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An empirical analysis of smartphone personalisation: measurement and user variability

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The present report is an empirical analysis of smartphone personalisation. We collected data from two groups of users to measure how they adapt the content, interface and physical appearance of their devices. This user-driven personalisation is measured with a simple heuristic approach to quantify the behaviour. Using these scores, we explore how users differ from each other in how they personalise their smartphones with a focus on gender differences, usability and device usage in the wild. Among our findings are that not all users personalise their smartphones, females and males personalise their iPhones differently, and those who personalised their phones more tended to rate it as more usable. The users who personalised more also used their device for greater periods of time on a broader range of applications. For instance, individuals who adapted their iPhones to a greater degree also accessed the Web more often and spent more time browsing once it was accessed. We conclude with a discussion of possible factors underlying the large user diversity of smartphone personalisation found in this research.

Keywords: personalisation; customisation; adaptability; smartphones; iPhone; usability

1. Introduction

Personalisation of technology has been assessed in Human Factors, Human–Computer Interaction (HCI), Computer Science and other disciplines for over 20 years (Sunikka and Bragge 2008). In general, personalisation of devices has several benefits. First, personalisation can have a positive impact on the interactions between the user and the interface. The user's desired actions may be quicker, easier and more aligned with the user's specific needs in a personalised computing environment. Personalisation is also viewed positively from a business perspective. Device makers work hard to add new personalisation features not only as a marketing strategy, but also to create 'stickiness' in the sense that high personalisation can create services and devices that become more important to users than those who are not personalised (Riedl 2001, Bush and Tiwana 2005). In a broad sense, personalisation allows for users to adapt technology to fit their needs, desires and environments.

Although there have been a large number of studies that have examined personalisation within the context of the personal computer (PC), there are a lack of studies that explore how users personalise smartphones. Smartphones offer users a personal and portable method to access information, communicate and perform other mobile tasks. These technologies are becoming ubiquitous. Over 940 million people own at least one smartphone and penetration is increasing at an exponential rate (ITU 2011). Smartphones are carried everywhere that their users go (Ling 2005) and are capable of doing a large number of tasks that could once only be done on a PC. Thus, these devices represent a step towards Weiser's (1991) vision of ubiquitous computing, where technologies are continuously available to support users in everyday activities. User adaptations of their smartphone devices, from new cases to new applications, allow users to conform their tool to suit their daily activities.

The aim of this study is to characterise these personalisations and understand how users differ in this process. In particular, our interest is to understand the relationships between personalisation, perceived usability and device use. Personalisation of computers has been studied at length and is a fundamental principle of design for the personal computing era. Research on the personalisation of traditional mobile phones has focused on the aesthetic and expressive reasons they are customised. Smartphone personalisation, however, can include a number of activities which are more fundamental to device usage (e.g. adding new applications). However, there is limited work on this topic. This report contributes an empirical study that explores how users personalise their smartphones using two sets of participants. Data from the first group is used to develop a simple and quantitative personalisation score. These scoring measures are used with a second group of users to understand user differences related to how new smartphones are personalised and

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then examine how their content, interface and appearance customisations reflect differences in real-world usage and perceived usability.

2. Background

Two types of personalisation have been widely described in the HCI literature: user-initiated personalisation and computer- or Web-based personalisation. The former is achieved by users manipulating aspects of their device based on needs or desires. For instance, moving icons on a computer desktop, organising email into sub-folders, installing a new application on a smartphone and buying a case for a mobile phone are just some of the tasks that users can do to customise their technologies for more personalised interactions. This self-directed personalisation has also been referred to as adaptation, customisation, end-user modification, extension and tailoring (Mørch 1997). Some types of self-directed personalisation require little to no programming skill, while others, such as end-user development (Lieberman *et al.* 2006) and agile programming (Beck 1999), require more advanced knowledge of programming.

Web- and computer-based personalisation has primarily been called adaptive personalisation (e.g. Kobsa 2001), but has also been referred to as intelligent systems, customisation, user adaptive systems and general user-modelling systems, among other terms (Kobsa 2001). These systems adapt content using information captured by the device or Web. An example of this type of personalisation on the Web is the use of cookies: Websites can store user information on a visit and adapt future Web content to each user based on the information collected and stored in the cookie. Fundamentally, these systems remove at least some control of personalisation from the user and leverage his or her previous interactions to customise future interactions. Many studies have shown the benefits of adaptive systems (Jameson 2003, Lavie and Meyer 2010), but usability problems still exist (Greenberg and Witten 1985, Oulasvirta and Blom 2008, Lavie and Meyer 2010).

The research described in this article is concerned solely with user-based personalisation (simply referred to as 'personalisation' hereafter). In particular, we focus on select personalisation behaviours applied to current-generation smartphones. We define smartphone personalisation as user-initiated modifications to the content, interface or physical/appearance of the smartphone that persist beyond one session. This is very similar to working definitions used in the past (e.g. Blom and Monk 2003). Smartphones are personalised for a number of reasons that range from improving the aesthetics of the device to increasing its functionality and relevance.

2.1. Personalisation and HCI

A high level of user-based personalisation is frequently advocated because it purports to give the user greater control over their interactions (Heidmets 1994, Blom 2000, Barkhuus and Dey 2003). Because user needs are constantly changing, designs that allow user-based manipulation of the device and content give the user the ability to self-monitor and make adjustments to the system. This control is generally preferred by users (Dourish 2001), especially experts (Shneiderman and Plaisant 2010). One reason it is preferred is that it gives users the opportunity to change the interface and product based on context, experience and/or preference (Thimbleby 1980, Innocent 1982).

From a design perspective, personalisation allows designers to target a broader user group and minimise discrepancies that can occur between the designer's mental model and user's mental model by designing flexibility into the system. Hancock *et al.* (2005) discussed the importance of designing for user-based customisation to allow for optimised interactions based on individual preferences. They argue the role of this individuated approach can enhance pleasure and efficiency over a sustained period of time. Designing in this way allows users to tailor technology to fit their hedonistic preferences and keep interactions novel and engaging. Personalised systems have also been shown to extend the usable life of a system (Maguire 1982, Greenberg 1991).

Allowing users to manipulate their own device also has the potential to lead to usability deficiencies. For example, novice users, the group that could benefit greatly from personalisation, may not know or have the time to learn how to modify the device (Greenberg and Witten 1985). Attempts to personalise technology could also lead to interaction failures. Large changes to the system could result in mental model/system model discrepancies, at least temporarily (Gaines and Shaw 1983), leading to user frustration. Additionally, if efficiency and productivity is critical, the time spent customising interfaces or devices may not help users achieve their goals (Rich 1983). For instance, Mackay (1991) found that even though personalising the interface could have potentially saved the user time in the long run, many users simply learned the system 'as-is' due to a lack of time to learn and implement customisation on work computers.

2.2. Personalisation of mobile phones

The existing research on the personalisation of mobile phones has examined appearance-related changes to the device and the dispositional factors underlying the personalisation process (Blom and Monk 2003, Monk and Blom 2007, Oulasvirta and Blom 2008). Blom and

Monk (2003) discovered several reasons why users alter the appearance of their mobile phones. These included personal, system and contextual factors such as knowledge of personalisation, absence of technical constraints and peer influence. When the appearance of the phone was altered, it resulted in cognitive, social and emotional effects on users. These included increased recognition of the system, a sense of personal identity and greater attachment to their mobile phone overall.

Oulasvirta and Blom (2008) discussed user personalisation of technology, including mobile phones, more generally. They theorised that there are three motivations behind why users personalise. The first is for autonomy. Users personalise their technologies to make generic technology more personal for increased sense of self and freedom of choice. The second reason is competence. Users personalise their phones to enhance the effectiveness of their interactions. The third reason is more social in nature, termed relatedness. The appearance of devices is changed to express emotion and identity among other social reasons. This research used a grounded theory approach to show the wide variety of psychological reasons individuals customise their technologies and how this process can lead to enhanced user satisfaction with their device (p. 13):

> . . .users are willing to expend effort when the product involves and nurtures their psychological needs of autonomy, competence, and relatedness, taps into and extends their interests and preferences, and makes it possible for a user to transform a company-supplied one-size-fits-all technology so that it becomes a personalised, personally useful, and enjoyable tool that can be used to improve and enjoy life and work. . .personalisation features are central in helping individuals in pursuing growth-oriented activities and in yielding positive socio-psychological states, such as increased ability to express personal identity or feeling of competence or relatedness. These benefits mean that well-designed personalisation features may help improving the acceptability and reducing underuse of new ICT.

We build on this research with an empirical analysis of user personalisation in the wild. Instead of focusing on the psychological factors that underlie the motivation of personalisation behaviours, we take an HCI approach to understand how users differ in their personalisation of smartphones to better design for a wider continuum of users. In particular, we are interested in how user variability in personalisation relates to the use of a new smartphone and the perceived usability of the device. We start with the measurement of content, interface and physical personalisation of smartphones (in this case, iPhones) as reflected by changes in their devices. These measures are combined to form an overall personalisation score. Using these scores, we then examine user differences in personalisation and explore how personalisation levels relate to usage and usability.

3. Development of a personalisation score

An overall personalisation score was developed to measure each user's level of personalisation on a continuous scale. Our approach was to generate personalisation measures using relevant criteria identified in previous research as a guide (Meister 1986, Muckler and Seven 1992). These criteria that require the measures (1) be relevant to the output (valid), (2) be observable, (3) not require additional interpretation, (4) reflect critical events, (5) be precisely definable, (6) be objective, (7) be quantitative, (8) be easily collected, (9) be meaningful to researchers and (10) be at appropriate levels. Using this framework, we developed items that reflected user-initiated personalisation of iPhones that could be measured from simple inspection of users' smartphones. This process was also informed by previous research (e.g. Monk and Blom 2007) and our definition of personalisation.

Only top-level personalisations to the device were of interest in this study. Numerous features could be personalised on iPhones (a total of 204 measures were identified). Measuring all of these could be considered unwieldy. For instance, we did not include the numerous accessibility personalisations (e.g. changes to text size, zoom, push notifications, ringer volume, etc.) due to difficulty in collecting these items (criterion 8 above) and fluidity of some of these customisations (criterion 5 above). Our interests and the information above constrained our measures to nine items that could be measured with simple inspection of the device (Table 1) and represented content, interface and physical/appearance personalisations based on our definition and heuristic approach. We developed the score to measure personalisation of an iPhone.

3.1. Personalisation scoring

First, the nine items of interest were weighted discriminately. These weights were determined before data were collected, and were based on the relative amount of change to the device and the amount of action required. Final weights satisfied the basic conditions found in Maggino and Ruviglioni (2009) to develop composite indicators based on objective principles (Ray 2008). After weights were applied to the raw scores, the weighted measures were synthesised to determine the overall personalisation score for each phone.

3.1.1. Content personalisation

Users can personalise their iPhones by downloading applications from the Apple AppStore. In this way, users add capabilities and content to their devices. Some applications have a one-time monetary cost to the user, but many are free, allowing all iPhone users to personalise the content of their iPhones.

In scoring content personalisation, more applications added to the iPhone represented a higher degree of personalisation. A common sigmoid function was used that grows the most near 100 applications, but slowest at the extreme ends of the scale. Default applications are not included in the equation, since their presence does not indicate any customisation.

Table 1. Items measured to determine personalisation scores.

Personalisation item	Measurement and (weight)	Scoring
Content		
Installed apps	Count of new apps (.10)	No new apps – 0 Each new app increases Score on sigmoid function
Interface		
Moved apps on bottom bar (BB)	Count of apps moved from bottom bar (.15)	1 – % of original apps in bar
	Assess order of apps on bottom bar (.15)	.25 for each app that moved From original location on the bottom bar
Moved apps on 1st screen	Count apps moved from first page (.15)	1 – % of original apps on page
	Assess order of apps on first page (.15)	1 pt for each nearest neighbour in same category and divide by number of apps on page
1st & subsequent screens	Count of holes on each page (.15)	Count number of holes on each page
Ringtones	View voice call settings (.05)	No change – 0 Change, no download – 50 Change with download – 100
Physical/appearance		
iPhone case	View exterior of phone (.05)	No case – 0 Case – 100
Lockscreen image	View lockscreen (.05)	No change – 0 Change to library image – 50 Change to personal image – 100

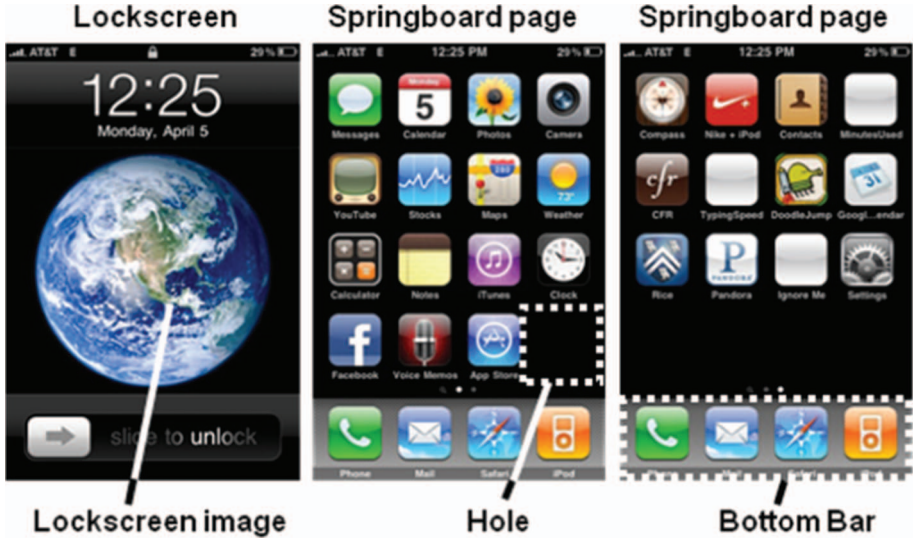

Figure 1. iPhone lockscreen and springboard pages.

3.1.2. Interface personalisation

After applications are installed, they can be moved within or across springboards (see Figure 1). Default applications that come pre-installed can also be moved. Applications that are used extensively can be moved to the first springboard page for easier access while those that are not used as much can be moved to latter pages. Applications located in the bottom bar can also be relocated. The bottom bar is a stable row of applications that remains on the screen when viewing any springboard. Because of this permanence across springboards, applications located in the bottom bar are assumed to have higher importance for the user. Users can also personalise items by location on the device, based on category. For example, all news applications could be grouped together on a specific springboard page. Instances where the user did not completely fill up all the available space on a springboard page, but left 'holes' (Figure 1) as a way of preserving some level of grouping on a specific springboard was also counted as an indication of higher personalisation. It also provides evidence of users' removal of applications to clean up their springboards as another indicator of personalisation.

Similar to older mobile phones, ringtones can be downloaded and used to indicate when a particular contact is calling. Changing the default ringtones to other factory-installed ringtones reflect a higher degree of personalisation. Downloading new ringtones and using special ringtones for specific contacts represents even higher levels of customisation, and were scored as such.

Interface personalisation scores were developed using an iPhone out-of-the-box as a baseline. First, we assessed the degree of personalisation of the first springboard page by determining the percentage of original applications that were moved. This percentage was used with the associated weight for this category to calculate the individual's personalisation score. Additionally, if the order of the applications on the first page was meaningful, the personalisation score increased. Nearest neighbours for each App were evaluated to see if they were in the same category. Using the official Apple Website for category distinctions, one point was added for each app in the same category as its neighbour. Table 1 shows the scores developed for each item.

3.1.3. Physical/appearance personalisation

Users can also change the physical appearance of the iPhone by using a case to cover the device. While some may do this for aesthetic reasons, others may buy a case primarily to protect their phone.

Another form of personalisation in this category involves the background images that are used on the lockscreen (Figure 1). Users can change the photo with a factory-installed image (the default image of a globe), or they can further customise by using a photo they have taken or an image they have uploaded to the phone. Phones with the default image changed to a preloaded image received customisation points, while phones that used user loaded images or photos received more points.

3.2. Score validity

The nine-item scoring system was developed using previous research and theoretically related to how we operationally defined personalisation. This provided adequate face validity for us to further assess the scoring measures with iPhone users. We recruited 32 undergraduate subjects from a university for this purpose. Personalisations were captured with a digital camera. Pictures were taken of the exterior of the phone, the lockscreen and all springboard pages.

Participants in this group had different versions of iPhone operating systems (OS) all before OS 4 (so, no folders could be installed) and varied in other dimensions as well (e.g. gender, major, length of iPhone ownership). As expected, they exhibited a wide range of personalisation behaviours. Figure 2 shows example screenshots from users at both ends of the spectrum.

The classical approach to construct validity suggests that the nine items in this scoring system should yield intra-item correlations with items purported to measure the same construct (Campbell and Fiske 1959). From a theoretical standpoint, we expected several of the interface personalisations described above to correlate for purposes of efficiency (or competence; Oulasvirta and Blom 2008). For example, individuals that move more items from their first springboard page may be more likely to personalise other springboard pages to access applications more rapidly. The latter could lead to more holes on a springboard page due to an organisational strategy based on category (e.g. 11 News applications on one springboard page would leave five holes) or deleting applications (which may also be considered a type of personalisation behaviour).

Content personalisation (i.e. adding new applications) could conceptually be related to particular interface personalisations as well. For instance, when applications are added (content personalisation) they could then be moved to the first springboard page (interface personalisation) to fit an overall organisational scheme. Additionally, in line with previous research (e.g. Blom and Monk 2003, Oulasvirta and Blom 2008), we expected relationships between

Figure 2. (a) Pictures of all screens from User A's iPhone. This participant's phone yielded a low personalisation score of 4.27. No changes were made to the lockscreen image, the organisation of apps or ringtones. Additionally, only five additional apps were installed from the AppStore. (b) Pictures of screens 1, 3 and 7 from User B's iPhone. Note the modified bottom bar, the rearrangement of preinstalled apps and the grouping of similar applications. This participant's phone yielded a high personalisation score of 88.

Table 2. Means, standard deviations and intercorrelations of personalisation measures.

		M	SD	1	2	3	4	5	6	7	8	9
1	Springboard	13.31	13.38	–	−0.04	0.32*	0.18	0.48**	0.29*	0.05	0.16	0.03
2	Order on Springboard	34.76	16.11		–	0.05	−0.06	−0.14	0.07	−0.20	−0.04	0.11
3	BottomBar	9.38	15.23			–	0.79**	0.13	0.12	−0.09	0.10	0.17
4	Order on BottomBar	38.28	23.99				–	0.01	0.04	0.13	0.20	0.21
5	Holes	4.32	6.79					–	0.15	−0.04	0.03	−0.21
6	Number of Apps	69.35	46.85						–	−0.06	0.12	0.20
7	Case	59.38	44.12							–	0.40**	0.26*
8	Ringtones	25	31.19								–	0.24*
9	LockScreen	87.5	33.61									–

Note: *r* values are PPMC coefficients. *$p < 0.05$, **$p < 0.01$.

measures related to the appearance of the phone. The lockscreen, ringtones and case are likely more noticeable by others compared to the other six measures. Thus, we expected correlations between these scores.

We found several correlations between our measures that aligned with these expectations (Table 2). Intercorrelations were measured using Pearson product-moment correlation (PPMC) coefficients. Moving apps to the first springboard page correlated with the number of holes on subsequent pages ($r = 0.48$), number of apps moved from the bottom bar ($r = 0.32$) and number of applications downloaded ($r = 0.29$). More exterior features, such as the case and ringtones and the lockscreen and ringtones, correlated as well. These correlations demonstrated evidence of convergent validity. Many of the measures also yielded weaker correlations with measures presumed to be less related (discriminant validity). For instance, the physical case did not correlate with any of the content personalisations mentioned above.

The grouping of applications on the first springboard page using the Apple categorisation scheme was not employed often, but weighted heavily (0.15). This suggested that applications were likely moved there for other reasons (e.g. putting the most frequently used applications together on the first page). However, we still kept this interface metric in our scoring system to explore how users are grouping these high frequency applications on their first springboard page.

We compared results from our scoring metric with self-reported levels of personalisation. Self-reports were captured on a 10-point scale with 1 reflecting extremely low personalisation and 10 reflecting high levels of personalisation. Our definition of personalisation was also displayed on the top of the page for enhanced precision. The significant correlation (using Spearman's rho to calculate the correlation coefficient) of medium effect (Cohen 1988) between these two scores also provided reasonable evidence of convergent validity ($\rho = 0.41$, $p = 0.03$).

3.3. User variability

Several demographic and experience variables were assessed to understand user variability to further validate the construction of the model. Personalisation scores from this training set ranged from 4.72 to 88.14.

Table 3. Percentage of males and females that made appearance personalisations.

	Male (%)	Female (%)
Using a case	42	81
New ringtones	5	27
Changed lockscreen image	62	100

There were no real differences in personalisation levels as a function of length of ownership, age or race. There were several significant differences due to gender (Table 3). First, every female ($n = 17$) changed the image on their lockscreen whereas only nine of the 15 males changed their lockscreen image. Second, most females used cases whereas less than half of the males had a case on their phones. Third, only one male changed a default ringtone to a custom ringtone. More females made changes to their ringtones ($n = 4$) though, like males, most females did not change their ringtones at all.

Males, in contrast, personalised their phones differently. Males tended to move one more app ($M = 3.48$, $SD = 2.41$) than females ($M = 2.00$, $SD = 2.03$) from their first springboard page. Similarly, they moved applications from their bottom ($M = 1.12$, $SD = 1.01$) bar slightly more than females ($M = 0.34$, $SD = 0.81$). Finally, they averaged one more hole ($M = 3.76$, $SD = 5.49$) across all springboards compared to females ($M = 2.42$, $SD = 6.13$). Though none of these individual personalisation item means were significantly greater than the means of female measures, the marginal differences here offset the lack of physical/appearance personalisation measures such that there were no real differences in the *overall* personalisation scores of males and females. An independent samples t-test between the mean personalisation score for each gender was not significant at a 0.05 level of significance, $t(30) = 0.23$, $p = 0.82$. The lack of a significant difference here also reflects the low weights applied to physical/appearance personalisations. However, males and females personalised their phones differently.

4. Personalisation and iPhone usage and usability

One important concern for designers of smartphone technology is how personalisation relates to device usage and usability. Using the personalisation measures developed above, we examined the relationships between personalisation, device usage and usability with a new set of participants. Our goal was to understand user variability and the relationships between personalisation and device usage outside of the laboratory as well as subjects' perceived usability of the device. Since gender differences manifested in score development, we compared males and females in their types and levels of personalisation here as well.

4.1. Method

4.1.1. Participants and materials

Participants selected for this group ($N = 24$) did not previously own a smartphone. These participants

represented a wide range of students in terms of socioeconomic status (SES), race and gender. The slight majority of these students were males ($n = 14$). After signing an IRB approved consent form, every student received an iPhone 3GS device operating iOS 3.1.3 in exchange for allowing us to log all of their usage data. As part of the study, they received unlimited phone, data and messaging (SMS) services for six months while their data were being collected. All other charges associated with phone use (e.g. application purchases) were borne by the participant.

4.1.2. *Instrument to measure perceived usability*

We assessed users' perceived usability of their iPhones with the System Usability Scale (SUS; Brooke 1996). The SUS has stood the test of time as a simple, yet reliable method to assess both the usability and learnability of a technology or product (Lewis and Sauro 2009). It has been used and validated across a wide number of domains to assess usability of a device with 10 questions (Bangor *et al.* 2008). Based on composite scores of the 10 items, the SUS yields an overall usability measure which reveals each user's perceived usability of the object being evaluated. This overall usability metric is on a 0 to 100 scale with higher scores corresponding to better usability and lower scores corresponding to poorer usability.

4.1.3. *Procedure*

Once they received their phones, participants were given no instructions about how to use their device. The only requirement they agreed to make was to use their instrumented iPhones as their only mobile phone. Device usage was captured via an embedded logger installed on their iPhones. The logger automatically started to record data in the background when the smartphone booted, and continued to run in the background anytime the device was on. Thus, the logger did not interrupt usage and did not require any actions from the participants to report.

Application usage was time-stamped, anonymised and recorded in real-time by the logger. For privacy, the logger obfuscated any personal information including phone numbers, names and message content. Details of the logger can be found in Shepard *et al.* (2010).

After the initial meeting to pass out phones, we met only once eight weeks later to record personalisation levels and collect survey data. Personalisation was captured using the measurement approach developed above. That is, we took pictures of each participant's springboard and lockscreen. The SUS was also administered during this meeting to obtain perceived usability.

5. Results

We first assess how users from this group personalised their iPhones and explore user diversity. Second, we present how personalisation scores related to iPhone use in the wild and participants' perceived usability. Differences between groups (i.e. genders) are assessed descriptively and inferentially through two-tailed independent-sample *t*-tests using a 0.05 level of significance. Correlations are also reported using the PPMC coefficient and significance is also evaluated using a two-tailed significance test at a 0.05 alpha level.

5.1. *User variability in iPhone personalisation*

How did participants customise their iPhones after eight weeks? As can be seen in Table 4, participants demonstrated a high range of personalisation, although generally on the lower end of the scale ($M = 37.19$, Median = 33, SD = 18.24, Range = 4.12–85.82). One participant only added one application over this eight-week period, did not change the order of his first springboard page, and did not change the image on his lockscreen. At the higher end of the

Table 4. Examples of users with different levels of personalisation.

	Level of personalisation				
	Very low User A	Low User B	Medium User C	High User D	Very High User E
# of added apps	1	12	22	40	82
# of holes	0	3	5	12	28
% original apps on first springboard	100	100	88	50	13
% of BottomBar modified?	0	0	25	25	0
Change ring tone?	No	No	No	Yes/own tone	Yes/own tone
Change lockscreen image?	No	Yes/own image	Yes/own image	Yes/own image	Yes/own image
Add case?	Yes	Yes	Yes	Yes	Yes
Overall score	3.0	10.5	31.7	59.8	79.9

spectrum, one participant added 82 applications, organised them based on category (leaving holes) and used downloaded ringtones for various contacts. However, there was not high variability across every item measured in our personalisation scoring. For instance, every user acquired a case for their iPhones.

The high variability in personalisation scores was driven by several of the personalisation items. In particular, the number of applications installed, amount of changes to the first springboard page and holes on each page produced considerable variability amongst our users. Participants who made changes to their first springboard layout also had more holes across all of their springboards ($r = 0.77$, $p < 0.001$). There was some evidence these individuals also installed more applications ($r = 0.39$, $p = 0.06$). Below we explore user differences in these personalisation behaviours. Since we had a similar number of male ($n = 14$) and female ($n = 10$) participants in our study, we also explored gender differences though we had no specific hypotheses about how these groups might differ.

5.1.1. *Adding and removing applications*

Figure 3 shows the number of unique applications added and removed by month over the six-month study period. Across the first two months, participants installed more applications compared to the entire rest of the study. The longer participants had with their iPhone, the fewer the number of new applications installed per month. Users installed more games than any other type of application and Facebook was the application installed by most users (every participant except one). Females ($M = 40.61$, SD = 22.93) installed more applications than males ($M = 23.01$, SD = 12.19) over the entire six-month length of the study, $t(22) = 2.02$, $p = 0.04$.

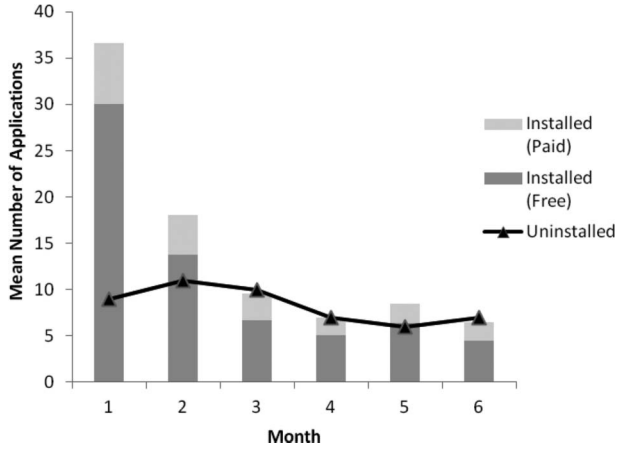

Figure 3. The mean number of applications installed and uninstalled by month.

As mentioned above, the holes on participants' springboards could have been the result of one of two types of user personalisation. The first is intentionally leaving holes to maintain a particular organisation on the springboard. The other reason could be due to participants removing applications. Surprisingly, it appeared that this latter action was the primary personalisation activity that created the holes. A review of the photographs captured of our users' springboards revealed only 12 of the 283 springboards contained only one category (as defined by Apple). Six of these pages were News applications and the other six were Games applications across two users. In contrast, there were a surprising large number of applications that were uninstalled per user over the six-month study period ($M = 43.39$, SD = 16.44) as recorded by our logger. This included applications that required a fee. It should be noted that we cannot say for certain that the holes were not due to other grouping strategies (e.g. apps used in class). However, it appeared that holes provide a proxy for the number of applications uninstalled. No differences were found between genders in the number of holes on springboards, $t(22) = 0.23$, $p = 0.89$.

5.1.2. *Changing the first springboard and bottom bar layout*

Users also varied in the customisations made to their first springboard pages. Six participants (25%) did not remove any applications from this page whereas one user moved every application but one to another location. Most users, however, left many of the default (out-of-the box) applications on the first page ($M = 23.31\%$ removed, SD = 28.86%). There was high similarity in the first three applications removed from this page. Everyone who moved applications removed the Compass, Stocks and Messages (SMS) applications. The former two applications were moved to subsequent pages. The SMS application was moved to the bottom bar, usually in favour of the iPod Music Player application there by default. There was some evidence that males ($M = 29.46$, SD = 18.21) moved more items than females ($M = 17.50$, SD = 16.88) from their first springboard page, $t(22) = 1.81$, $p = 0.07$.

None of our users organised their first springboard page to maintain category integrity. Instead, it appeared they used their first springboard page for their most frequently used applications. This was verified with an analysis of all of the applications used not on the bottom bar. First-page applications accounted for 81% of these application launches and

90% of total time consumed. The Facebook application, moved by 75% of the participants to the first page, was the largest contributor to these launches and duration. Across all users, it was used more frequently than all applications except SMS, email and voice phone. Similarly, it consumed more time than all applications except for the iPod music player, voice phone and SMS applications.

The six users who did not move any applications from the first springboard page had a different distribution of most visited applications compared to others (Figure 4). These users appeared to use their iPhone more as a phone and less as a computer. For instance, these 'non-app movers' used the voice phone application more than any other application followed by the SMS application and they did not access the Web very often (recall that we provided free unlimited data plans for all users). The users who moved applications from their first springboard pages (App Movers) texted more than making phone calls, browsed the Web more often and played a game (Words with Friends) more frequently than they opened their Camera application, visited the AppStore and launched their iPod Music Player application. In contrast, non-app movers did not use a diverse set of applications. Their vocabulary of applications used was quite small compared to app movers.

We explored reasons behind this lack of personalisation from our users via surveys. One open-ended question asked participants why they personalise or did not personalise their springboard pages. Three users who did not move apps from their first springboard stated they did not know they could move applications. The other three users who did not perform springboard customisations stated there was no need to move applications because they were aware of the layout and it was not difficult to access resources using the default layout. In contrast, users who personalised their phones stated their first springboard page was useful to quickly launch most frequently accessed or most important applications.

The applications on the bottom bar generally made up most of the iPhone interactions for each user. The Phone, Email and Safari applications were the most common applications left in the bottom bar. These applications made up 28% of all usage across all participants over the six-month period. The aforementioned users who moved the SMS application to the bottom bar used this application more than any other application on their iPhones. Interestingly, those that did not move the SMS application to the bottom bar (thus, leaving the iPod Music Player application) used the phone and email applications more than SMS. These users spent the most time on their iPod Music Player more than any other application. Clearly, the space on the bottom bar is real estate for highly-used applications.

Using the scoring system developed above, females personalised their iPhones to a larger degree and differently than males. Female scores ($M = 47.03$, $SD = 21.16$) were marginally larger than male scores ($M = 30.89$, $SD = 17.38$) after eight weeks with an iPhone, $t(22) = 1.83$, $p = 0.08$. Though males moved more applications from their first springboard page (as noted above), females added more applications, moved more applications from their bottom bar and changed the image on their lockscreen more often (every female but one changed the image on their lockscreen to a personal photograph whereas 50% of the males did not change the image at all). There were no differences

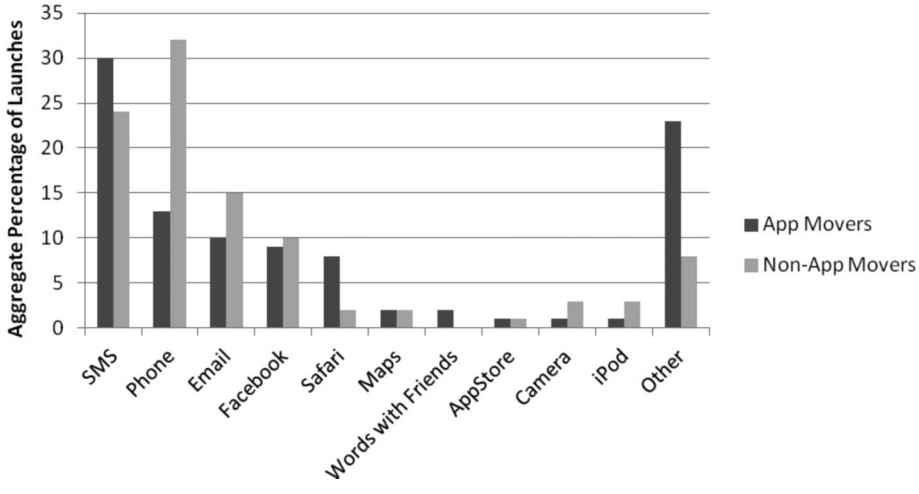

Figure 4. Aggregate percentage of application launches for users who moved applications from their first springboard page and those who did not move applications from their first springboard page.

in the number of holes left on springboard pages, ringtone changes or case use across genders.

5.2. Personalisation and smartphone usage and usability

Until now, we have explored user diversity in how smartphones were personalised. In this section, we assess the relationship between personalisation vis-à-vis usage and usability. We start by examining this relationship in a more general way, by correlating personalisation scores with total duration of use, total number of visits and perceived usability as measured by the SUS.

Personalisation scores captured during the second month of the study (Week 8) were used to assess the relationship between personalisation and iPhone usage over a consecutive six-month period. As shown in Table 5, personalisation scores were highly correlated with the amount of time participants spent on their iPhones. Users who personalised their device more, spent more time on their device but did not launch applications more frequently.

We separated the primary communication applications (i.e. SMS, phone and email) and non-communication applications for more precision. We thought the former would *not* relate to time spent using the phone for communication because time spent for this task could be prompted by variables other than personalisation (e.g. number of social ties). However, non-communication applications such as the Web and Games represent computing tasks that are more self-directed (e.g. not prompted by an incoming text message or phone call) and might better reflect users' reliance on their devices. Personalisation scores significantly correlated with the duration of time spent on non-communication applications. Interestingly, overall personalisation scores correlated with the number of times participants accessed their Web browser and the overall duration of browsing. Communication applications appeared to be more aligned with the core functionality of the device. Non-communication applications seem to represent tertiary components of device usage that can reflect user reliance on technology for a broader set of tasks.

Table 5. Correlations between personalisation scores and iPhone usage after six months.

	Personalisation score
All device usage	
Launches	−0.19
Duration	0.57**
Communication apps	
Launches	0.12
Duration	0.19
Non-communication apps	
Launches	−0.14
Duration	0.49*
Web browsing (Safari)	
Launches	0.53**
Duration	0.47*
Usability (SUS Scores)	0.57**

Note: Communication apps = SMS, Email and Phone. ** = significant at the 0.01 level, * = significant at the 0.05 level.

The evidence above seemed to show that the user differences in iPhone usage were at least partially due to the fact that user personalisations made important applications easier to access. We assessed users' perceived usability of their devices to determine the relationship between personalisation levels and ease of device use and learnability. Indeed, personalisation scores strongly correlated to perceived usability as measured by the SUS ($r = 0.57$, $p = 0.004$). Thus, users who personalised their iPhones more also perceived their devices as more usable.

We further explored what aspects of personalisation were driving this relationship. The correlation matrix presented below (Table 6) shows that the number of holes and the number of changes made to the first springboard page were most strongly correlated with usability. There was some evidence that application installs correlated with usability scores, though not quite significant at a 0.05 alpha level ($p = 0.06$). None of the physical/appearance personalisation measures correlated with usability, although the two that yielded user variance (ringtone and lockscreen customisations) did correlate with each other. No gender differences were found in SUS scores, $t(22) = 1.09$, $p = 0.78$.

Differences between personalisation actions recorded for this group of participants and the group of participants who were described in the previous section were also assessed (see Tables 2 and 6). Many of the mean personalisation behaviours were higher for Group 1 (Score Group) compared to Group 2 (Logged Group). Most of the participants in Group 1 owned their iPhone for a longer period of time and this could explain some of the differences such as the larger number of apps installed. There were also differences in the intercorrelation of personalisation items between groups. For example, in Group 1, the organisation of their first springboard page did not correlate with any other personalisation item. In contrast, the users in Group 2 who organised their first springboard page also personalised their device in other ways as well including both interface and physical/appearance personalisations. Group 2 personalisation items, in general, yielded higher intercorrelations. We suspect one reason is due to the fact we measured personalisation after only eight weeks into the study. As explained below by the diffusion of innovation, the novelty of

Table 6. Means, standard deviations and intercorrelations of personalisation measures and usability.

		M	SD	1	2	3	4	5	6	7	8	9	10
1	Springboard (SB)	23.31	22.87	–	0.02	0.26	−0.12	0.36	0.51*	–	0.08	−0.17	0.39*
2	Order on SB 1	21.94	14.48		–	0.38*	0.38*	−0.13	0.07	–	0.45*	0.37*	−0.04
3	Bottom bar (BB)	13.58	14.67			–	0.81**	−0.24	0.16	–	0.28	0.33	0.00
4	Order on BB	54.52	47.79				–	−0.28	0.20	–	0.52**	0.40*	−0.04
5	Holes	4.89	6.91					–	0.39*	–	−0.08	−0.14	0.41*
6	Apps	30.33	26.24						–	–	0.29	0.16	0.35
7	Case	100	0							–	–	–	–
8	Ringtones	62.5	49.45								–	0.51**	−0.01
9	LockScreen	72.91	44.17									–	0.24
10	Usability	80.42	11.21										–

Note: *r* values are PPMC coefficients. *$p < 0.05$, **$p < 0.01$.

using a new device could lead to more types of personalisation for some and not others. For instance, it was not clear that some of the users in the logged group discovered how to move or delete applications or change the image on the lockscreen on their devices and this could be driving the higher correlations between personalisation measures. This is discussed more in the next section.

6. Discussion

Our aim in this study was to explore user diversity in personalisation behaviours. A naturalistic and longitudinal approach was used based on empirical data from two groups of users. Data obtained from the first group allowed us to assess a simple heuristic method to capture personalisation levels. Using a classical approach to validation, we found that our measures captured the theoretical dimensions of personalisation found in previous research. Items that related more to autonomy and competence were correlated with each other whereas more appearance related items also yielded convergent validity. These items also diverged as expected. The scores were easily obtained from participants' technology, quantitative and captured considerable user variance in user-driven personalisation. Of course, our scoring system did not capture all personalisation actions, but represented primary ones from different categories (interface, content and appearance).

Data from the second group of participants was primarily analysed to understand how personalisation relates to device usage. The users who customised more also spent more time on their devices. This was not just due to the fact that they had more applications on their devices. For instance, users who personalised their phones more also navigated the Web more frequently and for longer periods of time. Of course, a browser comes standard on all iPhones. Additionally, there were marked differences in the type of usage from those that moved applications from their first springboard compared to those that did not. The latter seemed to use their iPhones more like flip phones and less like fully-functional smartphones (even with free service). They did not perceive their iPhone as usable compared to those that personalised more. Taken together, the addition of applications, removal of applications, changes to the springboard layout (on the bottom bar and first springboard) and other personalisation behaviours reflect an increased reliance on the device for a wider range of purposes (e.g. information retrieval from the Web). Indeed, our findings supported previous work suggesting that user personalisation increases the novelty of the device and creates a stronger attachment between the user and their customised technology (Hancock *et al.* 2005).

Of course, because our study was exploratory and largely based on correlational data, we cannot say for certain that increased personalisation caused users to spend more time on their devices or think of their phones more positively (i.e. higher usability). The reverse could also be true; more time on the technology and increased usability could lead to more personalisation. Of course, these relationships could indeed be influenced by a third variable as well. However, we found large individual differences in personalisation levels and this diversity was also reflected in usability and usage. Understanding the causal factors underlying this variability seems to be a fruitful area of future research.

6.1. *Gender differences*

One of these factors seemed to be gender. Females personalised their phones differently than males, though these differences did not remain in similar fashion across both of our participant groups. The results from our first group suggested that females personalised their phones more for appearance and social reasons. Males, in contrast, appeared to

personalise more to enhance personal competence and perhaps autonomy. We achieved more control over the second group (e.g. experience using a smartphone), though our sample size was slightly smaller. Still, we found that males and females personalised their iPhones differently. Females installed more applications, moved applications from the bottom bar and changed their lockscreen image more than males. This resulted in higher overall personalisation scores, though the differences between means did not reach the 0.05 level of significance. Male behaviours were not completely devoid of personalising. For example, they moved more items from their first springboard page compared to females.

Taken together, it appears that males and female personalisation differences are not static. We suspect that both males and females customise their device to satisfy all three motivations mentioned above (Autonomy, Competence and Relatedness; Oulasvirta and Blom 2008). However, it appears that female personalisations were driven by all three whereas males were motivated more to satisfy just the underlying competence-related aspects. More research is needed to explore these differences.

6.2. *Usability*

One important finding of our research is that users who personalised their devices more also found their iPhones more usable. This suggests that designers should not only *allow* personalisation of technology, but also *encourage it* in order to increase the likelihood of long-term adoption and enhance the perceived usability by the user. It could also suggest that more support is needed for users who do not personalise their iPhones. For instance, better support for finding applications not on the first springboard page or prompting users to remove unused applications (recall that holes and changes to the first springboard page were most strongly correlated to SUS scores).

This research has yielded important information for designers who seek to create more usable designs. Most smartphone usage results from interactions that take place with applications on the bottom bar and the first springboard page. Most users did not organise subsequent springboard pages based on category. Since smartphones are often used to fill dead time (Matthews *et al.* 2009), it could be the case that many interaction sessions are interrupted before secondary applications (applications not on the first springboard page) are accessed or these applications do not enter a user's active vocabulary. Additionally, as the number of applications increases, users may have difficulty in remembering the location of applications not on the first page. Our results showed that users tour a large number of applications immediately after receiving their phones. Once this period is over, an active vocabulary of applications is revisited frequently and most new applications do not get reaccessed regularly, unless the user moves these applications to the first springboard page or bottom bar. Put another way, applications have a shorter lifespan if users do not move them to the first springboard page (or bottom bar). The latter is in parentheses because it appeared like a more fixed location. Thus, application designers who desire repeat visits to their applications should encourage user customisations for increased likelihood of frequent revisits.

If repeat visits do not occur, those applications might be relegated to subsequent springboards or simply removed. The latter occurred much more frequently than we expected. Clearly, the high number of uninstalls we observed show that springboards are important real estate for users and that just because an application is installed does not mean it will stay installed. The first (home) springboard, along with the stable bottom bar, is the most 'valuable' real estate for users for frequently visited applications.

Since more downloaded applications increase the personalisation score, it seemed logical to assume that having more applications would also lead to more applications being launched. Surprisingly, overall number of application launches generally did not relate to personalisation. Because communication applications accounted for most of these launches, this dependent variable seemed to be driven by other factors (e.g. number of social ties). In contrast, the Web browser, an application that comes standard on the device, *was* correlated with higher personalisation levels. The personalisation process seemed to establish or reflect stronger links between user and technology for information access in real environments.

In both groups, users varied enormously in their personalisation behaviours. Most surprising was that not everyone personalised their devices after owning it for eight weeks. These individuals did not personalise their devices because it was, for them, more straightforward to learn their device as-is. Designers should note that not all users personalise their smartphones and these individuals will not find the device as usable compared to those that do customise.

6.3. *Personalisation and marketing*

Though we did not focus on the branding of mobile resources and technologies, our results suggest that personalisation provides an effective option for design in mobile space. Effective branding can result from the physical perception of the technology, usefulness and usability (Rondeau 2005). Previous research has found

that allowing users to customise their user interface (e.g. Vodafone) could detract from performance and usability (Koutsourelakis and Chorianopoulos 2010) and that standardisation is an effective alternative to enhance the learnability of new technologies (e.g. Norman 1990). At the broadest level, we submit that personalisation is an alternative design strategy to standardisation and branding that is effective for mobile technologies. Indeed, our study empirically shows the importance of personalisation in creating connections between users and mobile resources. For instance, users who moved applications adopted a more diverse set of applications and used their device for longer periods of time. Additionally, we found strong positive relationships between overall personalisation, usability and volume of device use (particularly for applications not used for communications). Previous research has speculated on the relationships between particular design strategies, usability and usefulness. With the data reported in the current study, we found that there is a clear relationship between personalisation, usability and device usage. Although we do not have specific evidence that personalisation is a better marketing strategy for design compared to branding or standardisation, this research suggests personalisation is effective to create usable and useful technologies and applications. Branding and standardisation are inherently company-focused and technology-focused, respectively. Personalisation, in contrast, is user-focused because it allows users to customise their device based on the specific needs and desires they perceive in their contexts.

For many previous-generation technologies, marketing had to figure out exactly what their customers needed and then provide that product to them. If marketing failed in their assumptions or their user data assessment, and the product had the wrong features, then it was likely that the product would fail. In today's world, highly customisable products allow marketing to focus on purely core functions and then let the consumer make the device what they need or want it to be. Indeed, for current-generation mobile systems, marketing can now focus on the most fundamental of capabilities that a user would want or need and then use customisation to serve as both a way to increase customer satisfaction (e.g. through enhanced usability) and thus, increase revenue. Customers can manipulate interfaces and install content based on their desires while companies work to deliver enhanced content (like more apps). Clearly, as evidenced by the large variance among users in this study, smartphone usage is extremely diverse and there is no standard smartphone user for marketers to target for many products and services. Personalisation capabilities are central, then, to reach the largest audience with mobile content.

6.4. Limitations and future research

There are several important limitations to the current study. Primarily, the small number of users who participated may not adequately represent the millions of smartphone users around the world. All of the students were under the age of 30 and attended a private university during the study period. As is clear in the diffusion of innovation (Rogers 1995), the early adoption of smartphones may be a characteristic of group attributes that likely do not apply widely to other types of users (e.g. the elderly). Additionally, the second study utilised participants who did not previously own a smartphone. The high volume of early usage data is likely due to the novelty of adopting a new technology.

Finally, this study focused on measuring iPhone personalisation and usage; the findings may not apply across all mobile technologies. Future research could target other devices with a wider range of users. Of course, adjustments would need to be made for different platforms, including an inclusion or exclusion of customisation features and a normalisation of the total number of applications that can be resident on the smartphone at any given time. Certain platforms will lend themselves to a more direct application of the model than others, to be certain. For example, the number of applications available for the family of Android phones is quite large ($>200{,}000$) while the number available for the Blackberry family is significantly smaller (~ 1000). Scoring metrics would obviously need to be adjusted for the Blackberry to account for this reduced universe of application, but not for the Android family. Other personalisation items, such as physical personalisation using a case are driven more by market availability. Even here, while the iPhone does have more options available, a quick perusal of Amazon.com shows that upwards of 5000 case choices exist for specific android and Blackberry class phone. Future studies are needed to determine how well the metric extends beyond the iPhone.

7. Conclusion

Three clear takeaways emerged from this research. First, though user personalisation may satisfy basic psychological needs (Oulasvirta and Blom 2008), not everyone makes the effort to adapt their smartphones to suit their individual needs, preferences and contexts. Even personalisation items that are fundamental to the use of the device, such as installing applications from the AppStore, were not universally used.

Second, those that personalised their smartphones also used it more and perceived it as more usable. Marketing tends to push the feature set forward, often

regardless of the user's actual needs or expressed desires. In the case of the smartphone environment, it would seem that the ability to extensively customise is seen as an integral part of the value of the device itself for many users. This symbiotic relationship warrants further research.

Finally, personalisation can be scored and systematically studied. Since HCI research has widely suggested personalised support for users, measuring behaviours of interest and assessing how and why users personalise is an important way ahead. Smartphones are quickly taking over many tasks that have traditionally been done on PCs. As seen in this research, personalisation is a key factor relevant to understanding important considerations for designing smartphones and other similar technologies. With this understanding, designers can better support users for enhanced functionality and applications.

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