Everyday Peripheral Tasks vs. Digital Peripheral Tasks

Figure 1. Everyday tasks - drinking tea, tying shoe laces and stirring the soup - carried out in the periphery while focusing on another task - reading a book, talking to a colleague, checking the recipe.

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Abstract
Peripheral interaction is very common in everyday interaction with the physical world. We seemingly effortlessly tie our shoe laces while being fully engaged in a conversation or stir the soup on the stove while reading the recipe. Recently researchers started to build on this human capability of dividing attention and develop digital devices that also are intended to be operated in the attentional (and visual) periphery. However, evaluating to which extent a device indeed moves into the periphery is hard to assess. This work aims at investigating everyday peripheral tasks with the physical world to offer insights on their effect on computer-based work and act as comparison for digital peripheral devices.

Author Keywords
Peripheral Interaction; Multitasking; Evaluation

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
Peripheral interaction aims at moving interaction with digital devices from the center of attention to the periphery of attention. The field is inspired by ambient information, which uses peripheral perception of information [10], and calm technology, which is described by moving between the center and the periphery of attention [12]. Moreover peripheral interaction is motivated by our physical everyday experiences and inter-

actions [2]. For instance, while reading a book we take a sip from our tea mug, without moving our attention away from the written text (see Figure 1).

Several peripheral interaction devices have been developed and evaluated (e.g., [1], [3],[4],[9]). Evaluation strategies range from lab experiments to field deployments [5] assessing for instance performance loss [9] or subjective ratings on imposed mental load [3]. Research in the context of multitasking tries to assess the influence of the environment on digital tasks [11], however, only few researchers compare peripheral devices to other non-digital peripheral tasks carried out in the same setting as the device [1]. Thus peripheral interaction devices are often evaluated isolated and detached from the real world context. We argue that the comparison to peripheral everyday tasks can be used to validate digital peripheral devices and assess to which extent they actually move to the periphery.

With our previously developed lab evaluation methodology [5] that we already used to assess two different peripheral devices [4][5], we here seek for a comparison to non-digital peripheral everyday tasks that people regularly carry out while working on a desktop computer. Examples for such tasks are drinking, switching on a desk lamp or having a short conversation. Previous work [1] up to now only offered a comparison to everyday tasks by asking study participants to rank the interaction with the digital device according to other everyday tasks, collecting solely subjective experience. With our work we add on that by offering a comparison to everyday tasks based on quantitative data.

Related Work

Peripheral interaction usually addresses dual task scenarios – a primary task, which captures the main attentional (and often also visual) focus and a secondary task, which ideally only asks for minimal attention. This division and distribution of mental resources is described by Kahnemann's theory of divided attention [8]. The amount of mental resources required by a specific task depends on several factors such as difficulty, training and effort. However, mental resources are not the only limiting factor. Based on Wickens' Multiple Resource Theory [13], four dimensions can cause interferences in parallel task execution, among them perceptional modalities (visual vs. auditory) as well as processing codes, which are used to describe interferences between manual interaction and verbal processing.

Bakker et al. [2] analyzed how people use the periphery of attention in everyday life and consider three types of peripheral tasks – sensorial, cognitive and bodily – with most of them being bodily and carried out by the hands. They further clustered activities into four categories, main activities, temporary side activities internally triggered, temporary side activities externally triggered and ongoing side activities. We will focus on side activities alongside another primary task.

Side activities – at least when not in the periphery – interrupt the main task. Research in multitasking and interruption management shows that half of the interruptions are internally (i.e. voluntarily) triggered [7]. Jin and Dabbish [7] depicted seven types of self-interruption: adjustment (to improve the situation), break (from current primary task), inquiry (of additional information), recollection (remembering a different task), routine (addressing a task out of habit), trigger (another task e.g., by the primary tasks) and wait (until the primary task can be continued).

Table 1. Selection of everyday tasks and their categorization

Task	Execution	Peripheral Task Type	Interruption Type
Drink	Binary	Bodily	Break Routine
Food	Binary	Bodily	Break Routine
Light	Binary	Bodily	Adjustment
Note	Non-Binary	Bodily Cognitive Sensorial (Auditory/ Visual)	Recollection
TV	Non-Binary	Bodily Cognitive Sensorial (Auditory/ Visual)	Break
Talk	Non-Binary	Cognitive Sensorial (Auditory)	Break Inquiry

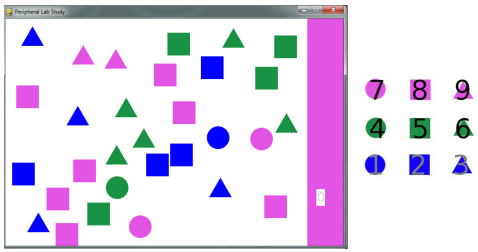

Figure 2. The primary task [5]: participants are asked to remove all items in the given color on the right by clicking on them and in parallel pressing the corresponding number of the item on the keypad.

Selecting Everyday Tasks

We selected six tasks resembling small everyday activities often carried out next to computer-based work and classified them in three dimensions (see Figure 2).

Execution Type: One possibility to execute a task such as switching on the light (binary), or a range of possibilities (also ranging in difficulty/disruption) such as watching TV, which can be carried out attentively or in the background when glancing at the screen every now and then and listening on the side (non-binary).
Peripheral Task Type: Based on Bakker et al. [2], tasks can be bodily (involving hands or body), sensorial (mainly visual or auditory) or cognitive (beyond the mere intention of carrying out the task). When covering several types, the emphasis between them might differ.
Interruption Type: Based on Jin's and Dabbish's seven types of self-interruption [7], but due to the artificial task of the lab evaluation, we only address task types unrelated to the primary task. Inquiry is an exception, because talking can be related to the primary task. In contrast, breaks, routine tasks, or adjustments on the desk are independent of the primary task. Finally, recollection is unrelated according to Jin and Dabbish, but, we can imagine that taking a note for recollection could be related to a primary task.

Experimental Design

The experimental design is based on an existing lab study methodology for peripheral interaction [5]. It consists of a bimanual task of clicking and removing items while in parallel pressing a corresponding key on the keyboard (see Figure 2).

The following six tasks were integrated in our study:

Drink: A drink in a glass was placed next to the keyboard. We asked them to take a sip for every trigger.
Food: A chocolate bar was placed next to the keyboard. We instructed them to take a bite for every trigger. The first trigger included unwrapping.
Light: A desk lamp with a flip switch was placed at reach. Participants were asked to switch the light on (first/third trigger) or off (second/forth trigger).
Note: Paper and pen were located next to the keyboard. Next to the displayed trigger, an audio recording was played stating a short message that should be noted (similar to an appointment e.g., a name and a date).
TV: A remote control was placed next to the keyboard. For every trigger participants were asked to switch the TV on (first/third trigger) or off (second/forth) trigger.
Talk: Next to the visual trigger a recorded question was played (e.g., How are you? Are you still at university?). Participants were told to answer the question but not necessarily truthfully. (Conversational interruptions are also investigated by Iqbal and Horvitz [6].)

Participants

18 participants (three female) took part in our study. They were 22 to 31 years old (average 25). While working on the computer, drinking is regularly carried out by most participants (94%), switching on a desk lamp by the least participants (56%).

Procedure

We used a Latin square design to counterbalance the six tasks (repeated measures design). All tasks were triggered four times visually on-screen next to the primary task and additionally auditory for note taking and talk. We made sure that participants could easily carry out the secondary task and return to the primary task before another trigger appeared.

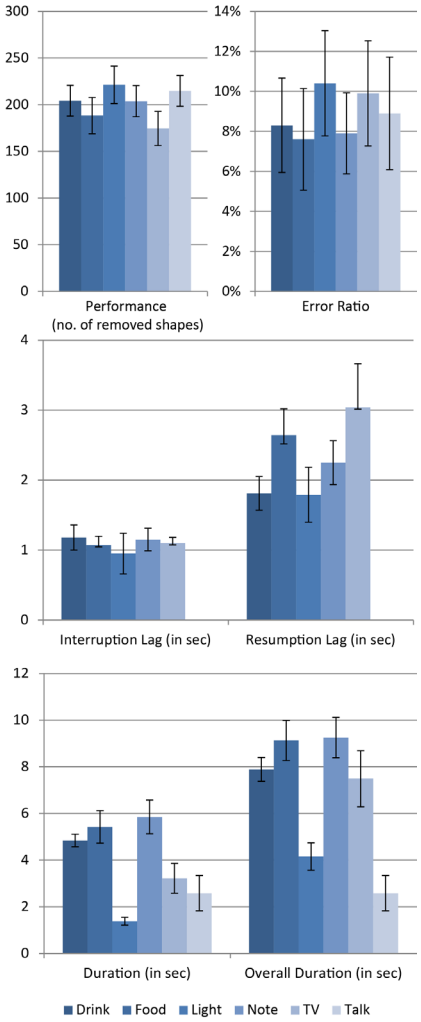

Figure 3. Quantitative data for the everyday tasks. Error bars indicate 95% confidence intervals.

As dependent variables we logged the number of correctly removed items in the primary task as well as errors (i.e., wrong color, wrong key press). We recorded interruption lag (time between last primary task interaction and start of secondary task), resumption lag (time between last secondary task interaction and resuming primary task) and measured the overall duration of the secondary task all via video analysis.

After an introductory questionnaire, we explained the primary task and let them train it without a secondary task. Then we introduced one secondary everyday task for each round, asked them to perform the primary and secondary task in parallel and handed another questionnaire. Finally, after all six rounds (one lasted three minutes) we handed out a comparative questionnaire. When applicable we used 5-point Likert scales ranging from 1=I strongly disagree to 5=I strongly agree.

Results

As our main focus of this study was not to derive which of the peripheral everyday tasks would disturb the primary task the least, we refrained from statistical analysis. Instead we focus on descriptive statistics, which can be used for a comparison to peripheral digital tasks (see Figure 3).

Performance

As performance we counted items correctly removed in the primary task. Performance was best for *Light* (m=221.3, sd=43.3) followed by *Talk* (m=214.8, sd=35.6), *Drink* (m=204.2, sd=35.5), *Note* (m=203.8, sd=36.1), *Food* (m=188.4, sd=42.1) and *TV* (m=174.6, sd=39.8).

When watching *TV* some participants stopped the primary task completely, explaining the bad performance, although the interaction itself, switching the TV on and off, was short. While chewing *Food,* participants were disrupted, although their hands were already available for the primary task. In contrast, participants carried out *Talk* without stopping the primary task, as their hands were not required. Still, cognitive processes seem to slow them down, as light, which interrupted the primary task, performed better.

Error Ratio

Looking at errors in relation to successfully removed items we observed least for *Food* (m=7.6%, sd=5.5%) followed by *Note* (m=7.9%, sd=4.4%), *Drink* (m=8.3%, sd=5.1%), *Talk* (m=8.9%, sd=6.1%), *TV* (m=9.9%, sd=5.7%) and *Light* (m=10.4%, sd=5.7%). Only three triggers were overlooked in total, so we did not further analyze them.

Interruption, Resumption Lag and Overall Duration

Interruption lag (time between stopping primary and starting secondary task) was shortest for *Light* (m=0.95s, sd=0.63s) followed by *Food* (m=1.07s, sd=0.27s), *TV* (m=1.10s, sd=0.17s), *Note* (m=1.15s, sd=0.35s) and *Drink* (m=1.18s, sd=0.39s).

Resumption lag (time between stopping secondary and restarting primary task) was again shortest for *Light* (m=1.79s, sd=0.85s), followed by *Drink* (m=1.81s, sd=0.52s), *Note* (m=2.25s, sd=0.68s), *Food* (m=2.64s, sd=0.82s) and *TV* (m=3.04s, sd=1.35s). Resumption lag was always longer than the interruption lag as already observed for digital peripheral tasks [4].

The duration of the secondary task was shortest for *Light* (m=1.38s, sd=0.36s) followed by *Talk* (m=2.58s, sd=1.64s), *TV* (m=3.22s, sd=1.38s), *Drink* (m=4.84s, sd=0.58s), *Food* (m=5.42s, sd=1.51s) and *Note* (m=5.85s, sd=1.57s).

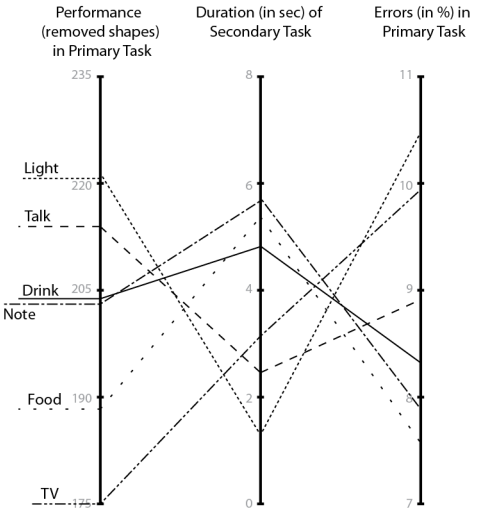

Figure 4. Results for all everyday tasks. While axis do differ in scale, the interesting finding visible is that lines do not even roughly run parallel, indicating that the performance while interacting with a secondary peripheral everyday tasks does not give insights on the duration or the errors caused by this task.

The overall duration (consisting of interruption lag, duration of the secondary task and resumption lag) was shortest for *Talk* (m=2.58s, sd=1.64s), because we could not detect an interruption or resumption lag, as participants carried on interacting in the primary task while talking. Next shortest is *Light* (m=4.15s, sd=1.27s) followed by *TV* (m=7.49s, sd=2.60s), *Drink* (m=7.89s, sd=1.11s), *Food* (m=9.13s, sd=1.85s) and *Note* (m=9.25s, sd=1.87s).

Subjective Data

Participants considered all tasks as fairly easy (median≥4). Based on a Condorcet Ranking *Note* was most difficult, followed by *Talk*, *TV*, *Food*, *Light* and *Drink*. The ranking for disruption only differs for *TV*, which was considered most disruptive followed by *Note*, *Talk*, *Food*, *Light* and *Drink*. This is in line with subjective ratings of having to be medium concentrated for *TV*, *Note*, *Talk* and *Food* (median=3) but less for *Light* and *Drink* (median=2).

Discussion

In our study we explored a selection of peripheral everyday tasks frequently carried out in everyday life. Please note that results (quantitative as well as subjective) might slightly differ for everyday situations. People would be familiar with the location of their desk lamp or the buttons of their remote control. In contrast, talks might be more complex than in our study. Nevertheless, we believe this is a first impression on the effect of peripheral everyday tasks on computer-based work and a basis for comparing digital peripheral tasks.

Comparison of Everyday Tasks

Figure 4 shows performance and errors during primary task, and duration of the secondary task. One interesting finding is that performance in the primary task is not deducible from the duration of the secondary task. Thus, just limiting the time of interaction and using this as indicator for a good peripheral interaction design is not an exhaustive measurement. More importantly cognitive processes, i.e. the distribution of mental resources, and disruptions need to be carefully assessed. We found that some interferences are far from obvious, for instancce chewing disrupted participants although their hands and visual channel were already available again. Thus, manual interaction can be easy or even already finished but peripheral interaction still disrupts the main task (e.g., eating, TV).

Comparison to Other Studies

We compared the data collected for everyday tasks to data we collected in two previous studies with the same lab evaluation method (see Table 2). For comparison we used performance (number of removed items per minute), error ratio and interruption lag.

The first study, the Peripheral Audio Controller [3][5], investigated four different input styles: graspable interaction, touch and freehand gestures as well as media keys. Some users were not familiar with the input styles (novice), others used each at home for two weeks beforehand (experienced). The second study [4] also investigated different input styles – graspable, touch and freehand – but for email sorting.

Table 2 shows that nearly all peripheral everyday tasks rank in the top positions, most likely because they are well known and far better trained than any new digital peripheral task. However, numbers do not differ greatly. Thus, we believe that with more training and habituation, results would improve and be close to the everyday tasks. This indicates that digital tasks indeed can be considered peripheral.

Table 2. Comparison of Results: Results for everyday tasks (in bold), results for the Peripheral Music Controller (in italic) (N=novice users; E=experienced users) [5] and results for Interaction Styles & Feedback [4].

Performance (per minute)	Error Ratio (in percent)	Interrupt Lag (in seconds)
73.8 **Light**	7.6 **Food**	— **Talk**
71.6 **Talk**	7.9 **Note**	0.95 **Light**
68.1 **Drink**	8.3 **Drink**	1.07 **Food**
67.3 **Note**	8.9 **Talk**	1.10 **TV**
67.2 *Grasp N*	9.9 **TV**	1.18 **Drink**
64.5 *Touch N*	10.4 **Light**	1.15 **Note**
64.0 *Grasp E*	11.0 *Touch N*	1.66 *Grasp E*
62.8 **Food**	11.1 *Grasp N*	1.74 *Touch E*
61.0 Freehand	11.2 *Grasp E*	1.97 *Grasp N*
60.8 Keys N	11.2 Freehand	2.02 *Keys E*
59.8 *Touch E*	11.9 *Keys N*	2.04 *Touch N*
59.1 Touch	12.0 Touch	2.06 Touch
58.2 **TV**	12.2 *Freehand N*	2.09 *Keys N*
58.1 *Freehand N*	12.4 *Freehand E*	2.31 *Freehand N*
55.0 *Keys E*	13.0 *Keys E*	2.32 Freehand
53.4 *Freehand E*	14.4 *Touch E*	2.58 *Freehand E*
52.4 Grasp	14.9 Grasp	2.73 Grasp

Conclusion

We offered first insights into different everyday peripheral tasks and their effect on computer-based work. We collected data available for comparison to future digital peripheral interaction designs[1]. We compared two previous projects to peripheral everyday tasks and found similar results. Thus we believe that the devices we designed for peripheral interaction indeed can move to the periphery of attention. We also verified the motivation of peripheral interaction research to design for the periphery based on our physical daily life actions.

However, this work comes with limitations. We only investigated a desktop computer scenario with one artificial primary task. We limited our tasks to self-interrupted tasks (although we had to trigger them in the lab). Thus, this work on peripheral everyday tasks and their effect on digital primary tasks is still in progress. In the future we will address other primary tasks (e.g., mobile) and secondary tasks (e.g., externally interrupted) to fully understand the effects of everyday peripheral tasks and apply these findings to peripheral digital tasks, strengthening the motivation for peripheral interaction of using our everyday life capabilities.

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