi.org/10.2196/15085

[28] Kathrin Probst. Active Office: Designing for Physical Activity in Digital Workplaces. *In Proceedings of the 14th International Conference on Mobile and Ubiquitous Multimedia (MUM '15)*. Association for Computing Machinery, New York, NY, USA, 433–438. https://doi.org/10.1145/2836041

[29] Nicolaas P. Pronk. 2021. Implementing movement at the workplace: Approaches to increase physical activity and reduce sedentary behavior in the context of work. *Progress in Cardiovascular Diseases* 64: 17–21. https://doi.org/10.1016/J.PCAD.2020.10.004

[30] RAAAF. 2015. The end of sitting. *Harvard Design Magazine*, 2. Retrieved October 26, 2022 from https://www.raaaf.nl/downloads/HDM40_ExtendedArtifact_Rietveld.pdf

[31] Xipei Ren, Bin Yu, Yuan Lu, Yu Chen, and Pearl Pu. 2018. HealthSit: Designing Posture-Based Interaction to Promote Exercise during Fitness Breaks. *International Journal of Human–Computer Interaction* 35, 10: 870–885. https://doi.org/10.1080/10447318.2018.1506641

[32] Ian Renfree and Anna Cox. 2016. Tangibly Reducing Sedentariness in Office Workers. In *CHI '16 workshop: Tangibles 4 Health.* Retrieved October 26, 2022 from https://discovery.ucl.ac.uk/id/eprint/1477628/

[33] Daniela Schmid, Cristian Ricci, and Michael F. Leitzmann. 2015. Associations of Objectively Assessed Physical Activity and Sedentary Time with All-Cause Mortality in US Adults: The NHANES Study. *PLOS ONE* 10, 3: e0119591. https://doi.org/10.1371/JOURNAL.PONE.0119591

[34] Sjoerd Stamhuis, Hans Brombacher, Steven Vos, and Carine Lallemand. 2021. Office Agents: Personal Office Vitality Sensors with Intent. *In Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems (CHI EA '21)*. Association for Computing Machinery, New York, NY, USA, Article 174, 1–5. https://doi.org/10.1145/3411763.3451559

[35] Jennifer Sween, Sherrie Flynt Wallington, Vanessa Sheppard, Teletia Taylor, Adana A. Llanos, and Lucile Lauren Adams-Campbell. 2014. The Role of Exergaming in Improving Physical Activity: A Review. *Journal of Physical Activity and Health* 11, 4: 864–870. https://doi.org/10.1123/JPAH.2011-0425

[36] Helena Tobiasson, Anders Hedman, and Sundblad Yngve. 2014. Still at the Office: Designing for Physical Movement-Inclusion During Office Work. In *Brazilian Symposium on Human Factors in Computer Systems (ICH'14 XIII)*. Retrieved October 26, 2022 from http://urn.kb.se/resolve?urn=urn:nbn:se:mdh:diva-52488

[37] Catrine Tudor-Locke, John M. Schuna, Lauren J. Frensham, and Mahara Proenca. 2013. Changing the way we work: elevating energy expenditure with workstation alternatives. *International Journal of Obesity 2014 38:6* 38, 6: 755–765. https://doi.org/10.1038/ijo.2013.223

[38] Viswanath Venkatesh, Michael G. Morris, Gordon B. Davis, and Fred D. Davis. 2003. User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems* 27, 3. https://doi.org/10.2307/30036540

[39] Viswanath Venkatesh, James Y.L. Thong, and Xin Xu. 2012. Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly: Management Information Systems* 36, 1. https://doi.org/10.2307/41410412

[40] World Health Organization. 2018. *Global action plan on physical activity 2018–2030: more active people for a healthier world*. Geneva. Retrieved June 6, 2022 from https://apps.who.int/iris/bitstream/handle/10665/272722/9789241514187-eng.pdf