Desktop PC, Tablet PC, or Smartphone? An Analysis of Use Preferences in Daily Activities for Different Technology Generations of a Worldwide Sample

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Abstract. Our daily life is characterized by increasing digitalization. As a result digital technologies are becoming an integrated part of everyday activities. The most used devices are desktop PCs or laptops, tablet PCs, and smartphones, which mainly differ with regard to the screen size and the method of data entry. Given the growing diffusion of technological devices, the increasing ownership of multiple devices, and the resulting different usage patterns between devices, it is essential to gain insights into which devices are used for which activities. The aim of this analysis was to examine a total of 21 activities people engage in on a day-to-day basis with regard to desktop PC or laptop, tablet PC, and smartphone usage. When considering user characteristics with regard to technology, one of the most influential factors is the user's age. Therefore, the sample (N = 1923) was analyzed with regard to four different technology generations. Results show that there are significant differences in device usage between the activities under study and between the four analyzed technology generations.

Keywords: Human-system interaction · Ergonomic design · Handheld devices Usability · Ageing

1 Introduction

The proliferation of smartphones and tablet PCs is now increasing the time people spend engaging with digital content and the range of places in which they do so. In 2017 the market share of smartphones was 50.9%, desktop PCs[1] 44.8%, and tablet PCs 4.3% [1], whereas in 2015 the market share was highest for desktop PCs with 62.4%, followed by smartphones with 31.1% and tablet PCs with 6.5% [2]. These numbers show that the market share of smartphones increased and even got ahead of desktop PCs in recent years.

[1] Desktop PCs and laptops can be used interchangeably through the use of external screens and input equipment. Furthermore, desktop PCs and laptops are less usable – or not usable at all – in mobile situations than smartphones and tablet PCs. Therefore, desktop PCs and laptops are regarded as belonging to the same category and therefore are termed desktop PCs throughout this paper.

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Although the boundaries between desktop PCs, tablet PCs, and smartphones are sometimes fuzzy, Lugtig and Toepoel [3] proposed that all devices can be classified along two dimensions: (1) method of data entry and (2) screen size. In order to use a desktop PC, information input is carried out by a combination of hand movements with a mouse and character entry is administered through a keyboard. Tablet PCs and smartphones on the other hand use touchscreens that are operated by finger contact with the screen while text entry is carried out via an on-screen keyboard. Another important difference between desktop PC, tablet PC, and smartphone is the size of the screen. Desktop PCs usually have a screen size of 17 inches or larger, while smartphones at the other extreme are endowed with a screen that is about 5 in. The size of tablet PCs can be ranked in between the sizes of smartphones and desktop PCs but the screen sizes of tablet PCs varies widely between 7 in. on the low end and 18.4 in. on Samsung's Galaxy View tablet PC as an example. Regarding the difference in screen size, variations may lead to differences in the visual presentation of information, which in turn might influence a user's perception of the information. Bruijne and Wijnant [4] studied the speed of the interaction comparing desktop PCs, tablet PCs, and smartphones and found that there was no difference between desktop PC and tablet PC usage, while smartphone users were slower than desktop PC and tablet PC users. The authors proposed the difference in screen size as a possible reason for their results, while variations in the Internet connection could not fully be ruled out. Overall, finger navigation is less precise than mouse navigation, which might lead to a decrease in interaction speed depending on the size of the device. Determined by the design of the software or the app, the necessity to scroll might also have an influence on speed and might cause smartphone usage to be slower.

Given the growing adoption of smartphones, the increasing ownership of multiple devices, and the resulting different usage patterns between desktop PC, tablet PC, and smartphone, it is essential to gain insights into which devices are used for which activities. Knowledge of the activities users pursue with which device might promote the design of relevant content in the form of, for example, user interfaces that are suited for interactions in mobile situations. In addition, knowledge of activities that are not pursued with a specific device up to now might give insights into possible problems and hurdles for the interaction. Knowledge about the non-use of a specific device may enable researchers and practitioners to consider ways to improve the interaction.

1.1 Previous Findings

So far, multiple studies have investigated different activities in relation to device usage. Jokela et al. [5] for example studied smartphone usage by means of a diary study and found that smartphones are used for a wide range of different tasks like e-mailing, text messaging, making phone calls, web browsing, social media, listening to music, and calculating. Commonly, the usage of smartphones also includes taking pictures, and for some subjects of the study the phone is in fact their primary camera. However, Jokela et al. [5] also found that smartphones are not regarded as suitable for handling large amounts of information or complex tasks. For complex tasks, which might include writing long texts, administering detailed work, and handling large amounts of content, the desktop PC or laptop is still the preferred device and has not yet been replaced by

other devices in the way it has for entertainment-oriented tasks. Computers are also considered as reliable devices that participants fall back to when their other devices fail at a task.

In research carried out with a young age group Galley et al. [6] found that the main functions of tablet PCs are the spontaneous retrieval of information and in the entertainment sector. The advantages of easy interaction because of their small and handy sizes and better start-up times compared to desktop PCs and laptops are striking. Another major advantage is the handwriting recognition capability [7–9], but the lack of 3G support for tablet PCs was an often reported disadvantage [6], and moreover they are acknowledged to be unsuitable for the typing of long texts [5, 10]. With technological developments over the past decade having resolved the issue of 3G support for a variety of devices, including the tablet [11], the only remaining issue is the difficulty of administering complex or detailed work.

To summarize the tablet PC's position in comparison to other devices, it can be said that in spite of good prerequisites, a tablet is an "intermediate thing" [6] due to various restrictions compared to other devices such as laptops, smartphones, or analog tools. So it seems to find its purpose where the small smartphone reaches its limits and the large, feature-rich desktop PC is not practical enough [6]. However, some statistics suggest that the tablet hype is over because of stagnating sales figures while sales numbers of smartphones continue to increase [12]. The main cause for this development may lie in the fact that people are not changing or upgrading their tablet PCs as often as other devices, in addition to a lack of use in their everyday lives [13].

Age-Differentiated Analyses. In order to further study the importance of age in the use of computational devices, age-related analyses have been carried out (e.g. [14–17]). With regard to the general usage of technological devices, different distributions of ownership by age are noticeable. While ownership of smartphones in 2017 is more or less comparable between the age groups of 14–29 (95%), 30–49 (97%), and 50–64 years of age (88%), only 41% of persons who are older than 64 years own a smartphone [18]. Tablet PC ownership even drops to 3.4% in this age group. Tablet PC ownership is highest in the group aged up to 19 years (29.8%), while the respondents aged 20–29 (21.5%) and 30–39 years of age (23.6%) achieve similar rates. In the middle-aged group (40–59 years of age) tablet PC ownership varies between 6.9% and 14.8% [19]. With regard to desktop PC usage the younger groups showed similar penetration rates as in smartphone ownership (10–15: 97%; 16–24: 98%; 25–44: 97%) and reaches values of almost 100%. The group aged 45–64 years is behind the younger age groups with a penetration rate of 88%. As was the case in smartphone and tablet PC ownership, the oldest age group older than 65 only has a comparatively small share proportion of computer users (48%) [20].

There is also a gap between subjects of different ages with regard to activities in the entertainment sector. As a study on the use of social networks in relation to age in the USA in 2017 shows, mostly people between the ages of 18 and 29 are the ones who use social networks such as Facebook (86%) to connect with people, Instagram (58%) for sharing photos, and YouTube (71%) to watch videos [21]. On the other hand, people over 60 years of age have the largest proportion of those who do not use these services at all (27%). In addition, entertainment activities like listening to Internet radio and

watching videos or TV programs online with a smartphone or tablet PC are significantly more common among younger age groups [22]. With regard to gaming, as an activity which is also included in the entertainment sector, age-related differences are also noticeable. Younger subjects are most likely to engage in gaming activities. Among subjects aged 16–24, 57% engage in gaming activities, followed by 39% of subjects aged 25–34. In contrast, users over 45 years of age are less likely to engage in gaming (16% of 45–54 s, 10% of 55–64 s, 4% of 65–74 s and 2% of over-75s). Regarding the device that is used for gaming activities it was found that users prefer smartphones and gaming consoles [23].

There is also a growing interest in online shopping, as was documented by Kuoppamäki et al. [22]. Surprisingly, the use of mobile input devices for online shopping does not differ between young and old consumers. Another service that is gaining increasing popularity and can not only be administered through personal contact but also through the use of desktop PCs or mobile devices is Internet banking [24]. Here, the most important variable that predicts the adoption of Internet banking services is age [25]. According to data from 2016, the usage of Internet banking differs between younger users, who most often use Internet banking for making cash withdrawals abroad or carrying out transfers, and older age groups, who prefer face-to-face service in bank branches [26]. No data are available about which device is preferred for Internet banking, but as banking is an activity that depends greatly on trust and is a rather complex activity, it can be expected that the desktop PC is the device that is used most often for banking activities.

Other activities that are often administered with smartphones and tablet PCs are navigation and buying tickets. Traditionally, maps that were either bought as large hardcopy versions or printed by using desktop PCs were used for navigation. Nowadays, navigation can easily be administered by mobile devices that use satellite information. But unlike younger users aged 18–29 years, who are likely to use their smartphones for turn-by-turn navigation (80%), the percentage of users who are 50+ and use their smartphone for navigation drops to 44.5% [27]. Young consumers, primarily aged between 16 and 24 years of age, are furthermore the most likely users to utilize the smartphone at least weekly as a ticket or boarding pass or to gain entry to an event [23]. The advantage of mobile ticketing lies in its general efficiency through the use of mobile technology, as access is possible independent of time and space. Furthermore, queues are reduced and activities like printing a ticket are made redundant [28].

Instant messaging has become a popular form of communication. In addition to the basic chatting feature, most instant messaging services provide additional features such as file transfer or video calling [29]. While the number of users of messaging apps worldwide in 2016 was 1.56 billion, the number by 2019 is expected to reach up to 2.18 billion and by 2021 2.48 billion, as forecasted by Statista in January 2018 [30]. According to a ranking of the most popular social networks and messengers, the Facebook Messenger and WhatsApp share the fourth place in January 2018 behind YouTube, and Facebook [31]. In Germany WhatsApp is one of the leading short message services [32]. According to a survey from the Social Media Atlas 2016/17, 55% of social media users in Germany actively use this instant messaging service [33]. Hameed and Kamran [34] reported that younger-aged participants may send and receive more than 100 text messages a day. In comparison, in 2011 adults aged over 55

sent or received on average a maximum of nine text messages a day [35], although Keränen et al. [36] pointed out that these numbers are increasing.

1.2 Technology Generations

Understanding user requirements is one essential part of studying human-computer interaction. Taking chronological age into account, however, is often not productive as aging processes are highly individual, resulting in ambiguous measurements. Therefore, considering the subject's age in combination with period and cohort effects seems promising. Age, period, and cohort effects must be considered as being interrelated, as it is impossible to deal with one without also dealing with the others. Age effects are the result of getting older and deal with specific effects in different age groups. Period effects are the consequences of influences that vary through time and are associated with all age groups simultaneously. Cohort effects are the consequences of being born at different times and are associated with variations in successive age groups in successive time periods (e.g. long-term habits or long-term exposures), so different generations are exposed to different factors. Estimating the effects of either one of those is not easy because the effects may be confounded with the others [37].

Building on existing theories regarding age-period-cohort models, the concept of technology generations was introduced by German sociologists in the early 1990s [38]. These researchers defined a technology generation as "groups of birth cohorts whose conjunctive experience with technology is differentiated by social change" (p. 493). The authors state further that technological change, and especially changes in basic technologies, enhances inter-cohort differences, thereby raising the likelihood of a conscious perception and description of differences as generational differences. The concept of technology generations includes technologically-related cohort effects and refers to cohort variations with regard to changes in the social and cultural environment.

A range of birth cohorts that show behavioral similarities or shared norms and values based on common sociological environments and predominant developments during the formative period (the period of time between adolescence and young adulthood, operationalized between 10 and 25 years) is called a generation. Studies about age cohorts have shown that after young adulthood, individuals are less likely to change their attitudes, norms and values. During the formative period, subjects undergo a number of crucial transitions, like from school to university or from parental home to independent living. Researchers found out that acquired norms, skills and values during that period tend to be constant and influence behavior later in life [39]. Sackmann and Weymann [38] point out that individuals experiencing the availability of the same types of products during the formative period display similar product usage many years later. Thus, different technology generations appear to behave differently with respect to technology, which is the result of differences in their experience gained in their formative years. Going further, Docampo Rama et al. [40], whose approach consisted of distinguishing technology generations by interface usage, infer that generation-specific technology experience could induce differences in the usage behavior of current consumer products. Older people may be at a disadvantage in using present complex user interfaces, as they did not acquire that skill in their formative period earlier in life.

The question then arises where the boundary between different birth cohorts occurred. Following earlier investigators [41, 42], Docampo Rama et al. [40] define changes in basic technology causing generational differentiation as the point in time where 20% diffusion within the population has been reached. At that point, it is regarded as likely that persons who do not have such technologies themselves have experienced them in their social surroundings (e.g. in their families, with their friends or at work). In order to get information about the degree of diffusion of a technology, Sackmann and Weymann [38] used qualitative interviews, group discussions, surveys, and secondary data analysis to develop and test their concept of technology generations. As a result of this, Sackmann and Weymann [38] distinguished generations from birth cohorts that currently are displaying similar behavior with regard to technology based on technological achievements in their formative periods. Hence, four different technology generations were initially identified:

- the mechanical generation (born before 1939)
- the generation of the household revolution (born between 1939 and 1948)
- the generation of technology spread (born between 1949 and 1963), and
- the computer generation (born between 1964 and 1979).

In 2013, a new generation was added by the authors to this typology of technology generations:

- the internet generation (born in 1980 and later)

In summary, generation-specific experience with technology might influence the usage of currently available technologies, as older people did not encounter the complex interaction patterns that are necessary to handle modern technologies in their formative period. Therefore, age differences in this study are analyzed with regard to different technology generations.

1.3 The Present Study

While previous work provides some approaches of analyzing different activities with regard to device usage, none of them takes a large group of users and a comparison between different devices into account. Furthermore, some numbers are quite obsolete, so that by now it can be expected that the numbers changed and need to be updated. Thus, the research that was conducted aimed to analyze the range of devices that are used for a total of 21 activities people engage in on a day to day basis. The activities were selected and reviewed in workshops with associates and scientists in the domains of psychology, computer science and engineering. To obtain a large sample size, the study was administered via an online questionnaire. Participants were assigned to four age groups according to the four youngest of the five technology generations proposed by Sackmann and Weymann [38]. The following research questions were addressed:

RQ1: Are there differences in the use of devices between different activities?
RQ2: Are there differences in the use of devices between different technology generations?

2 Method

2.1 Procedure

The questionnaire started with a short introduction of the study and demographic questions. After that, subjects were asked to specify with which device they administer different activities. The activities under study are depicted in Table 1. Subjects could specify whether they engage in those activities via desktop PC/laptop, via tablet PC, or via smartphone. Other answer options were "I engage in this activity via personal contact" or "I do not do". In addition, five activities (17–21) were added where the answer option "I engage in this activity via personal contact" is not possible and was therefore deleted.

Table 1. Activities that were analyzed and corresponding answering options

Activities	Answering options
(1) Internet banking, (2) acquire timetable information, (3) buying tickets, (4) navigating, (5) gaming, (6) writing letters, (7) shopping, (8) watching videos, (9) passing on confidential information, (10) watching television, (11) watching/reading news, (12) seeking information of everyday life, (13) taking notes, (14) using calendar function, (15) writing e-mails, (16) reading e-mails, (17) using short messaging services, (18) using video telephony, (19) sharing photos, (20) using social networks, (21) using voicemail	I engage in this activity via desktop PC/laptop, I engage in this activity via smartphone, I engage in this activity via tablet, I engage in this activity differently e.g. through personal contact, (only for activities 1–16) I do not do

2.2 Subjects

A total of 1923 subjects aged 19–77 took part in the online questionnaire. Their mean age was M = 49.67 years (SD = 14.96). The age structure was not equally distributed (Fig. 1). For the analysis, subjects were classified according to four age groups in accordance with the technology generations proposed by Sackmann and Winkler [43]. Due to a lack of subjects, the fifth group could not be studied. The resulting age groups are characterized as follows:

- The first group, called "the Internet Generation" and aged 19–36, consisted of $N = 461$ persons ($M = 30.6$, $SD = 4.24$).
- The second group, called "the Computer Generation" and aged 37–52, consisted of $N = 661$ persons ($M = 44.59$, $SD = 4.45$).
- The third group, called "the Generation of Technology Spread" and aged 53–67, consisted of $N = 514$ persons ($M = 60.51$, $SD = 4.4$).
- The fourth group, called "the Generation of the Household Revolution" and aged 68–77, consisted of $N = 287$ persons ($M = 72.6$, $SD = 3.05$).

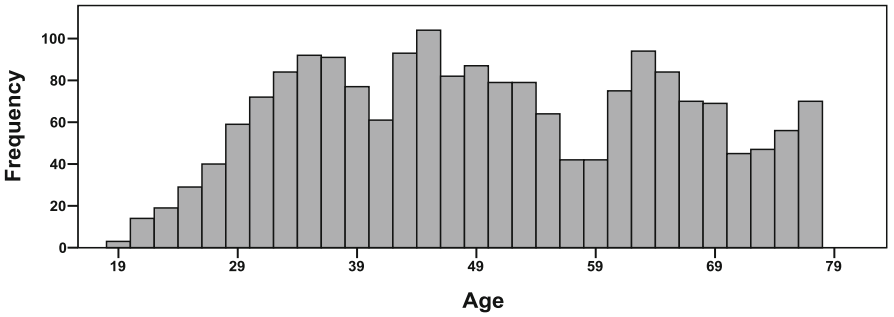

Fig. 1. Age distribution of participants

3 Results

In order to analyze differences between the four age groups, chi-square tests were analyzed for the different activities, as the measurement was at the nominal level. The level of significance was set to $\alpha = .05$. Effect sizes are depicted by Cramer's V and can be classified into low ($r \leq .10$), medium ($r \leq .30$) and large ($r \geq .50$) Field [44]. An overview of the results is shown in Table 2. Overall, significant differences were found between the tasks with regard to the activities and the four different age groups ($p < 001$). The detailed analysis of the specific results for each age group separately as well as a comparison between the age groups is added descriptively.

3.1 The Internet Generation

The Internet Generation as the youngest age group that was studied uses a smartphone for several of the activities that were analyzed and it was found that the smartphone is the most popular device in this age group. Figure 2 shows the rates of different activities according to device. Overall, the proportion of smartphone use never drops below 20%. This shows that the smartphone is a common device for all kinds of activities in the daily lives of young people. As such, the smartphone holds a leading position for sending short messages (78.6%), using voicemail (72.8%), sharing photos (67.6%) and using social networks (70.2%), appointment scheduling (67.6%), navigation (66%), and doing bank transactions (55.6%). The activity that the smartphone is used the least for is passing on confidential information (21.6%), and the proportion of young smartphone users who use their smartphone for watching TV is also low (23.7%) in comparison to the other activities. With regard to sharing confidential information, there was a high proportion of subjects who do not even carry out this activity (45%).

The tablet PC is more prominent regarding activities of the entertainment sector such as watching videos (23.5%), watching TV (20.8%), and gaming (22.1%). Desktop PCs are preferred when writing letters (38.5%) and writing e-mails (41.4%). But surprisingly, the smartphone has already replaced the desktop PC for writing e-mails (47.5%) and also for reading e-mails (smartphone: 54.2%, desktop PC: 29.5%).

Table 2. Results of significant chi-square tests ($p < 001$) for overall differences between technology generations

Activity	N	df	Pearson chi-square	Cramér's V
Internet Banking	1836	12	569.06	.32
Timetable Information	1708	12	340.50	.26
Buying Tickets	1810	12	436.73	.28
Navigation	1776	12	334.40	.25
Gaming	1783	12	436.72	.29
Writing Letters	1830	12	242.24	.21
Shopping	1764	12	502.88	.31
Watching Videos	1764	12	651.88	.35
Passing Confid. Information	1814	12	226.34	.20
Watching Television	1822	12	377.36	.26
Watching/Reading News	1667	12	328.69	.26
Seeking Information	1687	12	456.82	.30
Taking Notes	1774	12	233.74	.21
Calender	1754	12	317.09	.25
Writing E-Mails	1703	9	355.25	.26
Reading E-Mails	1649	9	451.48	.30
Short Messaging Service	1850	9	262.17	.22
Video Telephony	1827	9	427.74	.28
Sharing Photos	1801	9	451.22	.29
Social Networks	1784	9	603.475	.34
Voicemail	1843	9	296.83	.23

Comparison to Other Technology Generations. The proportion of subjects in the youngest age group that engages in the surveyed activities is at least 78%. In comparison, an average of 48.7% of the "Generation of the Household Revolution" does not carry out the surveyed activities. As a consequence, the results of the Internet Generation have a higher explanatory power than the results of the Generation of the Household Revolution. With regard to the activity "passing on confidential information" it is noticeable that the proportion of subjects engaging in this activity via a smartphone is low in all generations that were studied. Despite the low overall numbers using the smartphone in order to pass on confidential information, the proportion of subjects engaging in this activity in the Internet Generation is relatively high. It seems as if young people have more trust in technological devices and therefore share their confidential information via their smartphones.

Using the smartphone for watching TV does not seem very common, with 23.7% in the Internet Generation doing so. However, the other technology generations show even smaller numbers (the Computer Generation: 7.8%, the Generation of the Technology Spread: 2.5%, the Generation of the Household Revolution: 1.2%). It might be the case that using the smartphone to watch television is only on the rise and will spread among the other generations as well. Alternatively, older subjects might find the screen size not big enough for watching TV.

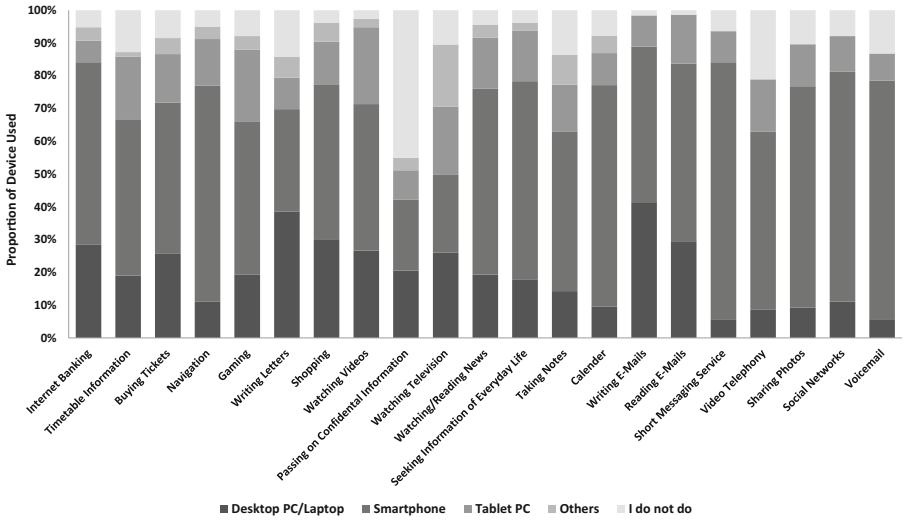

Fig. 2. Bar graphs for the different activities and the distribution of answers in percent for the Internet Generation

With regard to tablet PC usage it was noticed that the Internet Generation uses the tablet PC more often than any other generation. However, with an average usage of 13.8%, tablet PC usage is ranked in the lower segment.

3.2 The Computer Generation

Overall, the most popular device in the Computer Generation is the smartphone (on average 32.4%) followed by the desktop PC or laptop (on average 31.0%), as can be derived from Fig. 3, which shows bar graphs of the study results indicated in the percentages of device usage. For example, members of the Computer Generation more often use the desktop PC for shopping (48.7%) instead of the smartphone (23.1%). Smartphones are mainly used to send short messages (63.9%), for navigation (52.7%), and organizing appointments (51.60%). Surprisingly, this generation has a relatively balanced proportion of subjects that engage in specific activities and subjects that do not engage in those activities. For example, 33.8% use a smartphone for video telephony, while 47.1% do not, just as 37.9% use the smartphone to share photos, whereas 38.6% do not share their photos. Equally ambivalent is the use of social networks (smartphone: 41.8%, I do not do: 26.5%) and voicemails (smartphone: 47.9%, I do not

do: 41.7%). Tablet PCs are used on average with a proportion of 8.23% in the specified activities, while gaming (15.7%) and watching videos (16.5%) still stand out with the highest percentages.

Comparison to Other Technology Generations. Compared to the Internet Generation, the preference for the desktop PC in competition with the smartphone shows an opposite order of precedence (Computer Generation: smartphone: 34%, desktop PC: 55.1%; Internet Generation: smartphone: 54.2%, desktop PC: 29.5%) and writing e-mails (Computer Generation: smartphone: 28.2%, desktop PC: 61.3%; Internet Generation: smartphone: 47.5%, desktop PC: 41.4%). The same pattern is seen in activities related to bank transactions (Computer Generation: smartphone: 25.4%, desktop PC: 47%; Internet Generation: smartphone: 55.6%, desktop PC: 28.6%) and watching videos (Computer Generation: smartphone: 23.1%, desktop PC: 48.7%; Internet Generation: smartphone: 44.7%, desktop PC: 26.7%). In comparison to device usage in the Internet Generation, where the smartphone is ahead of the desktop PC by over 30% points, the Computer Generation shows results that are similar, as smartphone and desktop PC usage only differ by roughly 1.5% points.

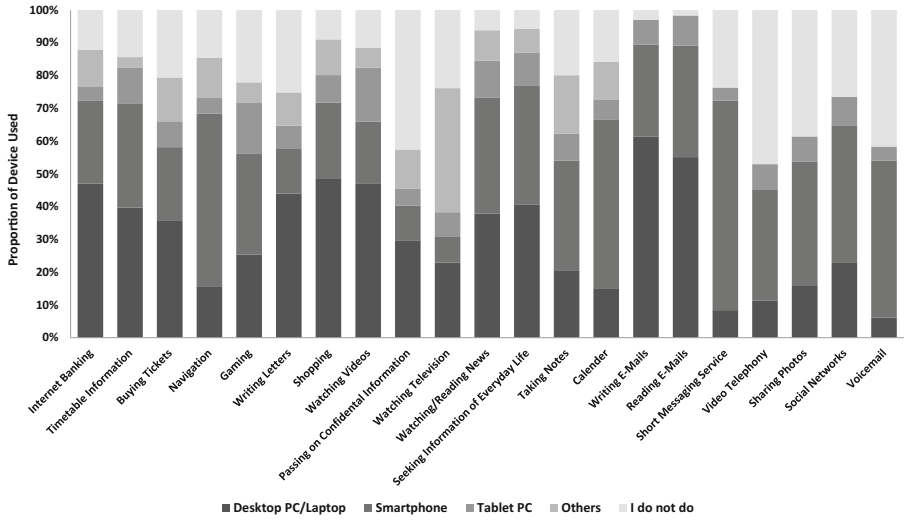

Fig. 3. Bar graphs for the different activities and the distribution of answers in percent for the Computer Generation

3.3 The Generation of the Technology Spread

The Generation of the Technology Spread is characterized by a high percentage of answers that state that the activity in question is not carried out (on average 32.6%), as is depicted by bar graphs in Fig. 4. It is particularly noticeable that this generation does not engage in activities that have emerged in recent years. Examples include video calling (72%), sharing photos (61.9%), social networking (52.9%), using voicemail (52.6%), gaming (47.3%), and watching TV (43.1%).

The device that most activities are carried out with is the desktop PC or laptop. The use of the PC is particularly evident in collecting timetable information (43.5%) and shopping (48.9%). Also, the gap between the proportions of smartphone and PC users in relation to reading (smartphone: 16.8%, desktop PC: 67.5%) and writing e-mails (smartphone: 13.4%, desktop PC: 73%), as well as writing letters (smartphone: 3.8%, desktop PC: 63.5%), is striking. The smartphone is used in particular for writing short messages (56.1%), sending voicemails (39.2%), acquiring calendar information (37.2%), and navigation (37.5%). Particularly notable is the low proportion of smartphone users in this category with regard to shopping (7.3%), watching videos (6.6%), writing letters (3.8%), and buying tickets (5.2%).

Comparison to Other Technology Generations. Noteworthy is also the fact that tablet PC usage is very limited in the Generation of the Technology Spread. The highest level of tablet PC usage was found in the category watching/reading news (15.2%). In comparison, the Computer Generation showed the highest proportion in tablet PC usage for the activities gaming and watching videos. Regarding smartphone usage the biggest difference was found between this group and the Internet Generation. Smartphone usage in the Internet Generation only rarely drops below 30%, whereas in this group smartphone usage is generally below 30%.

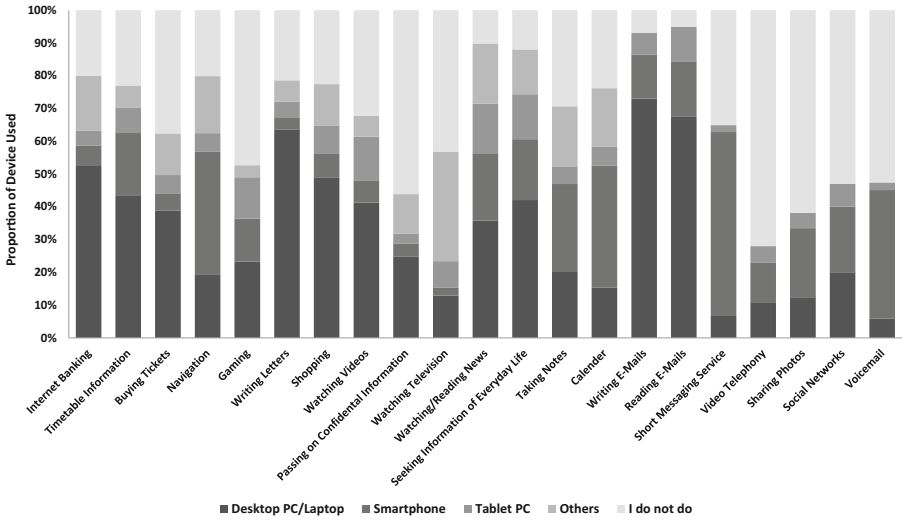

Fig. 4. Bar graphs for the different activities and the distribution of answers in percent for the Generation of Technology Spread

3.4 The Generation of Household Revolution

The most striking finding regarding the Generation of the Household Revolution is that most of the subjects under study stated that they are not engaging in the surveyed activities (on average 48.73%), as is depicted by bar graphs in Fig. 5. In exact percentages, this means that 33.1% of respondents do not use electronic devices to

undertake bank transactions, 30.2% do not use them to collect timetable information, and 41.5% do not use them to buy tickets. In addition, 39.9% do not use a device for navigation, 42.2% of respondents do not watch TV on computer devices, 44.4% do not write notes on such devices, and 40.7% do not schedule their appointments with the help of an electronic calendar. Even more striking is the proportion of people who do not play computer games (67.4%), do not watch videos on a computer (66.9%), do not send short electronic messages (56.7%) or send voicemails (73.7%), do not make any video calls (83.1%), and do not share their photos electronically (78.1%). The activity that the most people in this age group do not engage in, however, is social networking, with a proportion of 86.9%. It might be possible that spouses or close relatives engage in those activities for the subjects in this group, which would explain the high levels of non-engagement in the surveyed activities. The fact that many things are generally not done electronically is also reflected in the levels of smartphone and tablet usage. It was found that only a small proportion of subjects in this generation use a smartphone, with the average proportion of smartphone users below 10% in this group. The only activity that stands out is using a smartphone in order to send short messages (38.7%). Compared to the smartphone, the tablet is even less used by this generation, so that the average proportion of tablet users is below 5%. Nonetheless, almost one in ten uses them to read news or to seek information on everyday life.

Comparison to Other Technology Generations. The electronic device that is most used by this age group is the desktop PC or laptop. A particularly high use of the PC is evident in the writing of letters (62.6%) as well as in writing e-mails (63.5%) and the reading of e-mails (59, 9%). These proportions of users are almost as high as in the Generation of the Technology Spread. Since there is a high proportion of subjects that do not engage in the surveyed activities, the explanatory power of device usage is less strong in this group than in the three younger technology generations.

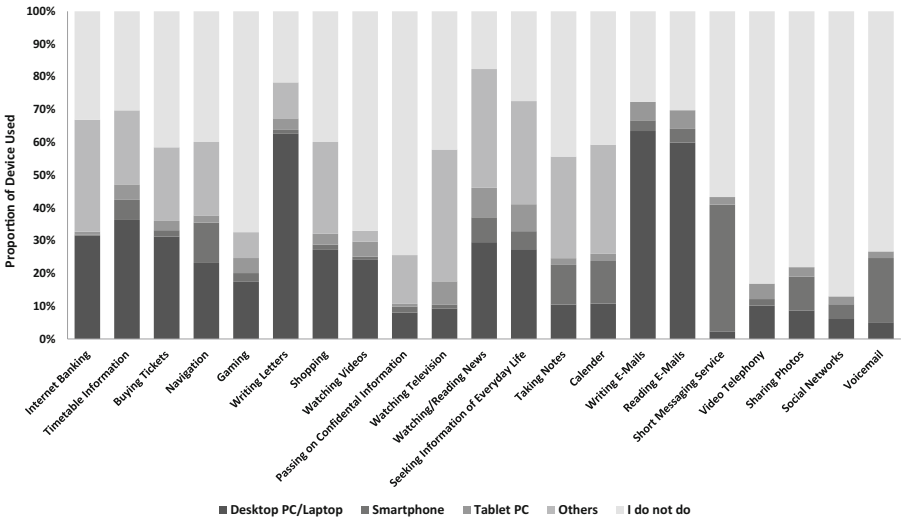

Fig. 5. Bar graphs for the different activities and the distribution of answers in percent for the Generation of Household Revolution

4 Discussion

Developing ergonomic user interfaces requires an understanding of which activities users carry out with their devices. The analysis presented in this paper provides up-to-date numbers of which activities are carried out by users, which devices are used for those activities, and which activities are not carried out with electronic devices but rather through personal contact. To understand how different age groups interact with electronic devices, the results were analyzed for four different technology generations.

First of all, it was noticeable that the proportion of subjects that stated that they are not engaging in the surveyed activities is steadily increasing the older the subjects get. It might be the case that the types of tasks subjects engage in are changing depending on age. As a result, for further analysis more tasks that are typically performed by older people should be added to the questionnaire, for example monitoring vital parameters.

Furthermore, results showed that the older subjects get, the more likely they are to use a desktop PC or laptop instead of a smartphone and/or a tablet PC. This trend might be caused by the fact that smartphones as well as tablet PCs were developed later than desktop PCs and laptops and therefore the diffusion is less progressed. Another explanation for not using smartphones and tablet PCs as often as desktop PCs and laptops might be their smaller screen sizes. Smaller screen sizes might be a problem for the elderly as aging is frequently associated with visual impairments as well as impairments in the fine motor skills required to input information when the screen is small.

Another interesting outcome was found in the statistical analysis. Effect sizes that were calculated for the chi-square tests that tested the differences between activities and age groups showed significant effects that can generally be classified as moderate according to the guidelines by Field [44]. The smallest effect sizes and the fewest differences between the age groups were found for the activities writing letters, taking notes, writing short messages, and passing on confidential information.

Comparing the results of the analyses presented in this paper to previous findings showed that the use of technological devices in the older group was a lot lower than the rates of ownership that were found by other researchers. For example, it has previously been found that of subjects aged 64 years and older 48% own a desktop PC, 41% own a smartphone, and 3.4% own a tablet PC. The result for the oldest technology generation of this study showed an average of 24% for desktop PC usage, an average of 7.2% for smartphone usage, and an average of 3.9% for tablet PC usage. Maybe the reason for this discrepancy lies in the sample. Previous studies tended to base their sample mainly on single cultural groups, whereas this study used a sample composed of subjects from the United States, Germany, China, and Japan.

With regard to the classification of the sample of the study there is one limitation that is worth noting. The participants were grouped into four different technology generations based on their age. As was already mentioned, age processes are highly individual and this makes the arrangement of participants in groups according to chronological age difficult. Furthermore, there are aging processes which might account for the differences in the studied activities, such as impairments in fine motor skills. To derive a complete picture, these factors need to be included in future research.

Table 3. Overall device preferences

Desktop PC:	Writing letters
	Writing e-mails
	Passing on confidential
Smartphone:	Taking notes
	Using calendar function
	Navigating
	Using short messaging services
	Using video telephony
	Sharing photos
	Using social networks
	Using voicemail

4.1 Conclusion

Generally, the device that is used the most for the analyzed activities and taking all technology generations together is the smartphone, followed by desktop PC and tablet PC. With regard to the activities it was found that participants primarily use their smartphone for short message services, the tablet PC is primarily used for watching videos, the desktop PC is primarily used to write e-mails, while the answer option "other" was most commonly stated for watching TV.

Overall, the results of the questionnaire study show significant differences in the way technology generations carry out daily activities. This supports the structure of those age groups while highlighting the importance of studying age effects in human–computer interaction. It places particular challenges on computational design approaches that postulate accessibility and equal opportunities for all age groups. According to ISO/DIS 9241-11 [45] accessibility is defined as "usability of a product, service, environment or facility by people with the widest range of capabilities." It is noted that the concept of accessibility considers the whole range of user capabilities and is not restricted to users with disabilities. Bearing this approach in mind, the results of this study should be interpreted with regard to commonalities between the age groups in terms of device usage. As a result ten activities were extracted that are characterized by agreement in device preference for at least three of the four analyzed technology generations. The technology generation that showed a preference for another device was taken into account only as long as the deviation from the overall preference was less than ten percentage points. The resulting ten activities that are eligible for "design for all" approaches are depicted in Table 3. As a main result of this study was that a large proportion of older subjects do not engage in the activities that were surveyed, a next step would be to analyze why the elderly do not engage in those activities and how engaging in those activities can be supported.

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