DESIGNING FOR DIVERSE USERS –
A CASE STUDY ON TOUCHSCREEN SMARTPHONE CUSTOMIZATION

A Dissertation
Presented to
The Academic Faculty

by

Vicki Haberman

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy in the
School of Industrial Design

Georgia Institute of Technology
May 2012

DESIGNING FOR DIVERSE USERS –
A CASE STUDY ON TOUCHSCREEN SMARTPHONE CUSTOMIZATION

Approved by:

Dr. Ellen Yi-Luen Do, Advisor
School of Industrial Design
Georgia Institute of Technology

Dr. Alexandra Mazalek, Minor Advisor
School of Literature, Communication and Culture
Georgia Institute of Technology

Jim Budd, Reading Committee
School of Industrial Design
Georgia Institute of Technology

Dr. Michael L. Jones, Reading Committee
School of Industrial Design
Georgia Institute of Technology

Bruce Claxton, Reading Committee
Senior Director of Innovation Design
Motorola Solutions

Date Approved: March 28, 2012

ACKNOWLEDGEMENTS

In the years spent pursuing my PhD, I have sat at the crossroads of design and science, academia and industry. For this diverse experience and exposure, I will forever be grateful. I would like to thank those individuals whose paths I have crossed in this process and whose guidance has made an indelible impact on me as well as my work. I also could not have made this journey without my friends and family who provided their love, support and patience. For this, I offer my most heartfelt thank you.

I am greatly indebted to my advisor Ellen Yi-Luen Do. When I showed up on her doorstep, I had a topic but struggled to pinpoint a concrete direction. It is through her guidance, support and enthusiasm that I was able to rein in the ideas. When I became frustrated, she talked me through it. When I proposed a schedule, she made me stick to it. When I doubted my ability to finish, she instilled in me the confidence that I could. She helped reinforce the beauty of simplicity.

I would like to thank the Industrial Design Program (now the School of Industrial Design) for giving me the opportunity to teach. Thank you to those students who challenged me and made me think on my toes. Your enthusiasm and passion made me strive to be a better designer, researcher and teacher.

I would like to thank Michael Jones not only for his role as a dissertation advisor, but also for providing me with the opportunity to work as Research Project Coordinator with the Rehabilitation Engineering Research Center for Wireless Technologies (Wireless RERC). In this role, I worked with individuals with

disabilities to better understand their needs and desires for mobile phones. I was also given the opportunity to engage with the mobile phone industry to learn about their struggles in addressing the needs of individuals with disabilities. These experiences provided me with perspective, context and a platform to pursue in my dissertation research.

I would like to thank Ali Mazalek for her guidance in the area of digital media and insight on the convergence between the physical and digital worlds. I would like to thank Jim Budd for his helpful suggestions. I would like to extend a thank you to Bruce Claxton for being my professional industry touch point for validation and verification on my direction.

I would like to thank past faculty advisors from my graduate school education for introducing me to different perspectives on problem identification and inquiry: Charles Eastman, Diane Gromala, Lorraine Justice, Stephen Sprigle and Koert Van Ittersum. While I purposely engaged diverse disciplines and expertise (and may have struggled in this process), it is evident that as a result of their assistance I was able to achieve a more complete and applicable outcome.

I first met Michelle Berryman when she was pursuing her Masters at Georgia Tech, and I was about to begin my senior year of undergrad. Through a mutual passion for interaction design she became a mentor and a friend. In a fortuitous turn of events, I began to work with her company Echo Visualization, LLC. I owe many thanks to her and her co-principal, Brian Lynn and the rest of the EchoViz team. The industry experience gave me first-hand knowledge of disconnects I identify in this

effort. The team provided me with flexibility, support, balance and perspective allowing me to reach my PhD goals.

I met Kevin Shankwiler in the Fall of 2004 when he started the Masters of Industrial Design (MSID) program at Georgia Tech. As a fellow industrial designer, graduate student (oh, by the way, one of mine) and now professor, he is great to bounce ideas off of and help connect the dots. Thank you also for introducing me to your wife, Heather. An immense amount of "thank you" goes to her, the least of which reason is for helping edit this dissertation. Her friendship and mentoring added so much through direction and ideas. Over coffee, wine and walks she talked me off ledges, told me it was worth it and told me I could do it.

To all of those friends near and far (yes, Mary Houlihan and family this is for you), thank you for supporting me including smiling and nodding when I digressed and when the conversation held no interest. Thank you all for giving me a haven and an escape while I juggled life through this journey.

I also must thank Brooke, for curling up at my feet as I worked countless late nights and for giving me those looks that reminded me to get away from the computer. I look forward to more visits to the park.

To my parents, who may not have always understood what it was I was doing or why I was doing it, thank you for supporting me anyway. Thank you for instilling in me the importance of education. Thank you for teaching me to find something I'm passionate about and to go after it, making sure that what I spend my time doing every day is something I enjoy and something of value. To my brother, Ken

Haberman, thank you for going first and showing me graduate school was possible. To my extended family, I'll be taking you up on those offers to come visit.

Finally, I'd like to thank my research participants without whose time, thoughts and insight this work would not have been possible.

TABLE OF CONTENTS

Page

LIST OF FIGURES

SUMMARY

The touchscreen smartphone platform is inherently flexible, giving it the potential to meet the needs and desires of individuals diverse in age and ability. Despite universal design research efforts providing industry with guidance to address this opportunity, current designs fall short. The disconnect stems from differing priorities in design and development and opposing approaches to defining and grouping the user population. The research presented in this dissertation aims to remove these issues from the process of discovering touchscreen smartphone design opportunities. It focuses on users' prior and desired customizations rather than ability- or market-factors. Data were collected on participants' devices' out-of-the-box, current and desired device states along with related stories about their actual and desired device modifications. Template and image analyses identified patterns in the data, which also revealed an underlying structure for organizing and presenting participants' needs and desires associated with smartphone touchscreen customizations. The needs and desires suggest opportunities for industry to shift towards universal design. The structure offers an approach to addressing the gaps between the ability-centered and market-driven approaches to the design of consumer technology.

CHAPTER 1

INTRODUCTION

I explore approaches for improving the design of touchscreen smartphone customization capabilities in order to better meet diverse user needs and desires. In reviewing existing research and reflecting on my personal industry experience, I find design and development perspectives conflict in addressing this area.

"Among the varied designs, operating systems, and technical specifications coming from a long list of manufacturers, one thing is clear – there's really not an enormous amount of innovation going on. The smartphone, it seems, has hit an evolutionary dead end." Kit Eaton, *FastCompany*, 'The Smartphone Revolution Is Over (For Now)' (Eaton, 2012)

Eaton continues, noting that progress will only emerge through entirely new devices of alternate forms. The goal of my dissertation is to demonstrate that there are still possibilities through design and development to advance the current platform and provide industry with growth opportunities and users with enhanced choices.

Mobile phone design has evolved from the numeric keypad-based "brick" capable of making phone calls. Size and weight decreased as features increased. QWERTY keyboards were included as feature phones and smartphones emerged (Webdesigner Depot, 2009). Smartphones introduced the capability for advanced

computing with data exchange. With this extended functionality including the ability to connect to the Internet and use third-party applications (e.g., games and digital newspapers), the mobile phone's role and importance in personal, social and professional activities continues to increase (Turkle, 2008).

The smartphone's form has evolved, with touchscreens replacing physical buttons and controls as the primary form of input (Landay, Joseph, & Reynolds, 2009). The touchscreen smartphone's rectangular shape and dependence on a graphical user interface has changed little since it was introduced and later made popular by Apple Inc.'s launch of the original iPhone in 2007 (Curwen, 2010; Webdesigner Depot, 2009). The similarity in physical device characteristics across manufacturers has led to homogeneous product offerings (Figure 1.1).

Figure 1.1 - Mobile phone form factor evolution towards touchscreen smartphones, adapted from.

In their current state, touchscreen smartphones present design shortcomings that often hinder individuals with disabilities. Instances that mar interactions for individuals without disabilities can become insurmountable barriers (Hellman, 2007). For example, mobile phone use is negatively impacted if individuals find documentation or device content too difficult to comprehend or interface modalities to require too much coordination.

The factors that make touchscreen smartphone designs similar also make it an inherently flexible platform. This may be its greatest asset for addressing diverse user needs and desires. I identified four areas of device design that reflect these possibilities based on their characteristics and customization capabilities: interaction modalities, interaction styles, available content and content presentation. These areas are mediated by each touchscreen smartphone's operating system with many elements conveyed to users through the graphical user interface and device home screens (Curwen, 2010).

Customization centers on user-driven device modifications. The changes take place over time as users strive to align device capabilities and appearance with their needs, desires and inherent behaviors (Blom, 2000). The device itself can also trigger changes based on machine-learning algorithms. However, their accuracy is limited (Montague, Hanson, & Cobley, 2011). In focusing this effort towards industrial, interaction and graphic designers as well as others related to those areas of expertise in the design and development process, I determine that addressing these technology concerns was out of scope. Therefore in this dissertation, I mainly

focused on opportunities associated with improving design related to user-driven modifications.

1.1 Current State

To frame the study's approach, I considered why current efforts have had limited success towards universal design of mobile phones. I discovered conflicts between and shortcomings of universal design efforts and marketing-driven (or business) practices. The latter bears primary responsibility for bringing products to market. "Universal design remains a marginal rather than a common approach in mainstream technology businesses (Law, 2010)." In reviewing general and mobile phone domain-specific works, I identified underlying factors perpetuating this disconnect. The universal design and marketing-driven design and development perspectives differ in their priorities, indicated by their definitions and categorizations of the user population and their measures of design success.

Mobile phone companies centered on marketing-driven practices are motivated by profit concerns tied to customer acquisition and retention. This prioritizes consumption-based factors, or those based on the purchasing of goods and services, in measuring design and development success. To address these concerns, marketing-driven efforts strive for product differentiation. By identifying needs and desires for a narrow population segment, they create targeted offerings for the select group. They determine the market segments based on personal factors including: demographics, life-style attributes and purchasing behavior. In inquiring about needs and desires consumption-based efforts focus on device features and

understanding the details that will excite consumers. Findings from marketing-driven research efforts are added to requirement documentations used to drive detailed design. This approach supports a culture where processes, procedures and core values go against those required to create devices that meet the range of the populations' abilities (Baines, Fill, & Page, 2008; Hair, Bush, & Ortinau, 2005; Kotler & Armstrong, 2007).

The universal design approach categorizes the user population by ability. Extremes in functional limitations define the sub-groups with refined detail (Keates & Clarkson, 2003; Persad, Langdon, & Clarkson, 2007). Research efforts establish a knowledge base to provide industry with insight on designing for individuals diverse in age and ability. Focus is on improving device and user performance based on measures of task completion, including those outlined in usability evaluation methods (e.g., effectiveness and efficiency). Findings are disseminated with hopes of supporting industry in achieving tangible results towards universal design (Dong, Keates, & Clarkson, 2004; Goodman, Dong, Langdon, & Clarkson, 2006). The findings focus on narrow design decisions and statements (e.g., specific font size or contrast ratio), supporting the mobile phone industry's gradual approach to change (Milne et al., 2005). Their specificity provides detailed short-term solutions. This contributes to the development of specialized designs to address the needs and desires of individuals with disabilities versus integrated mainstream solutions (Gregor, Sloan, & Newell, 2005). The mobile phone industry resists these efforts, perceiving high costs for low returns (Law, 2010). In Figure 1.2, I reflect the universal design- and marketing-driven approaches, highlighting the differences in perspective.

Approach	Measures for design success	Method of grouping user population	Factors for defining population groups
UNIVERSAL DESIGN	**Performance** allowing for task completion	**Ability**	**Functional limitations**
MARKETING (Business)	**Consumption** leading to financial returns	**Market segment**	**Personal factors**

Figure 1.2 - Comparison of design and development approaches.

1.2 Aims

After outlining current touchscreen smartphone technology and its design and development context, I realized following a traditional performance-based design research approach was inappropriate. Findings of such approach would center on short-term solutions, perpetuating the issues I aimed to address. I focused on high-level problems by shifting away from designing for disabilities or presupposed market segments. I centered on the characteristics of touchscreen smartphone customization. I placed importance on the central relationship between customization and time. In doing so, I positioned the effort towards identifying progressive solutions (Milne et al., 2005). I framed a holistic approach where insight into short-term solutions was still identified; however, I emphasized arriving at long-term opportunities that could be incorporated over time (Carter, 1999). The latter allowed for a deeper dive that went beyond surface-level device features to address underlying issues (Dourish, 2004a). To improve the possibility of both

performance- and consumption-focused perspectives finding the research output applicable, I considered design research practices and core concerns of both.

I identified three device states based on customization and the construct of time: out-of-the-box, current and desired. I leveraged these to create a platform for determining appropriate research and analyses methods for exploring the following two questions:

1. Does comparing touchscreen smartphone device states (out-of-the-box, current and desired) identify opportunities for design improvements that address the needs and desires of individuals diverse in age and ability?
2. Does the approach identify design opportunities that would have remained unidentified or unassociated through performance- and/or consumption-based inquiry alone?

1.3 Exploring Areas for Design Improvement

I focused on touchscreen smartphone home screens because of their central relationship to the four identified areas related to the design of device customizations: interaction modalities, interaction styles, available content and content presentation. I used qualitative research methods, determining that one-on-one participant sessions would be most appropriate for gathering data associated with the device states. This included stories about transitions between out-of-the-box and current device states. During the sessions, I gathered details on participants' devices' brands, models and operating systems. With this information, I conducted Internet searches for user guides to identify each out-of-the-box state. I

used contextual inquiry techniques to probe for insight on current device states and the stories about participants' devices evolution over time. With many customizations taking place weeks and months prior to the sessions, I deviated from the traditional contextual inquiry approach that centers on probing about present-day tasks (Holtzblatt, Wendell, & Wood, 2004). I focused on having participants use their current devices as prompts for spurring their memories and telling stories about changes they made in the past. I also captured static images of participants' devices' home screens to later aid in data analyses. I selected generative research, a design-led approach, to gain insight into participants' desired device states (Sanders, 2000, 2008). Figure 1.3 presents the research methods in the context of their related device state. Figure 1.4 shows an example of device state images that I captured for each participant.

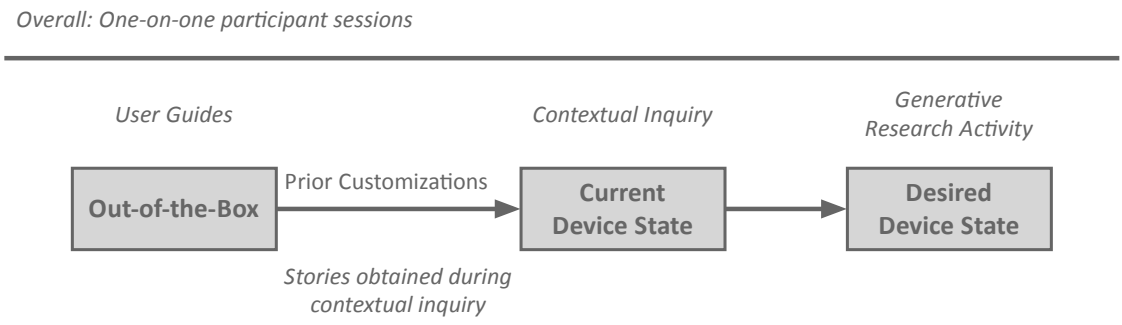
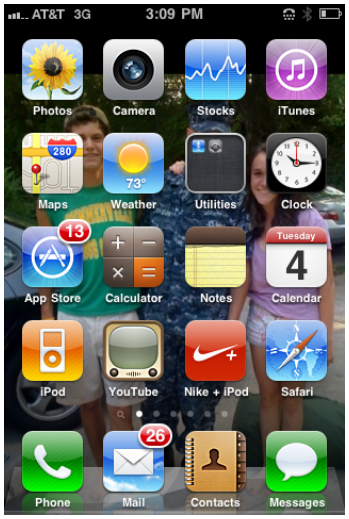
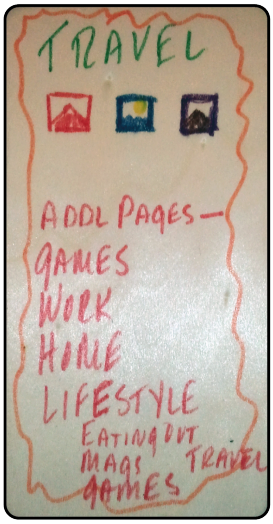


Figure 1.3 - Research methods used in inquiry based on device state.

Out-of-the-Box State



Current State



Desired State

Figure 1.4 - Example of a participant's three device states.

Nine (n=9) touchscreen smartphone users whose devices ran either Apple iOS (iPhone) or Google Android OS participated in the study. I selected these platforms because they were the top two touchscreen smartphone operating systems in the United States at the time of the study (The Nielsen Company, 2011). I reviewed the data as it was gathered.

I employed two forms of thematic analysis in exploring the data: template analysis and image analysis. For the template analysis, I created a tiered structure that included themes suggested by prior research efforts and my personal experience (King, 2004, 2007). In the template, I also represented the relationships between the themes. I leveraged the template in the data analysis process, confirming, refining, adding or removing themes as indicated by the findings. Figure

1.5 presents the core areas of the initial template I created. I noted two primary areas: motivators and customizations. Motivators included a breakdown of performance- and consumption-factors, viewing them as drivers for users to modify their devices. In this area, I also show the theme of "time" based on the role it plays in device customizations. I divided customizations into: interaction modalities, interaction styles, available content and content presentation. In reviewing data against the template, I created vignettes for each participant to summarize significant findings. These were later used in the inter-participant analyses.

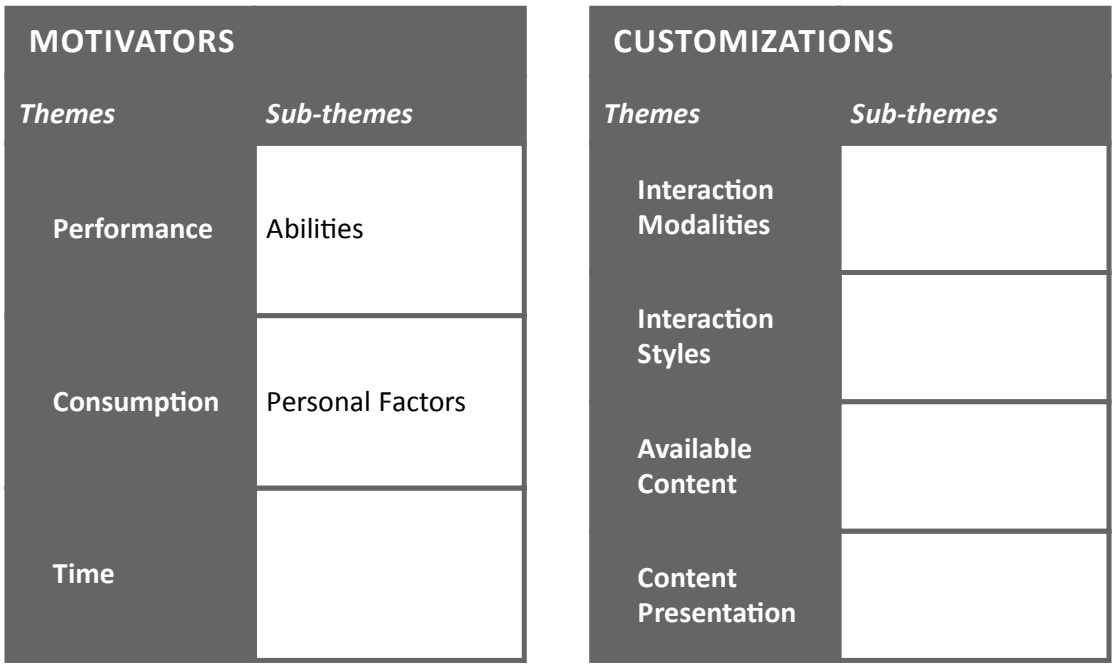


Figure 1.5 - Core areas of initial template used in data analyses.

I also used image analysis techniques to create diagrams representative of participants' desired device home screens. As part of this process, I established a platform and set of symbols representing participants' touchscreen smartphone needs and desires.

1.4 Findings and Study Significance

Through the intra-participant data review I updated the analysis template and established the symbol key, clarifying initial and identifying additional sub-themes to interaction modalities, interaction styles, available content and content presentation. I used the updated structure to address the research questions. In seeking design opportunities, I found participants desired customization capabilities that:

- Were directly motivated by their abilities;
- Were associated with abilities that they did not directly experience themselves;
- Aligned closely with current market offerings; and
- Were available, but not appropriately designed, for those indicating interest.

I identified that these findings linked to performance- and consumption-based motivators and revealed short-term design solutions related to narrow design decisions.

I also discovered participants desired customization capabilities that were motivated by factors of time. Based on scenarios presented in the data, I associated

these time-related customizations to situational- and extended-device use. I positioned time as a motivator for change addressing higher-level problems. With this insight, I outlined a long-term design strategy for aligning performance- and consumption-based perspectives towards improving touchscreen smartphone design. The design strategy centers on "spectra," a set of relative variables where individuals' alignment along each collectively indicates their inclination towards customization capabilities. I use scenarios to present how spectra can be applied in identifying long-term design opportunities for addressing diverse user needs and desires.

In addition to the strategy and approach to identifying long-term design opportunities, I found template and image analysis techniques to be an important contribution to future design research. I feel the updated analysis template can be used in future efforts exploring touchscreen smartphone design, reducing resources required to complete them. The image analyses provided a wealth of insight I feel exceeded the resources required to complete them, acting as a model for effective and efficient data processing. Finally, data indicated the potential to leverage the spectra and overall research approach in similar technology domains.

In presenting this work, I hope to inspire continued explorations of the role of time in driving users needs and desires for device customization. My hope is that extended efforts will further support aligning performance- and consumption-based design and using the spectra-focused approach I propose. By reinforcing the alignment of performance- and consumption-based design, I hope to introduce an alternate and complementary perspective on universal design.

1.5 Thesis Outline

I divide the thesis into three main sections.

- Introduction and background (Chapters 1-3).
- Research approach and execution (Chapters 4-5).
- Findings and conclusions (Chapters 6-8).

Chapter 2: Touchscreen Smartphones, Missed Design Opportunities provides an overview of touchscreen smartphones and the platform's customization capabilities. In the chapter, I highlight potential areas for design improvements towards addressing diverse user needs and desires. *Chapter 3: Defining Users and Identifying Design Perspectives* addresses details of efforts prioritizing performance- and consumption-based factors in design and development. I present details on how the different approaches segment the user population and define successful design efforts. I end Chapter 3 with an outline of the project aims and exploratory research questions.

In *Chapter 4: Research and Analysis Methods*, I include details on how the participant study was structured to address the questions. I describe the current performance- and/or consumption-based design research methods I found to be applicable to this effort. I discuss the application of template and image analysis techniques towards identifying short-term solutions and long-term design opportunities. *Chapter 5: Data Collection Process and Review* provides an overview of the participant sessions. I review the process of creating the participant vignettes and desired device home screen diagrams, both of which are included in Appendix A. In Chapter 5, I also outline updates to the analysis template.

Chapter 6: Meeting Diverse User Needs and Desires through Customization presents the inter-participant data review focused on short-term solutions associated with interaction modalities and interaction styles. *Chapter 7: From Short-term Solutions to Long-term Design Strategy* includes the introduction of spectra and how I arrived at a long-term design strategy. In *Chapter 8: Conclusion*, I indicate potential future directions. I provide guidance on applying the strategy to identify long-term design opportunities for addressing diverse user needs and desires. I also provide thoughts on overall contributions of this research and analysis effort.

CHAPTER 2

TOUCHSCREEN SMARTPHONES, MISSED DESIGN OPPORTUNITIES

The proliferation of the mobile system has made it an essential part of daily life. It allows information access and exchange independent of time and location. This flexibility created a mobile culture that centers on individual freedoms, social engagement and community networks (Jones & Marsden, 2006). Devices are personal, intended for users to take them wherever they go (Landay et al., 2009). The impact of this connectivity continues to expand alongside the rapid pace of technology change (Turkle, 2008). This has been heightened by the emergence of smartphones that are rapidly replacing their basic and feature phone predecessors (Want, 2009).

The basic phone (also traditional or "dumb") is based on a physical numeric keypad. For text entry, keys must be selected multiple times until it cycles to the desired character. Primary capabilities included voice calling and text messaging. Feature phones expand the method of content entry to a full QWERTY keypad that is implemented either via physical buttons or a touchscreen interface. These devices focus on social communication, extending voice calling and text messaging capabilities to social media integration. Social media centers on the publishing of user-created content (text, audio and/or video) online to a select audience in order to engage in conversation (Kaplan & Haenlein, 2010).

Smartphones advance these capabilities even further by offering advanced computing with data exchange (Landay et al., 2009). This includes the ability to

store information, surf the World Wide Web, send and receive e-mails and use third party applications (e.g., games and digital newspapers). At the end of 2011, 44% of mobile phone subscribers in the United States owned a smartphone, up from 18% two years earlier (The Nielsen Company, 2011).

While there are smartphone models with physical keyboards, offerings have moved toward touchscreens with a few having both input options. This design and technology trend is expected to continue (Buchanan, 2008). The touchscreen only or "slate" form introduced homogeneous device characteristics across manufacturers. This included a rigid rectangular shape, few buttons or controls and a glass front surface. The format allows users to add multiple software applications and connect with additional system components (e.g., application stores, wireless headsets) (Curwen, 2010). The flexibility of touchscreen smartphones presents greater opportunity to meet the needs and desires of individuals diverse in age and ability than the earlier, more constrained, generations of mobile phones (Verstockt, Decoo, Van Nieuwenhuyse, De Pauw, & Van de Walle, 2009). However, I found current device designs to fall short in taking advantage of these possibilities.

From a touchscreen smartphone device perspective, I identified four primary factors of design mediating these opportunities:

- Interaction modalities,
- Interaction styles,
- Available content, and
- Content presentation.

I formed this categorization based on a combination of industry terminology as well as my design training and work experience. I also used these reference points to support their descriptions and application. For example, available content and content presentation were supported through:

- Industry advertisements and user guides for touchscreen smartphones running the most prominent operating systems in the United States at the start of this effort: Research in Motion's BlackBerry OS, Google's Android and Apple's iOS (Apple Inc., 2009, 2011; *BlackBerry Storm Series User Guide*, 2009, *Nexus One: User's Guide*, 2010);
- Prior mobile phone design research efforts and reports that focused on device features, functions and scenarios of use (Economides & Grousopoulou, 2009; Han, Kim, Yun, Hong, & Jongseo Kim, 2004; Kiljander, 2004; Ling, Hwang, & Salvendy, 2007; VanBiljon, 2006); and
- Mobile phone specific universal design-related guidelines (CTIA - The Wireless Association, 2011; ISO JTC 1, 2009; Mueller, Jones, Broderick, & Haberman, 2005; Trace Center, 1999; Wireless RERC, 2006; Federal Communications Commission, 1998).

The execution of these primary factors is differentiated across touchscreen smartphones based on hardware specifications (e.g., processor speed, memory and screen types, size and resolution) and operating systems. Operating systems are the central actor controlling hardware resources. They act as intermediaries between software applications and those resources (Kenney & Pon, 2011). Touchscreen smartphone operating systems have graphical user interfaces associated with them.

These support user interactions through visual information displays versus text commands (Charlesworth, 2009). Home screens are the primary user facing aspect of operating systems on touchscreen smartphones. Current touchscreen smartphones have at least one primary home screen. Some devices may have multiple secondary home screens, depending on their operating system design. Home screens are the main starting point for users accessing more in-depth content. They also present top-level information (e.g., time, signal strength, battery power, etc) (Haywood & Boguslawski, 2009).

2.1 Interaction Modalities and Interaction Styles

Interaction modalities describe the forms of content input and output available to users for engaging with their devices (Maragos, 2008). They are dictated by hardware specifications and limited by proprietary rights. Input modalities reflect the forms of user-initiated action. They allow users to navigate, review and react to content (Abascal, Arrue, Garay, & Tomás, 2003; Keating, 2007; Nguyen, Garrett, Downing, Walker, & Hobbs, 2007; Renaud & van Biljon, 2008). For touchscreen smartphones, input modalities include physical buttons and controls, speech and gestures. Output modalities control the method of system feedback and feedforward. They are primarily auditory, tactile and/or visual in format. Feedback is described as content returned by the system following users' actions. It can be used to direct or cue users or simply provide content. Feedforward is content provided by components prior to users performing actions (Wensveen, Djajadiningrat, & Overbeeke, 2004).

On touchscreen smartphones, the inclusion of soft (or onscreen) keyboards minimized the number of physical buttons and controls. The soft keyboards take multiple formats, differing in layout (landscape vs. portrait) and in the visual feedback provided to users to indicate activation. The remaining physical buttons and controls include but are not limited to a power button, volume up and down controls and a home button. Home buttons take users back to their primary home screens. This is often a point of comfort for users, as it allows them to quickly return to a known point in the interface if they get "lost" during interactions (Haywood & Boguslawski, 2009).

Voice activation allows users to navigate through the device and complete actions with voice commands that are typically predefined. However, some devices are capable of adaptive behavior, improving performance by learning their users' intonations over time. Auditory feedback uses forms of sound to provide information to users (e.g., ringtones, message chimes). Tactile or haptic feedback is based on devices relaying information through the sensation of touch (e.g., vibrate alert) (Maragos, 2008).

Gesture-based input involving touchscreens allows individuals to use their fingers to manipulate content displayed on graphical user interfaces. Screen technology dictates hand movements a device can detect (Maragos, 2008). Current mainstream touchscreen smartphones primarily use capacitive screen technology versus resistive technology. In resistive screen technology, the screen is pressure sensitive. It requires force to identify the portion of the screen users are selecting. Capacitive technology uses conductive properties of objects (e.g., users' fingers) to

determine active areas of the screen. Capacitive screen technology allows for more complex hand movements to complete actions. This has led to increased use of physical gestures to manipulate touchscreen smartphones. Examples include using one or more fingers to swipe, pinch or rotate items on the screen. These forms of multi-touch manipulation have direct impact on the types of interaction styles that can be implemented (Hoye & Kozak, 2010).

As a final note on interaction modalities, many newer touchscreen smartphones also include compasses, gyroscopes and accelerometers. These detect orientations of users and devices in space and expand gesture-based input to include gross body movements. There are ongoing efforts to explore novel use of these hardware components in interacting with objects on screens as well as users' environments (Maragos, 2008).

Together interaction modalities and interaction styles dictate how users can navigate or flow through interfaces. Interaction styles identify the formats by which specific objects can be selected and/or manipulated. There are multiple forms of interaction styles that can be implemented on touchscreen smartphones. A single device typically employs several. Examples include:

- Drag-and-drop where users select an object and then move their finger across the screen to place it to a new location;
- Drop-down menus where users select a point on the screen and a menu appears; and
- A series of screens where users flick through them by quickly moving their fingers across the touchscreen.

On touchscreen smartphones, many interaction styles are indicated through visual cues on the graphical user interface. This creates a strong association between interaction styles and content presentation. I found the core interaction styles of devices to usually be conveyed through characteristics of their home screens.

2.2 Available Content

Using the identified sources, I outlined five categories of content that can be presented on and accessed through touchscreen smartphones. It is of note that what they encompass is not mutually exclusive. More granular types of content (e.g., applications) can be considered to bridge multiple categories. *Organization* groups potential content associated with users' personal information including calendar, contacts, notes, reminders, etc. *Communication* includes content associated with the two-way synchronous and asynchronous exchanges. Related applications include, but are not limited to, those based on voice calling, text messaging, multi-media messaging, email, instant messaging and downloading of networked information (e.g., content from a website). *Entertainment* is primarily associated with video, pictures or images, music and games. It is also linked to communication, representative of the exchange of content between individuals for leisure purposes. *Location-based* is an area of emerging content offerings. It centers on providing users with timely and relevant content based on their physical location in space. Examples include driving directions, nearby restaurant recommendations and museum guides. *Safety and Security* focuses on content associated with providing or

receiving emergency assistance. While not as extensive as the other categories, I found it to be a prominent driver for device ownership and use, especially for individuals with disabilities or who are aging.

Touchscreen smartphones come with multiple applications representative of these content areas. Users also have the ability to access marketplaces where they can download additional software for free or charge. Many of these applications pull and push data to provide real-time connectivity and communication. The applications and their associated capabilities extend smartphone touchscreens' reach as powerful, personal products (Landay et al., 2009). Applications are a primary focus of mobile phone industry growth (Martinez, 2010; Zheng & Ni, 2006).

2.3 Content Presentation

I outlined content presentation as the manner available content is displayed to users on graphical user interfaces. Focusing on touchscreen smartphone home screens, primary forms of content presentation include: icons, labels, widgets, status bar and soft keys. *Icons* are pictograms that act as representations of content, often identifying applications. They are points that users can select to access content. *Labels* often accompany icons but can be present on their own. They are short text-based representations or descriptions of content and frequently link to content. *Widgets* are visual representations that present small amounts of relevant and/or timely content. They provide users with a base level of knowledge and often are links, much like icons and labels, to more detailed content. A *status bar* is an interactive or static area typically located at the top of a screen. It displays

information including battery life, time and messages as well as connectivity to the network and peripheral devices. As noted in relation to keyboard-based input, *soft keys* are representations of physical buttons on the display. They can be associated with more than one function. In certain scenarios, they may not be displayed at all (Zhang & Liu, 2010).

Figure 2.1 shows an Android OS home screen, with noted examples of these five forms of content presentation and arrangement. Variables associated with these forms of content presentation include color, shape, size/scale and location. From the perspective of an individual device, I found the variability of interaction modalities, interaction styles, available content and content presentation to be based on capabilities and parameters of customization.

Figure 2.1 – Home screen presentation based on Android OS, adapted from (HTC, 2010).

2.4 Customization

The construct of customization is tied to additional terminology: personalizable, adaptable and adaptive. Existing research efforts vary in their delineation of the terms. Collectively, their focus is on describing an increase in a device's personal relevance through changes to product capabilities and appearance. The device modifications take place over time. I differentiate between the terms based on the impetus of change. This was a core characteristic identified

by Blom in his effort to outline a taxonomy for the constructs (Blom, 2000). I view customization as user-driven actions taken to modify devices to address individual needs, desires and inherent behaviors. It requires a multi-step decision process (Oulasvirta & Blom, 2008). There is little semantic difference between this presentation of customization and adaptable systems.

On the other hand, I view personalization as system-driven. It involves changes initiated or prompted by the system. These are primarily formed through the analysis of users' prior activities and set preferences. Changes are relayed to users through modifications to interaction modalities, interaction styles, available content and/or content presentation (Montague et al., 2011). This parallels adaptive systems. There are instances where a system includes both user- and system-driven changes, taking place as a shared exchange between the two (Findlater, 2009). The sophistication and validity of machine-learning algorithms is at the core of personalization. This presents a lack of transparency that makes it difficult to identify the root cause(s) of changes made to devices (Gil, Giner, & Pelechano, 2011). At the time of this effort, I also found machine-learning algorithms to be inconsistent in their ability to accurately predict and address user needs and desires (Montague et al., 2011).

Messerschmitt notes that the breadth of customization possibilities has business advantages. The ability to configure devices can be marketed to users as an opportunity. However, to be successful, the availability of and relationships between the options must be appropriate, valuable and apparent to users (Messerschmitt, 2007). Park, et al. conducted surveys and focus groups to explore preferences for

customizing mobile phone menu structures, button combinations and automated actions. They found that preferences differed based on individuals' needs and predispositions. However, they also identified a lack of insight on how to address this diversity in design (Park, Song, Kim, Park, & Jang, 2007). Research efforts have revealed that many customization options designed to provide greater accessibility are themselves inaccessible. This includes users' lack of awareness and lack of understanding of where to find and how to utilize available options (Gregor et al., 2005).

The mobile phone industry has put forth an effort to address the inability for mainstream devices to meet the needs of individuals with disabilities through developing specialized devices, or assistive technology. Viewed as a form of customization, alternate input and output modalities and targeted content are offered to users through unique handsets and accessory- and software-based solutions (Abascal & Civit, 2001). Regardless of its form, assistive technology often brings its own limitations of higher development and consumer costs as well as reduced access to features (S. K Kane, Jayant, Wobbrock, & Ladner, 2009). Assistive technology designed to enable access to mainstream systems is reliant on other companies. As a result, there are delays in reaching the marketplace and concerns when the associated system is discontinued or modified. Aesthetic elements can be less pleasing and highlight the fact that it was designed to address specific needs or functional limitations. Individuals will often ignore assistive technology, not self-identifying as having the impairment(s) the design intends to accommodate. This is despite the fact that they would greatly benefit from it. Potential users are driven

away by the labels and stigma (Gregor et al., 2005). These issues demonstrate why reliance on assistive technology as a solution for addressing the needs and desires of individuals diverse in age and ability has not been successful (Keates, 2006).

Collectively, I found the issues and possibilities I identified to support exploring customization capabilities towards improving touchscreen smartphone design for all users. Before framing a research approach, I felt it was important to better understand how diversity was currently being addressed and why efforts to date have been unsuccessful in meeting diverse user needs and desires. By combining this insight with knowledge of the technology domain, I established a more informed research approach.

CHAPTER 3

DEFINING USERS AND IDENTIFYING DESIGN PERSPECTIVES

Universal design aims to resolve issues of exclusion through promoting development of mainstream systems that meet the needs and desires of as many people as possible (Coleman, 2008; Keates & Clarkson, 2003; The Center for Universal Design, 1997). Universal design research efforts collectively build a knowledge base lending valuable insight on designing for individuals diverse in age and ability. Focus is on improving product and user performance. The approach intends to provide industry with support to help them achieve tangible outcomes towards universal design. However, this practice is often met with industry resistance (Law, 2010).

In reviewing prior research efforts on universal design as well as those aimed at identifying barriers to applying their findings in industry, I found two underlying factors indicative of the disconnects:

- Approach to defining users, and
- Priorities in design and development.

The works I examined were general and mobile phone-domain specific. They included, but were not limited to, those stemming from the following disciplines:

- Business (Bühler, 2008; Dong et al., 2004; Law, 2010; Ling, Hwang, & Salvendy, 2006; Macdonald, 2007);

- Human-computer interaction (Crerar, Benyon, & Wilkinson, 2001; Dong, 2007; Hellman, 2007; H. Kim, Heo, et al., 2007; M. Kim, Jung, Park, Nam, & Choe, 2007; Ziefle, 2010; Ziefle & Bay, 2004); and
- Industrial design (Darzentas & Miesenberger, 2005; Goodman, Langdon, & Clarkson, 2007; Großmann, 2008; Iwarsson & Ståhl, 2003; Lewis & Clarkson, 2005; Mieczakowski, Langdon, & Clarkson, 2009, 2010)

I found universal design efforts to define their study populations based on age and/or ability. Within these groups, they focused on the extremes in individuals' functional limitations. This was based on the premise that if those individuals are able to use the devices, the majority of others should be able to as well (Keates & Clarkson, 2003). It is probable that associated research findings will support improved design for all users. However, there is the need for greater acknowledgement of the possibility that findings lending insight into enhancements for one population may hinder another (Cooper, 2004; Story, 2006). This highlights limitations imposed by basing design decisions on the needs of a narrowly-defined population rather than a collective understanding (Laurel & Lunenfeld, 2003).

I found universal design efforts to center on factors of "performance" when determining the extent to which a product was successful in addressing the needs of individuals with functional limitations. These assessments address the relationship between users' abilities and task completion. The focus on performance measures contrasts with industry's marketing (or business)-driven design and development approach (Goodman et al., 2006; Law, 2010).

Marketing-driven efforts tend to focus on factors of "consumption." The aim is to provide value to consumers and capture profits and customer equity in return (Kotler & Armstrong, 2007). To do so, current and/or potential customer characteristics are examined to identify market segments. These smaller population groups are then placed in the context of opportunity and competitive analyses to identify target market(s). Market-driven efforts then target products towards the selected group(s) (Hair et al., 2005). The act of exclusion is inherent to this process (Wind, 1978).

In this chapter, I further outline the differences between the performance- and consumption-based approaches as well as their individual shortcomings. In this discussion, I frame the general situation as well as provide insight into the implications on the touchscreen smartphone domain.

3.1 Performance

Keates and Clarkston stress the importance of defining individuals by functional characteristics and abilities, as these are what lead to barriers to system use (Keates & Clarkson, 2003). Their model on functional capability loss and impairment outlines the association between functional limitations and abilities. It also shows how they lead to performance-related problems (Figure 3.1).

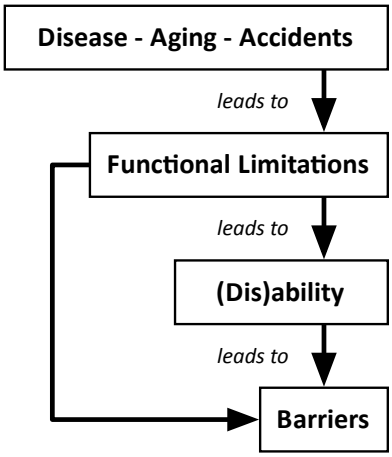


Figure 3.1 – Relationships between functional limitations and ability, adapted from (Keates & Clarkson, 2003).

3.1.1 Abilities

I found not all performance-based efforts group functional limitations into abilities in the same manner or use the same labels. I chose a perspective that based groups on the impact of functional limitations on device interactions. This approach aligned with categorizations used by the Rehabilitation Engineering Research Center for Mobile Wireless Technology (Wireless RERC) in their Survey of User Needs (SUN). The SUN is an ongoing survey that began in 2001 to gather information from people with disabilities about their mobile phone use. The identified abilities reflect the categories of the World Health Organization's International Classification of Functioning, Disability and Health pertaining to the personal level (Mueller et al., 2005).

3.1.1.1 Sensation and Perception

Sensory discrimination centers on users' abilities to determine the quality of attributes associated with visual, auditory, olfactory, taste, touch and introspective stimulations (e.g., pain, nausea) (Schiffman, 2001). Perceptual discrimination is a top-down process involving abstract analysis of sensory information. It is dependent on cognitive abilities (Schiffman, 2001). For example, individuals may lose their vision due to the inability to receive visual stimuli (sensory discrimination) or they may lose it because of the inability to perceive information sent to the brain from the eye (perceptual discrimination). I found it important to review the sensory modalities in respect to limitations and their potential impact on mobile phone use. I reviewed seeing and hearing abilities and their impact on product interactions. I addressed "touch" in the context of physical abilities.

3.1.1.1.1 Seeing

Persad, et. al. (Persad et al., 2007) identified five impairments that can lead to barriers in technology use based on limitations in seeing ability. *Acuity* is the ability to refine fine detail where the degree of sharpness and clarity impacts the extent to which a person can see things as distinct. *Color perception* is the ability to differentiate between hues along the full spectrum of color. Users can become confused if color is the only differentiator used to convey information. *Field of vision* is the area individuals can see. Primary limitations are based either on reduced central or peripheral views. Barriers to use can occur if important content or interactive zones are located outside individuals' fields of vision. *Stereopsis* is the

ability to perceive depth. Limitations can cause difficulty in understanding and operating aspects of a 3D environment, system or device.

3.1.1.1.2 Hearing

Hearing involves the interpretation of noises such as the human voice, music, alarms, chimes, etc. Impairments are associated with limitations in conductive hearing and/or sensorineural hearing. The former is associated with the loudness of sound. The latter impacts individuals' abilities to differentiate between sound frequencies. System interaction is affected by three core hearing functions: detecting sound, detecting and recognizing speech and telling the direction of sound origin (Persad et al., 2007).

3.1.1.2 Cognitive Ability

Cognitive ability relates to the mental processes associated with information and knowledge. Attentional mechanisms filter the constant stream of sensory stimuli and reduce users' breadth of focus (Schiffman, 2001, p. 159). The top-down operation of selective attention involves "a complex interplay of higher-level mental structure, social expectations for behavior and the psycho-social need to participate in the world (Oulasvirta, Tamminen, Roto, & Kuorelahti, 2005)." Points of concentration are dictated by working memory (short-term) capacity, speed and accuracy. The number of stimuli and/or the anticipated amount of time available for processing also influences focus. Long-term memory is responsible for storing and retrieving knowledge gained through prior interactions and then leveraging it in future ones (Persad et al., 2007). In recent years, there have been research and

design efforts aimed at developing smartphones and smartphone applications as assistive technology to aid individuals with cognitive impairments (Fenwick et al., 2009; LoPresti, Simpson, Kirsch, Schreckenghost, & Hayashi, 2008; Stapleton, Adams, & Atterton, 2007).

3.1.1.2.1 Mental Models

The concept of "mental models," as presented by Persad, et. al. (Persad et al., 2007), is an underlying factor guiding the direction of interaction. Discussed in the context of users' processes for planning and solving problems, mental models are users' internal representations of system behaviors. They are constructed by individuals' finite means to translate external stimuli (Johnson-Laird, 1983). Mental models are descriptive of how people understand device functionality and how it relates to tasks at hand. Users construct their mental models as they engage with systems by combining their prior knowledge from long-term memory with incoming information. Therefore, individuals present unique mental models based on both contextual and ability-based variables. Mental models continually evolve, resulting in different levels of performance at different times (Vander Veer & del Carmen Puerta Melguizo, 2002). Constantiou (Constantiou, 2009) suggests leveraging the concept of mental models in understanding individuals' decision-making process.

3.1.1.3 Physical Behavior

Physical behavior can be distinguished based on activities that require use of hands or larger movements such as walking, standing and climbing stairs (Wireless RERC, 2010).

3.1.1.3.1 Using Your Hands

There are three primary factors affecting individuals' abilities to use their hands in relation to device interactions: dexterity, grasping and force exertion. Dexterity involves the coordination of small hand movements with the eye and allows individuals to perform small muscle movements with accurate placement and force direction. Grasping is either precision- or power-based. The former centers on the use of fingers for finely controlled linear or rotational movement. The latter focuses on performing movements that require greater force through the use of the palms of the hands. In association with hand movement, force exertion describes the amount of effort required to interact with product interfaces within the coordinate system including: vertically (up-down), horizontally (left-right) and ventrally (forward-back). It also includes the rotational forces. Using your hands can be associated with the sensory modality of touch through tactile feedback. This not only affects users' actions and reactions but also the receipt of information from devices and surroundings. Efforts have been made to produce mobile phones with larger buttons and grips to accommodate for functional limitations associated with using your hands (Samsung, 2012).

3.1.1.3.2 Walking, Standing or Climbing Stairs

Walking, standing or climbing stairs are associated with gross body movement. Limitations stem from variables including gain or loss of endurance, motion range, muscle strength, skill, reaction time and control (Weedon et al., 2001). Many individuals with motor limitations use aids to help compensate, which can impact their mobile phone use. For example, individuals using canes can improve their balance, but they now only have use of one hand as they move through the environment.

3.1.1.4 Communication

The Wireless RERC addressed communication skills, which include aspects of receiving and extending information. From the receiving side, communication centers on the ability to sense, perceive and comprehend visual and iconic messages. It also involves the interpretation of linguistic and non-linguistic sounds and gestures stemming from interactions. From the extending side, it is the ability to exchange information with others or a system in the same manners as the extending side (Persad et al., 2007). Limitations can stem from physical, sensory and/or cognitive limitations. They can lead to incorrect understanding and expressions of information.

3.1.2 Performance-Based Design Approach and Considerations

Performance-based design and development efforts follow user-centered (also human-centered) design. User-centered design is an iterative process-based approach focusing on end-users throughout the planning, design and development stages. Without specifying design activity details, the International Organization for

Standardization (ISO) put forth a framework for user-centered design activities within the design and development cycle (TC 159/SC 4, 1999) (Figure 3.2).

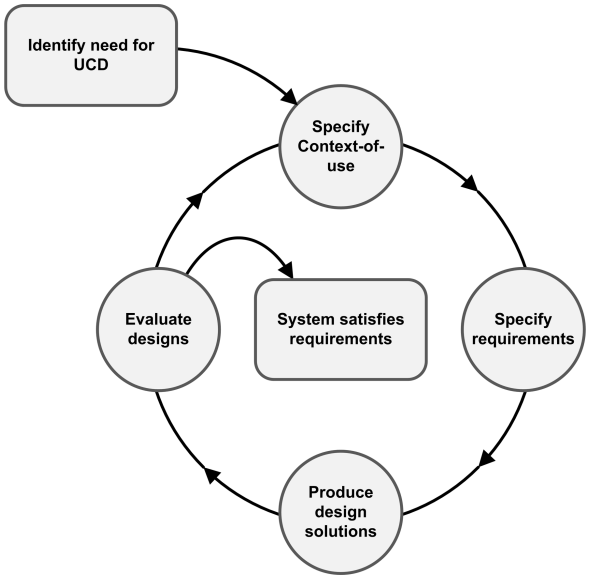


Figure 3.2 – User-centered design process, adapted from ISO 13407 (TC 159/SC 4, 1998).

User-centered design is tied to the construct of usability, or the extent to which individuals successfully use specified equipment to achieve specified goals while meeting specified performance measures (TC 159/SC 4, 1998). Designing for and evaluating based on usability places focus on the interface elements required to perform noted tasks. Results of usability assessments are susceptible to context-of-use variables, including physical and social environmental factors. Identifying context-of-use variables prior to system development aids in determining user goal(s) and design requirements (Jordan, 1998; TC 159/SC 4, 1998).

3.1.2.1 Physical Context

The physical context has significant influence on mobile phone interactions. This is primarily due to their portable nature and ability to be used indoors or outdoors, in public or private (Blom, Chipchase, & Lehikoinen, 2005). Users' physical location can alter environmental factors such as lighting, climate and auditory and visual noise. Physical and animated artifacts present in an environment can also differ from one location to the next. These changes can predictably and unpredictably alter mobile phone functionality and, therefore, task performance (Darzentas & Miesenberger, 2005). While characteristics of the physical context can lead to barriers to use, the portability of mobile phones can also enhance use by allowing for interactions regardless of time or location (Rogers, 2003; Yen & Chou, 2000). With the variability of factors, the relevancy of the physical context is not based on its static state that can be observed and/or described. Rather, it is it the role it plays in interactions and the ways in which it is or is not sustained. Both of these should be considered in research and design efforts (Dourish, 2004b).

3.1.2.2 Social Context

Social context involves the presence of third party actors and influencers in users' interaction with systems. These exchanges can include friends, family, caregivers, cultural practices and societal pressures. For mobile phones, social context extends to communication recipients and senders as well as bystanders engaged due to their physical proximity. It relates to societal pressures that can

influence individuals' buying behavior and cause them to use mobile phones as status symbols. However, mobile phones are also viewed as "citizenship commodities" or essential objects for social integration and participation (Fortunati, 2002; Keates & Clarkson, 2003). By not designing mobile phones for inclusive populations, individuals are unable to fully participate in today's social and professional atmosphere and to benefit from the potential usage scenarios.

3.1.2.3 Task Performance

Verifiable performance measures and their target values are needed to evaluate the usability of design solutions. International Organization for Standardization (ISO) identifies three measures to ensure optimum usability: effectiveness, efficiency and satisfaction. Effectiveness aims to determine users' accuracy and completeness in performing tasks and attaining their goals. Efficiency is associated with effectiveness. It assesses the task-related findings against resource expenditure. Satisfaction evaluates users' attitudes in performing tasks with systems to reach their goals (Jordan, 1998; TC 159/SC 4, 1998). Each of these supports the functional value that products provide to users.

Jacob Nielsen in his "Usability Engineering" approach presents three additional performance measures (Nielsen, 1993). He notes that users must find systems easy to learn and remember and must encounter few errors during their interactions. In performance-based research efforts, these measures are applied throughout the user-centered design process based on the following intentions: to gather an initial set of design requirements, to obtain feedback on prototypes prior

to the final system development, and to learn about usability problems post-launch in hopes of informing future designs. Findings from performance-focused research can be distilled into principles and guidelines targeted towards establishing best practices (Dumas & Redish, 1999). These primarily center on narrow design decisions and statements. For example, I found multiple to address specifics such as font sizes, color, auditory feedback and button size (Federal Communications Commission, 1998; Hellman, 2007; Lee, Jhangiani, Smith-Jackson, Nussbaum, & Tomioka, 2006).

There is limited exploration of higher-level problems such as interaction modalities and interaction styles. Shifting towards this focus has the potential to promote progressive solutions. It also establishes a holistic approach where key areas can be addressed immediately and the remainder can be incorporated over time (Carter, 1999; Milne et al., 2005).

3.1.2.4 Accessibility

In discussing perspective on addressing the needs and desires of individuals diverse in age and ability, it is important to include the concept of accessibility. There are two ways this term is viewed. One shifts the approach to meeting diverse user needs and desires from performance-based measures to compliance-based ones. Accessibility is defined as the degree to which a product meets all individuals' functional needs within particular environments. It is understood that no product is completely accessible. Rather, each provides a degree of accessibility (Story, 2006). The other view on accessibility is performance-based. In taking this stance, it

associates accessibility with laws and regulations that have been established to help equalize opportunities. It centers on selecting guidelines that match a population's functional capabilities and on ensuring products adhere to those guidelines (Iwarsson & Stahl, 2003).

Underlying both the performance- and compliance-centered definitions is the principle that the user base is comprised of two separate populations: the normal population and the population divergent from the norm (Iwarsson & Stahl, 2003). The divergent population drives the accessibility performance evaluations and the development and selection of guidelines. I found that despite this approach being counter to the fundamental intention of universal design, selecting research study populations based on disability or age is often the path taken in universal design efforts.

3.1.3 Research Outputs and Shortcomings

Findings of performance-based research efforts are primarily used to resolve design issues in future product generations and/or distilled into principles and guidelines targeted towards establishing best practices (Dumas & Redish, 1999). In both instances, they form the basis for design and development requirements. For performance-based efforts focused on universal design, principles and guidelines are also applied in the development of laws and regulations that aim to help equalize opportunities.

Examples within the United States are Section 255 of the Telecommunications Act of 1996 and Section 508 of the Americans with Disabilities

Act. These legislations have the goal of ensuring telecommunications products and services and information technology are accessible to people with disabilities. They require mobile phone equipment manufacturers and service providers "to make products and services accessible to people with disabilities, if such access is readily achievable (Federal Communications Commission, 1998; U.S. Congress, 1998)." In instances where it is not readily achievable, companies must ensure products and services are compatible with peripheral devices.

Less formal design recommendations have also been established through performance-based research efforts. Design recommendations aim to provide industry with additional support for addressing accessibility and universal design. As extended or tangential thoughts on regulations, they intend to provide exploratory insight and use-case specific information. The authors of design recommendations form an expectation that industry reference their works in both design and development. They also believe that industry should ultimately conform to them and use them as benchmarks for assessing their solutions (Tetzlaff & Schwartz, 1991). However, multiple shortcomings inhibit this desired outcome.

The guidance provided by performance-based efforts is often promoted as task-centric checklists (Fain, 2004). The checklist format projects the false idea that if a regulation or recommendation is achieved, good, accessible design will result (Grudin, 1989; Reed et al., 1999). This opens up the potential for debate on whether each design directive or activity has been satisfied (Jaeger, 2006). In addition, organizations often undermine regulations, finding the risk of defiance less than the cost of conformance (Goodman et al., 2007).

The format in which regulations and recommendations are provided also highlights the irony that while they aim to improve the usability of products and systems, they have profound usability issues (Carter, 1999). Several studies have noted how the presentation of findings from universal design focused efforts fail to address the needs of designers in industry (Bevan, 2009; Fain, 2004; Joy Goodman et al., 2007; Law, 2006; Milne et al., 2005; Paul Reed, 1994). Frequent confusion about whether a statement is mandatory or recommended creates further disconnect in their application and execution (Stewart, 2000).

The noted issues frequently lead companies to take a tactical versus strategic stance to addressing the needs of individuals diverse in age and ability. They become reactive or risk averse, focusing on ensuring the compliance-based practices do not affect their operations. This results in limited internal support for establishing a culture where the desire is to address diverse needs and build the customer base by providing improved designs. Collectively, the shortcomings associated with a performance-based approach towards universal design have resulted in industry cynicism towards making accessibility modifications and the premise of universal design in general (Law, 2010).

Factors related to mobile phone development priorities also limit the efficacy of performance-based research findings. Mobile phone industry structure requires multiple organizations to be involved in the execution of design regulations and recommendations. However, not all groups may find addressing diverse needs and desires a priority (Kanayama, 2003). Frequently this results in the implementation

of separate, disjointed development tracks to address the needs of people with disabilities (Law, 2006).

The approach of using regulations and recommendations to address diverse user needs and desires has also been complicated by the speed of technology development (Kanayama, 2003). It is impossible to predict what information will be appropriate and applicable to future advances. This makes regulations and recommendations inherently unstable and threatens their relevancy. By the time they are published, they are frequently misaligned with the current state of technology and can, therefore, become unduly constraining for designers (Hellman, 2007; Milne et al., 2005; P. Reed et al., 1999; Stewart, 2000).

Standards often present unified models for helping designers integrate the design details and constraints proposed by regulations and recommendations. Standards strive to provide insight into strategic ways to employ the tactical based outputs of performance-based efforts. However, the methodology-based guidance fails to fully sync with the processes, procedures and core values of companies. It is these core values that are the primary driver of enthusiasm for addressing the issues (Law, 2006).

3.2 Consumption

3.2.1 Market Segments

Consumption-based efforts group the user population based on market segments. These are groups of individuals that display common characteristics and respond similarly to marketing actions and are perceived as having similar needs.

The division of the mass market is based on the premise that it is not possible to provide solutions for all people all the time. Rather, efficiency and success are based on providing selected offerings to select groups. This parallels product differentiation practices where a core product is designed with different variations. The small changes are created in hopes of satisfying different markets. Regardless of whether the group is selected first and the design effort follows or the product is developed and then targeted towards a group, the intention is not to address diversity but to produce products that increase market penetration (Baines et al., 2008; Hair et al., 2005; Kotler & Armstrong, 2007).

Market segments are formed through research efforts that aim to identify heterogeneous groups where individual group members share homogeneous characteristics. Segmentation criteria are based on personal factors. These can be articulated on three levels: behavioral, psychological and general profile. They are used as a platform for determining inquiries necessary for identifying the market segments related to a specified domain. Inquiry into consumers' behavior focuses on both general and domain specific actions associated with purchasing, usage scenarios, media consumption and technology use (Hair et al., 2005; Kotler & Armstrong, 2007). Psychological factors are based on personality traits or user characteristics that are impervious to situation and time (Jordan, 2002). They also encompass lifestyle factors that describe patterns of living. Examples include individuals' attitudes, values, activities, interests and opinions. Finally, general profile information used to establish market segments includes demographics (e.g.,

age, gender, occupation, education, social class, income and family size) as well as geographic considerations (Kiljander, 2004).

3.2.2 Business Forces

I found that efforts to promote use of market segments are susceptible to the business fundamentals illustrated through Porter's Five Forces (Figure 3.3). The Five Forces provide a framework for assisting businesses in determining an appropriate market strategy and response. They address the following areas of consideration: threat of new entrants, bargaining power of buyers, bargaining power of suppliers, threat of substitute products or services and rivalry among existing competitors (Porter, 2008). While they are written from a system development perspective, users' consumption behaviors incite a continuous effort to shift focus for what is created. Ultimately, forces identified in the framework dictate system components and their marketplace availability and use.

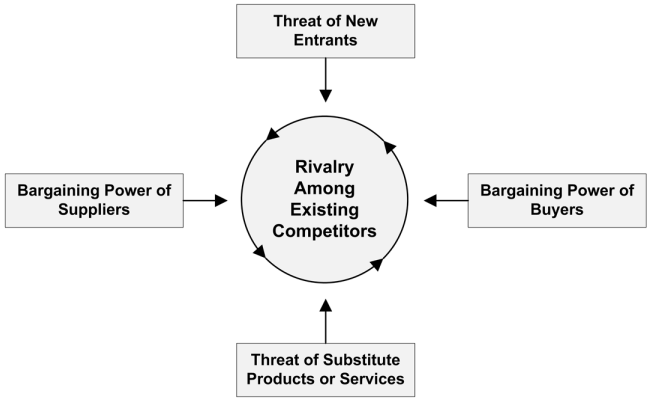


Figure 3.3 – The Five Forces that shape industry competition, adapted from (Porter, 2008).

For example, within the mobile phone industry, mobile network operators act as intermediate customers between device manufacturers and users. With their buying power, they gain significant bargaining capabilities and heavily influence the purchasing decisions of the final customers. However, device manufacturers attempt to diminish the power of distributors through the arrangement of exclusive deals. These enable them to market directly to consumers (Porter, 2008).

A substitute uses different means to perform the same or similar function as another product or service within the industry. The mobile phone was initially a substitute for the land-line. The compatibility between the mobile phone and the land-line system is responsible for the initial growth of the later technology (Rogers, 2003, p. 263). While assistive technology is introduced as a substitute, in practice, the limited demand does not create a threat nor encourage movement towards universal design.

Rivalry of existing competitors takes multiple forms including: discounting prices, introducing new products or services, advertising changes or improving services (Kotler & Armstrong, 2007; Porter, 2008). There is greater chance of overall industry profitability and opportunity to expand the industry when collectively the needs of diverse groups are addressed (Porter, 2008). However, thus far, the mobile phone industry's use of market segmentation practices has not resulted in the necessary breadth.

This is further perpetuated by the mobile phone industry's reaction to perishability where the passing of time can quickly deem technology obsolete (Porter, 2008). Long periods of gradual, technology-driven change are interspersed

with times of rapid change. The mobile phone industry is inclined to reap benefits from current services for as long as possible before introducing advances (Gressgard & Stensaker, 2006). This practice adds resistance to the efforts aimed at addressing diversity within the mobile phone domain.

3.2.3 Identifying Marketplace Opportunities

While market segment focused organizations consider the noted business factors in making design and development decisions, they also look at other sources to drive future product direction. These include research practices used in identifying market segments and delving deeper into specified segments' needs and desires. When inquiring about needs and desires, consumption-based efforts focus on the features that should be included in designs to appeal to the target audience and incite excitement towards purchase (Hair et al., 2005; Kotler & Armstrong, 2007).

A consumption focus also aims to assess general market trends, internal company situations and the current competitive landscape. Aspects from each find their way into requirement documentation. These are used to help prioritize and drive efforts within design and development. Insight into general market trends can also include aspects of the macro-environment, such as political, economic or cultural climate (Hair et al., 2005).

3.2.4 Current Touchscreen Smartphone Market Segments

To understand current touchscreen smartphone market segments and their relationship to consumption-based factors, I gathered documentation from device

manufacturers, mobile network operators in the United States and consumer research sources (Experian Simmons, 2010; InsightExpress, 2010; Rozen, Anulewicz, & Senn, 2010; Samsung, 2008; Sprint, 2011; T-mobile, 2008). Each source divided the population into multiple groups, defined by various personal factors. I found the market segments from the sources to align with each other. I also found the identified groups to parallel Rogers' five categories profiling the types of technology adopters (Rogers, 2003). I have listed Rogers' categories in order starting with the first adopter.

- *Innovators or experimenters*: pursue technology regardless of function;
- *Early adopters*: blend technology interest with significant application;
- *Early majority*: balance technology comfort with concrete application;
- *Late majority*: balance technology inexperience with concrete application; and
- *Lagards*: are unlikely to adopt.

In reviewing the documentation, I identified personal factors that appeared most relevant to the mobile phone industry in defining their market segments:

- Demographics:
    - Age
    - Gender
    - Education
    - Family size
- Life-style attributes:
    - Balance between work and play

        - Importance of style and sophistication
        - Value of friendships or personal relationships
        - Inclination to share
    - Purchasing behavior:
        - Desire for latest technology
        - Loyalty to service provider
        - Concerns about initial and monthly costs
        - Features or functionality of importance

Finally, I discovered concrete applications that were noted as important to the mobile phone early majority. These included entertainment applications, business functions and personal style qualities.

3.2.5 Shortcomings to Market Segment Approach

The consumption-based approach conducts research efforts aimed at serving the needs and desires of consumers. However, there are several shortcomings that need to be addressed to move towards universal design of mobile phones. Based on the review of consumption-based efforts, I summarized the following primary concerns:

- While exclusion of individuals with disabilities is not intentional, market segmentation on the whole is inherently exclusive;
- Industry often equates universal design with accessibility, taking a tactical stance to ensure regulations do not impact operations rather than a more strategic and supportive approach;

- Features are often promoted because they are based on the latest technology, not necessarily because users want them. Although, there are instances where users are unaware of a feature and once introduced find it to be advantageous; and
- Within the mobile phone industry, end-users are not the initial purchasers. Requirements also have to address mobile network operators' needs and desires that may counter those of device manufacturers and the users they identified.

3.3 Addressing Disconnects and Shortcomings

To address the identified disconnects and shortcomings of performance- and consumption-based efforts, I reviewed them in the context of touchscreen smartphone customization. Through this assessment, I formed an approach for exploring possibilities for improving touchscreen smartphone design. It was based on four central drivers:

- Leverage the construct of customization, including its central relationship to time;
- Shift focus away from designing for disabilities or pre-supposed market segments;
- Ensure the impartiality of methods and findings to both the performance- and consumption-based perspectives; and
- Address the core concerns of performance- and consumption-based perspectives.

I chose to focus on the customization of touchscreen smartphone home screens. With their central relationship to the higher-level problem areas of interaction modalities, interaction styles, available content and content presentation, I was able to shift the effort away from a focus on narrow design decisions. I decided to center on near-term technology where identified design solutions would be immediately applicable to design and development efforts. I structured the research in hopes of also providing guidance for long-term design opportunities. In doing so, I intended to promote the continued exploration of customization as a means for addressing the mobile phone needs of individuals diverse in age and ability as technology evolves.

By reflecting on customization and the construct of time, I outlined three device states that related to discovering user needs and desires associated with touchscreen smartphone home screens.

- Out-of-the-box states defining device characteristics prior to use;
- Current states defining device characteristics at the current point in time, including those users have modified to better meet their needs and desires; and
- Desired states defining device characteristics at a future point in time, including those users would like their devices to have in order to better meet their needs and desires.

I used the three device states as a platform to identify questions to explore in this effort and determine appropriate research and analysis methods. The questions I identified are:

1. Does comparing touchscreen smartphone device states (out-of-the-box, current and desired) identify opportunities for design improvements that address the needs and desires of individuals diverse in age and ability?
2. Does the approach identify design opportunities that would have remained unidentified or unassociated through performance- and/or consumption-based inquiry alone?

CHAPTER 4

RESEARCH AND ANALYSIS METHODS

I used a case study approach to explore customization as a way to address universal design of mobile phones. Case studies are defined as a form of "inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2009)." Case study inquiry is flexible. It allows for questions of "how" and "why" to be asked. It concentrates on tracing phenomena over time rather than examining frequency of incidence (Benbasat, Goldstein, & Mead, 1987). A key element to case studies is the use of multiple data sources to describe relevant phenomena. The sources can be associated with a single subject or participant. However, they can also come from multiple sources where the case study describes the accumulation of the accounts (Yin, 2009). I followed the latter approach, choosing to engage multiple participants in different research activities.

To illustrate my approach, I created a diagram of the three device states I introduced in 3.3 Addressing Disconnects and Shortcomings (Figure 4.1). I use numeric markers in the text and figure to draw connections between the two. For each of the states (out-of-the box [1], current [2] and desired [3]), my inquiries centered on home screens and information associated with interaction modalities, interaction styles, available content and content presentation. I documented participants' stories about the customizations they made between the out-of-the-box state and their current device state, or the interim "current states" [4].

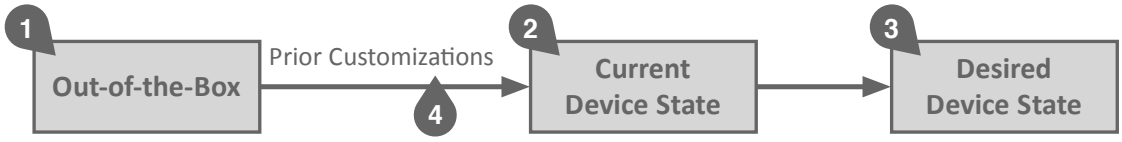


Figure 4.1 - Three device states and points of exploration.

To support addressing diverse user needs through a focus on customization rather than ability or market segment, I needed to understand participants' functional limitations and personal factors. To gather this information, I asked participants questions about their abilities and demographics (See Appendix B). With this data, I identified associations between the customizations individuals made and their abilities and/or personal factors, including their technology adopter profile (See 3.2.4 Current Touchscreen Smartphone Market Segments). I found points of alignment to suggest compatibility between the respective approach and a customization focus. I also identified these instances as reinforcing the potential for a customization-based perspective to lend new insight towards universal design of mobile phones while addressing concerns of performance- and consumption-based efforts.

To select research and analyses methods associated with the points in Figure 4.1, I reviewed performance- and consumption-based approaches. Where appropriate, I used approaches from one or both perspectives. By doing so, I aimed

to align with current design and development practices and hoped to ensure effective and efficient data gathering and analyses. Finally, I selected methods based on project scope and resources. I chose to conduct one-on-one participant sessions in order to gather detailed information about individuals' prior, current and desired device use. I held the sessions in participants' homes. This allowed me to gather rich field data while also benefiting from advantages associated with lab-based environments, including ease of documentation and a reduced number of external variables. Using this blended approach, I addressed each of the identified areas (See Figure 4.1).

4.1 Identifying Device States

Gathering information on out-of-the-box states [1] did not require participants' involvement. After identifying their current devices and operating systems, I obtained user guides via Internet searches. Each of these contained images and descriptions of the home screens and described available forms of customization. I gathered the remainder of the data related to device states through two primary research methods: contextual inquiry and generative research.

4.1.1 Current Device State

I used contextual inquiry techniques to gather information about participants' current device states [2] and the transitions that took place from their out-of-the-box states [4]. Contextual inquiry is a field interview approach currently used in performance-based efforts. The methods focus on understanding how individuals solve problems and perform activities in the primary context of device

use (Holtzblatt et al., 2004). Participants are encouraged to talk with the researcher as they complete identified tasks. Researchers can ask questions to probe for additional insight.

To shift away from task related evaluations and collect accounts of past events, I deviated from the traditional contextual inquiry approach. Placing focus on understanding participants' home screen customizations required that I gather retrospective accounts from participants. Holtzblatt, et. al. (Holtzblatt et al., 2004) note that the reliability of contextual inquiry is diminished after two weeks of participants not performing the associated tasks. However, artifacts, such as individuals' touchscreen smartphones leave "trails" that can spur memories and facilitate storytelling. Therefore, in probing participants for details on their prior customizations [4], I asked them to refer to their current devices (Hassenzahl & Ullrich, 2007).

Ariely, Carmon and Zauberman noted that when people reflect back in time they are selective, extracting a few defining moments and events to relay in the stories they tell (Ariely & Carmon, 2000; Ariely & Zauberman, 2000). Through their work, Ariely, et. al. concluded that individuals' retrospective accounts reflect the intensity of changes stemming from their interactions. They identify four parameters: rate of changes, maximum intensity, final intensity and trend. I took the potential impact of these factors into account during the data analyses activities.

I first focused on gathering information on participants' current device states. I asked participants to reflect back on prior customizations and tell stories about changes they made. This included seeking insight into their motivations

behind the modifications. I probed for and observed frustration points that led to less than ideal interactions; functional limitations that impacted their device use; and positive outcomes that improved their interactions. I used the following topics, listed based on users' progressive engagement with products, as needed to direct the contextual inquiry:

- Reason for initial purchase of devices;
- Assistance obtained in purchasing, learning and/or modifying device;
- Transition from prior device to current device, lending insight into whether customization behaviors are related to prior mobile phone use;
- Motivations for including or not including different types of content;
- Unmet needs and desires related to home screen customizations;
- Customizations performed related to earlier modifications they made, including instances where after making a change they later returned the device to its initial state; and
- Thoughts on obtaining a new device.

In addition to field notes and video recordings of the contextual inquiry, I captured images of participants' devices' home screens. This provided concrete visual evidence of the current device states.

4.1.2 Desired Device State

While contextual inquiry was appropriate for gathering insight into current device states [2] and the transition from out-of-the-box [4], I found it was not suitable for gaining complete insight into desired device states [3]. To do so, I

needed to discover tacit knowledge, that which is difficult for individuals to articulate. It was also important that I gather information on participants' latent needs and desires. These are the needs and desires that remain unarticulated, sitting between current and idealistic. The more traditional research methods are helpful for matching participants to an existing knowledge base or learning about current behavior, thoughts and ideas. However, they are limited in their potential to identify insight into tacit knowledge or latent needs and desires (Hanington, 2003; Suri, 2003). Therefore, I reviewed alternate design research methods to determine an appropriate approach for exploring participants' desired device states.

Design-led and participatory research approaches were introduced to the field to help identify tacit knowledge and latent needs and desires towards improving future product offerings (Holt, Geschka, & Peterlongo, 1984; Sanders, 2001; Visser, Stappers, van der Lugt, & Sanders, 2005). In Figure 4.2, I show design-led and participatory research approaches in the context of contextual inquiry to help convey the type of participant insight that is targeted. I indicate how contextual inquiry focuses on gathering explicit and observable knowledge [A] through using interview- and observation-based design research techniques [B]. Data are based on either what participants say or the actions participants take [C]. I also note how contextual inquiry is rooted in the mindset of user-centered design [D]. Design-led and participatory-based techniques provide a deeper level of knowledge that relates to participants' feelings and visions that have yet to be triggered and/or brought forth [E].

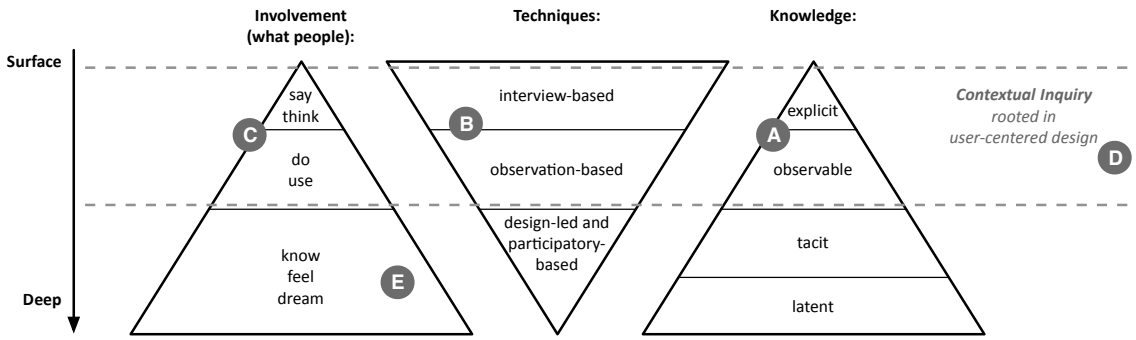


Figure 4.2 - Levels of knowledge and associated research techniques, adapted from (Visser et al., 2005).

Sanders mapped design-led and participatory research in relation to user-centered design, identifying three primary techniques: critical design, design and emotion and generative research (Figure 4.3). The practices shift away from participant conversations, constrained by industry ideals and perspectives, and move towards exploratory activities. Each of the techniques is a combination of expert and participatory mindsets, where participants become active contributors in providing insight into their current interactions and unmet needs and desires. I identified each of the three techniques as having potential methodologies to employ in my effort to discover insight into desired device states. In her presentation, Sanders also made a general observation: participants' understanding of their needs and desires is based, not on the reality of what is feasible, but on their understanding of what is possible (Sanders, 2008). I later found this to have a large impact on my data gathering and analyses activities.

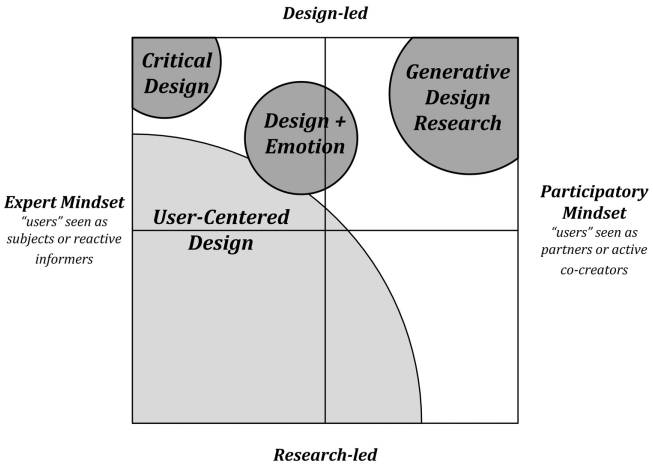


Figure 4.3 - Design-led and participatory-based research techniques in the context of user-centered design, adapted from (Sanders, 2008).

In critical design, participants are given design probes or probe kits such as diaries and cameras to self-document regular (e.g., hourly, daily) occurrences associated with the subject in question. Afterwards, researchers engage participants in debriefing sessions. The documentation is used to guide the research-participant conversations. Much like with using an artifact in contextual inquiry, this technique has been found to minimize issues associated with retrospective memory (Mattelmaki, 2006).

In the context of mobile phones, users' devices themselves have become the mechanism for self-reporting. The built-in cameras, video recorders and/or audio recorders can gather data (Palen & Salzman, 2002). As customizations typically do not consistently occur, I determined critical design was not fully appropriate for this effort. However, with mobile phones retaining artifacts and markings associated with past interactions, they inadvertently act as critical design probes and become

artifacts for examination. I found this to further support the deviations to the contextual inquiry approach that I outlined.

"Design and emotion" sits at the intersection of expert and participatory perspectives. It aims for balance between the researchers' and participants' roles. Where cultural probes and generative research have established tactical procedures, the area of design and emotion is more ephemeral and hard to articulate. This stems from the fact that it is difficult to define emotion itself. In order to measure it, there must be the ability to characterize the different states and distinguish between them (Desmet, 2004). Based on this ambiguity, I did not focus on design and emotion other than reflecting on any indications of it found in the qualitative assessments of participants' stories.

I ultimately selected generative research as my approach based on its ability to elicit "experiences not yet lived or felt, but imagined (Sanders, 2001)." Sanders identified these "dreams" as colliding with "memories" in "the moment," projecting future desires. She also noted that generative research is rooted in participatory practices where individuals are empowered to create and promote alternate frameworks to the domain(s) in question (Sanders, 2008). The technique is typically used at the beginning of the design process; although, it can be used later to gain additional insight into refining current design directions.

In generative research, materials are gathered to create "toolkits." These are given to participants to involve them in an activity where they are asked to create their ideal device. An item acting as a "background" or "platform" is typically provided to help participants begin to convey their thoughts and ideas in a visual

format. Smaller, ambiguous components that can be juxtaposed in an infinite number of ways are also included in the toolkits. Minimal instructions are given to participants. Instructions typically center on asking individuals to use the materials to express and describe their feelings about a specified subject as well as their thoughts on ideal device characteristics and behaviors. Emphasis is placed on conveying that there is "no wrong way" to complete the activity. The only requirement is that the constructed artifacts make sense to their creators (Sanders, 2000).

As users are constructing their artifacts, they are often asked to "think aloud," talking through the stories surrounding the object they are creating. These stories are often reflective of memories of interactions with similar systems and contexts. These extended conversations reveal aspects of participants' mental models. Generative research activities also enable individuals to communicate their expectations and provide evaluative feedback (Courage & Baxter, 2004). Researchers can use the ongoing dialogue to form additional questions to ask during the generative research activity or a follow-up debriefing conversation. Output from the activity provides insight into participants' perceived design problems and proposed solutions.

Figure 4.4 summarizes the research methods I selected for this effort based on the three identified device states. For reference, it includes the same numeric markers as shown in Figure 4.1.

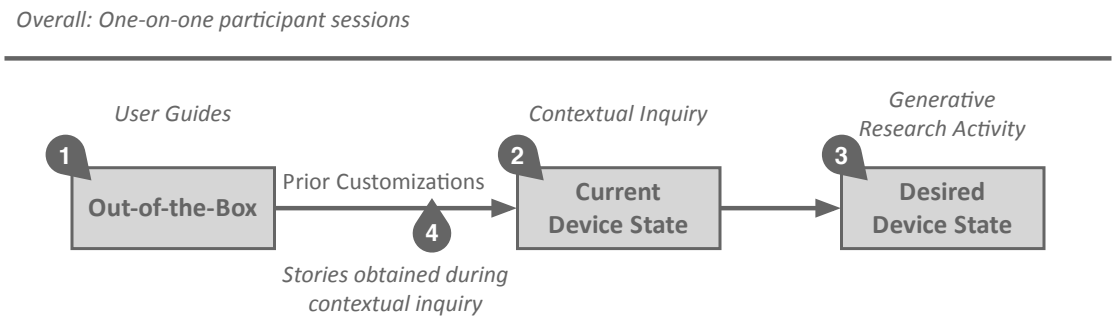


Figure 4.4 - Research methods used in exploration.

4.2 Data Analyses Approaches and Tools

The nature of qualitative research allows data analyses to begin immediately after the first participant session. Therefore, I selected methods that provide this capability while addressing the types of data I envisioned being collected. I centered data review efforts on thematic analysis techniques. Thematic analysis is a common approach to assessing qualitative data and is primarily used in exploratory research activities. It places focus on the discovery of explicit and implicit ideas or themes. Each of these can be tied back to multiple occurrences in the data, but the form of analysis does not center on counting the number of occurrences. There are no pre-supposed or determined categories related to the data. The thematic approach can also be applied in confirmatory situations where existing information has led to the identification of themes a priori. In these instances, the analysis concentrates on aligning data with the proposed codes (Guest, Guest, MacQueen, & Namey, 2011). Template analysis, a form of thematic analysis, is a blended approach (King, 2004). I found the balance introduced by this technique to be appropriate.

4.2.1 Template Analysis

In template analysis, a coding "template" is used as a platform for reviewing data (King, 2004, 2007). Templates are intended to be malleable. As data are reviewed, themes can be added, modified or removed as appropriate. I found this inherent feature of template analysis to fit well based on having already identified a breakdown of customizations for touchscreen smartphones: interaction modalities, interaction styles, available content and content presentation. Templates are presented using a tiered structure where themes are organized in meaningful and useful ways. The themes indicated in a template are generic, where participant findings associated with each theme are potentially unique. For example, I divided available content into sub-themes based on the five categories I identified in 2.2 Available Content. I envisioned that all participants would reveal insight into the types of content they have on their devices (e.g., entertainment). However, I anticipated that individuals would likely describe different types of content and details of that content (e.g., games, music players). Instances where two or more participants are found to connect on multiple themes can indicate cause and effect and/or dependency relationships between the themes. In the manner described above, the template forms a structure for both intra- and inter-participant analyses.

I present the initial template that I used in the analysis effort in Figure 4.5. I indicate sub-themes for the four primary aspects of home screen customization [1]: interaction modalities, interaction styles, available content and content presentation. I also show a "motivators" theme to provide structure for identifying the factors that led to the different customizations [2]. By including this as part of

the template, I framed relationships between what prompted changes, what changes (if any) were made and what shortcomings in device capabilities were revealed.

I sub-divided motivators into “performance,” “consumption,” and “time” themes [3]. I associated time with motivators based on the premise that customizations take place over time as people adapt devices to better meet their needs and desires [4]. I added performance and consumption to acknowledge that factors related to these design priorities play a role in people modifying their devices. In addition, I aimed to indicate that as outlined this design research effort addresses the concerns of performance- and consumption-based approaches. I used the previously identified ability categories that reflect functional limitations to establish performance sub-themes [5]. I identified consumption sub-themes from the personal factors I discovered were used in defining mobile phone market segments [6].

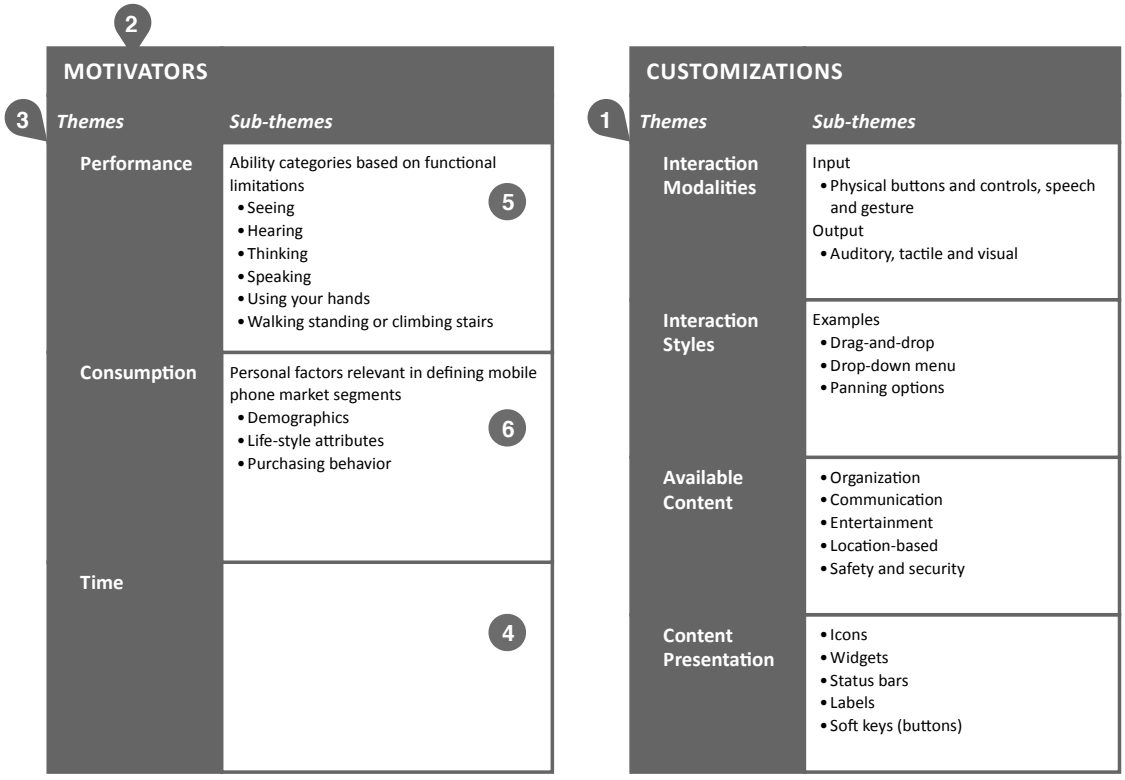


Figure 4.5 - Initial template for data analysis.

4.2.1.1 Vignettes

I constructed vignettes to aid in processing each participant's data, specifically the session notes. Vignettes are a form of narrative used to highlight significant research findings. As written sketches, they capture dynamic participant data while summarizing associated themes and/or issues. Vignettes place people in the context of time and place, describing events in a manner that reveals the compelling nature of stories individuals reveal (Ely, 1997).

Vignettes are not intended to depict the actual events. Rather, they are abstractions where certain details are presented and others are not included. Portrayals can be refined to ensure intent is conveyed through the rich

interpretations. This makes them effective for reviewing participant sessions and transitioning data toward presentable findings (Erickson, 1985). In writing the vignettes, character presentation should include elements reflective of internal or personal factors as well as inter-personal or relationship-based factors. Vignettes have been used to help with the interpretation of observational data in technology-related design efforts. In this application, vignettes were identified as effective when they centered on users' motivations rather than descriptions of actions (Wright & McCarthy, 2005). I found this view to align with my intention to move away from task and performance-based descriptions.

4.2.2 Image Analysis

Image analysis was another form of thematic analysis that I employed. Where I used template analysis and vignette development to aid in the review of notes from the conversations and observations, I used image analysis to help identify patterns in the images I gathered on the different device states. Primary sources discussing the approach mainly focus on the assessment of landscape- or event-based photographs or other two-dimensional artwork forms (Bohnsack, 2008; Grady, 2008; Lohse, Biolsi, Walker, & Rueter, 1994; Penn, 2000). I found the methods used to assess these types of imagery to be applicable in analyzing the static artifact states I documented.

Images capture the immediacy of a moment from the documenter's perspective. They also depict aspects of space-time relationships and form a record of behavior-related information. While there are no formal, step-through processes

for conducting image analysis, I followed general guidelines. These included seeking the identification of patterns, determining how strong or weak they were and identifying relationships between them. A key reason for incorporating these activities was to follow a linguistic approach, identifying signs and what they signify and reducing images to a more diagrammatic form (Lohse et al., 1994). I aimed to use the technique to arrive at simplified visual representations of participants' desired touchscreen smartphone home screens. I intended to use the process of seeking patterns in visual data to aid in the intra-participant analyses. I also planned to use the process to conduct preliminary comparisons between the participant data to look for consistencies to apply in reporting findings. I employed guidance on creating visualizations in completing the image analysis.

4.2.2.1 Visualizations

Visualizations are created to aid in the systematic review of unstructured, non-numerical data. Going through multiple iterations of development facilitates visual thinking. Conducting this process of forming and evolving visualizations as data continue to be gathered allows for thought progression to be seen and understood (Lockwood & Walton, 2008). The end result enables researchers to reflect back, resolving problems by revealing insight that would otherwise remain hidden in descriptive text (Roam, 2008). The use of visualizations improves the possibility of drawing valid conclusions through synthesis. It also facilitates data comparison and theme, pattern and trend identification (Lohse et al., 1994). In conducting the image analysis, I applied the network form of visualizations.

Networks involve multiple "nodes" that are interconnected. The approach is used to show complexities of variable interactions and narrative structures influenced by temporal tensions (Miles & Huberman, 1999). In final form, visualizations are also helpful for presenting findings as they allow people to explore relevant information in a non-linear, non-prescriptive fashion. They become malleable to the current viewer, task or conversation and aid in comprehension of the work. I used visualization technique resources to help in this effort, including those of Edward Tufte (Tufte, 1990, 1997, 2001) and Lidwell, et. al. (Lidwell, Holden, & Butler, 2010).

4.2.3 Addressing the Project Aim

In this chapter, I frame the approach for exploring opportunities towards improving the design of touchscreen smartphones to address diverse user needs and desires. I identify how I intended to gather data on and make comparisons between participants' three device states: out-of-the-box, current and desired. I present analysis methods and techniques based on themes and templates (See Figure 4.4 and Figure 4.5). In the next chapter (*Chapter 5: Data Collection Process and Review*), I describe my data collection and intra-participant analyses efforts. I outline the inter-participant analyses that led to the identification of short-term design solutions and a long-term design strategy.

CHAPTER 5

DATA COLLECTION PROCESS AND REVIEW

In this chapter, I present:

- An overview of the nine (n=9) participants, including information related to their abilities and personal factors;
- The data collection effort and a critique of the appropriateness of the research methodologies;
- The intra-participant analyses including:
    - Image analyses process and outputs and
    - Analysis template application; and
- A description of the vignette and diagram creation process along with the implications this had on the analysis template.

Final vignettes and desired device home screen diagrams for all participants are included in Appendix A.

5.1 Participant and Session Overview

Nine (n=9) touchscreen smartphone users whose devices ran either Apple iOS (iPhone) or Google Android OS participated in the study. I selected iOS and Android OS as the device operating systems based on their having the largest current and projected market share in the United States at the time of this study (The Nielsen Company, 2011). I recruited participants by convenience sampling, contacting them via email or phone. No compensation was provided. Geographic

proximity to Atlanta, Georgia was a factor in selecting participants. This allowed sessions to be conducted in individuals' homes. With the intention of viewing the population as a whole versus by ability categories or market segments, I did not consider factors associated with either in the recruitment process.

I videotaped sessions to assist in data collection and analysis. One participant requested that the session not be recorded. Additional documentation from each session included: researcher notes, constructed artifacts and photographs of participants' current device states. The photographs focused on capturing aspects of home screen customizations.

Participant sessions were divided into four sections: introduction, generative research activity, contextual inquiry and debriefing with fluid transitions between them. During the introduction, I gathered basic information on participants' abilities, demographics and current devices' brands, models and operating systems. I also inquired about tendencies to use different types of content and comfort with technology. I remained aware of the flow of the discussion and need to keep total session time at less than two hours. I began preliminary analyses of participants' data as soon as it was collected. After conducing five participant sessions, I reviewed the data collection methods and analyses techniques to assess their appropriateness. I identified the need to modify the order of participant activities for future sessions. I have included the two versions of the participant session discussion guide in Appendix B.

Figure 5.1 presents an overview of the research participants including their basic demographic information, functional limitations and current devices' brands,

models and operating systems. In presenting findings, I gave each participant a pseudonym to facilitate internal discussions. I also aimed to make the presentation of findings more personable while protecting participants' identities. The pseudonyms are presented along with color-codes to help differentiate participants in the figures. I note a break between the five participants whose sessions took place prior to the interim review and the final four participants.

NAME	AGE	GENDER	FUNCTIONAL LIMITATIONS	INDUSTRY and POSITION	DEVICE	OS
Brian	27	Male	• None specified or observed	• Transportation, *Program Manager: eCommerce*	Apple iPhone 4	iOS 4.3*
Edward	28	Male	• Seeing, *colorblind* • Hearing, *total loss in one ear* • Broke bones, *collar bone dominant arm*	• Voice Communication, *Software Engineer*	Apple iPhone 3Gs	iOS 4.3*
Charles	37	Male	• Seeing, *corrected low vision*	• Education, *MBA Student*	HTC myTouch 4G	Android 2.2
Rebecca	32	Female	• Thinking, *ADHD*	• Beauty, *Hair Stylist*	Samsung Vibrant Galaxy S T959	Android 2.2
Martha	64	Female	• Seeing, *corrected low vision*	• Health and Insurance, *Geriatric Care Manager*	Apple iPhone 3	iOS 3.1
Karen	55	Female	• Seeing, *corrected low vision*	• Real estate, *Residential Realtor* • Nonprofit Organization, *Founder*	Apple iPhone 3Gs	iOS 4.3*
Sally	54	Female	• Seeing, *magnifying glasses for small print* • Hearing, *hard of hearing* • Thinking, *ADHD*	• Real estate, *Residential Realtor* • Entertainment, *Voice-over and On-camera Talent*	HTC Droid Incredible ADR6300	Android 2.3*
Wendy	34	Female	• None specified or observed	• Banking, *Commercial Loan Auditor*	Motorola Droid, 1st Generation	Android 2.2
Jack	30	Male	• Thinking, *Remembering*	• Computer: Web Services, *Systems Administrator*	Apple iPhone 4	iOS 4.0

*Latest version of operating system at time of participant session

Figure 5.1 - Research participants.

5.2 Data Collection Process and Methods

5.2.1 Data on Device States

For the initial five participant sessions, I decided to conduct the generative research activity prior to the contextual inquiry. I chose this task order in hopes of freeing participants' thoughts and ideas from those of their existing devices and home screens as they envisioned their desired ones.

5.2.1.1 Generative Research Activity

I provided participants with a toolkit (Figure 5.2) and asked them to create their ideal touchscreen smartphone home screen(s) using any of the supplied materials. Details of the toolkit artifacts are presented in Appendix C. Wooden platforms, approximately the length and width of touchscreen smartphones, were included as part of the toolkit. I suggested that participants use them as starting points. In addition, I gave participants printouts of common symbols associated with touchscreen smartphone home screens. Participants could cut these out and place them on their creations. While making their artifacts, I prompted individuals to address the types of content they would include, where they would include it and how they would access it. I also asked them to think aloud and describe their designs. These statements often led to further conversation. I probed for additional insight into how their designs may reflect prior mobile phone use and how their current devices do or do not meet their needs and desires.

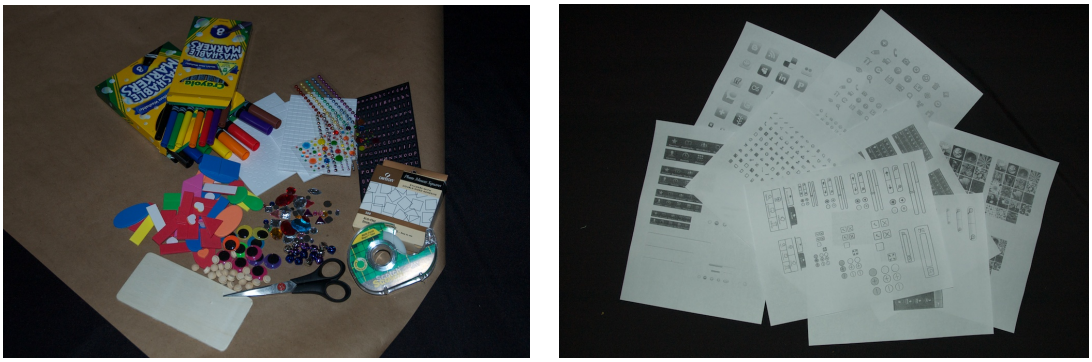


Figure 5.2 - Generative research activity toolkit.

After conducting sessions with the initial five participants, I determined the flow of activities was ineffective in limiting the extent to which participants reflected on their current devices during the generative research activity. This supported reversing the order of the generative research and contextual inquiry for the remaining four participant sessions. The hope was that by doing so participants would:

- Have greater understanding of the topic being discussed prior to creating the artifact, resulting in their having an easier time with the activity; and
- Identify shortcomings of their current devices and reference them in forming ideas for their ideal home screens.

In the subsequent sessions, participants remained constrained by the design of their current devices. I found ideas to not extend beyond past, current or soon-to-be-released mobile device designs and technology capabilities. Thoughts appeared to be based on individuals' current comfort with and knowledge of technology and

interface-based products and devices. However, I questioned the appropriateness of the materials and instructions I provided and the potential impact they may have had.

Three of the nine participants resisted the process of using the materials to create their vision of alternate home screens. One participant initially struggled to use the materials but was eventually able to engage and use them to help convey ideas. I used interview techniques to gather information from the other participants on their desired device states. I found those participants who were comfortable with the activity to not have a difficult time talking about their creations while they constructed them.

The wooden platform was successfully used as a starting point for the six participants that completed the activity as designed. Only two participants took advantage of using more than one wooden platform in representing their home screens. I found participants to struggle in integrating the different elements I suggested into their creations, including the construct of time and varied product forms. I asked participants to use inherently static items to construct something that had altered or dynamic states. I identified that this may be a difficult task for individuals not accustomed to using artistic or creative means to convey their ideas. It is also possible that the artifacts too closely resembled existing device designs and, therefore, contributed to the constrained ideas.

Despite the noted limitations, both the artifacts representing the desired device states and the dialogues I had with participants during their creation process lent valuable insight. For the instances where the visual elements fell short, I was

able to leverage the conversations to support the image analyses and diagram development.

5.2.1.2 Contextual Inquiry

I found the contextual inquiry approach to be appropriate for gaining insight into how participants have customized their devices to date. All participants made modifications at the time of device acquisition (out-of-the-box). Some modifications were completed immediately prior to and during the research sessions. I was able to use the identified probes (See 4.1.1 Current Device State) to guide conversations on how participants became progressively engaged with their devices. During this activity, I also focused conversations based on the analysis template themes (See Figure 4.5). I was able to capture stories participants told about their prior customizations. A previously noted shortcoming of contextual inquiry is the limited ability individuals have to recall in detail events occurring more than two weeks prior (Holtzblatt et al., 2004). With this effort I found this to be true. However, I found that participants were able to use their current touchscreen smartphones to trigger memories about their prior customizations to overcome this obstacle.

I noted instances where design flaws led participants to make changes to their devices. Some described these changes as sufficiently addressing the problem while others were still not satisfied with the outcome of the related customization(s). I also identified customizations related to functional limitations and personal factors. Participants noted situations where they were motivated and attempted to make changes, but they were unable to do so. I present instances of

each in the participant vignettes (See Appendix A). I also discuss them in the context of the inter-participant data exploration in *Chapter 6: Meeting Diverse User Needs and Desires through Customization* and *Chapter 7: From Short-term Solutions to Long-term Design Strategy*.

5.2.1.3 Documenting Visual Data

Using website searches, I had no issues gathering user guides for all of the participants' current devices. They provided the out-of-the-box documentation I needed in order to complete the image analyses. I took photographs of participants' devices' home screens to record their current device states. I also took photographs of the artifacts constructed by participants, documenting the visual representations of desired device states.

5.3 Intra-Participant Data Analysis Process and Output

The intra-participant data analysis began after the first participant session. After the first five participants, I reviewed the appropriateness of using the identified analysis techniques. This included reflecting on the template content, noting some potential shifts in sub-themes. By creating and reviewing interim states of the desired device home screen diagrams for those initial participants, I was able to refine the approach. I addressed concerns related to consistency in representation. Ultimately, through the intra-participant data analyses, I was able to:

- Summarize each participants' data set through vignettes and desired home screen diagrams;

- Identify each participants' met and unmet needs and desires;
- Determine whether these were based on time-, performance- and/or consumption-based factors; and
- Refine and clarify the analysis template.

5.3.1 Creating Vignettes and Diagrams

To begin outlining content for each vignette, I reflected the data set against the initial template (See Figure 4.5). I remained cognizant of details that may still be relevant despite their not aligning with the suggested structure. I found the process of creating vignettes to help remove the "noise" in data. I was able to narrow participant session output to what I deemed most pertinent to discovering design opportunities and assessing the study approach's appropriateness.

As I outlined vignettes for the first five participants, I also created initial iterations of their desired home screen diagrams. I based these off the generative research artifacts and image analyses. I used notes from participant conversations to help clarify details that were not well expressed through use of the provided materials. For individuals where there was no artifact, I relied solely on session notes. In creating the vignettes and simplified diagrams, I also reflected on the contextual inquiry activity. Through reviewing participant stories about prior customizations and motivations for those customizations, I sought indications of met and unmet needs and desires. These included mentioned or implied shortcomings, apparent or expressed preferences and "work-arounds," as well as reactions along a delight to frustration spectrum.

Using Brian as an example, I describe the process of comparing visual documentation to identify patterns and aid in the creation of the simplified diagrams (Figure 5.3). I looked at aspects of interaction modalities, interaction styles, available content and content presentation. I first compared the out-of-the-box and current device states. The interaction modalities available on Brian's device were the same from the out-of-the-box state to current state. The main interaction style also remained consistent, centering on the gesture of flicking through multiple home screens to access different folders and application icons. However, I noted how aspects of this interaction style changed based on how he chose to prioritize content. Brian identified Mail as more important than Phone [1]. He found Messages, Calendar and Camera of similar importance as was presented out-of-the-box [2]. Brian placed Contacts, initially on a secondary home screen, in a prominent location on his main home screen [3]. He grouped Social (Media) applications into a folder and displayed key ones independently on his primary home screen [4]. Unsure what to do with pre-installed applications that he wanted to remove but was unable to do so, he created a "Random" folder on the primary home screen, placing them inside [5]. He also grouped Settings with Utilities [6]. In addition to creating the Social and Random groups, he identified Sports, Business and Entertainment as important areas of content [7].

As presented by his generative research artifact, Brian found his current device to lack a physical keyboard as an interaction modality [8]. He also desired to have multiple widgets displayed on his home screen, a capability currently unavailable on iOS [9]. Brian wanted to have multiple ways to access content

including through the widgets and customizable, prioritized icons [10]. He placed less important content as independent icons or in folders on a secondary home screen that acted as an application menu [11].

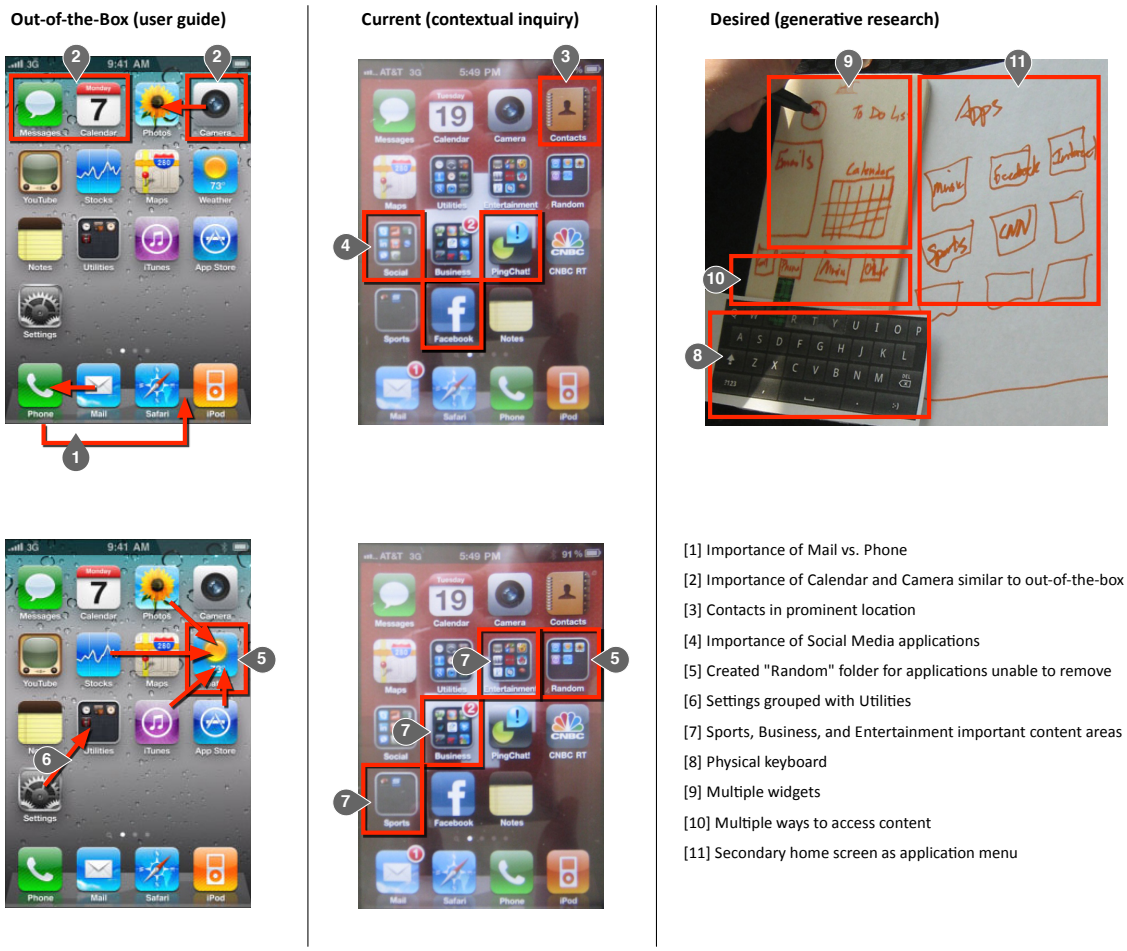


Figure 5.3 – Brian's device state comparison/image analysis.

After conducting the above form of review (See Figure 5.3) for the first five participants, I created an initial iteration of the desired device home screen

diagrams (Figure 5.4). I gained insight into the types of findings that were emerging from the data. I also identified ways to improve the diagram creation process. I found the diagrams began to reveal commonalities across participants. Examples include those noted below and indicated in Figure 5.4:

[1] Settings for system and applications;

[2] Grouping of organization-based applications;

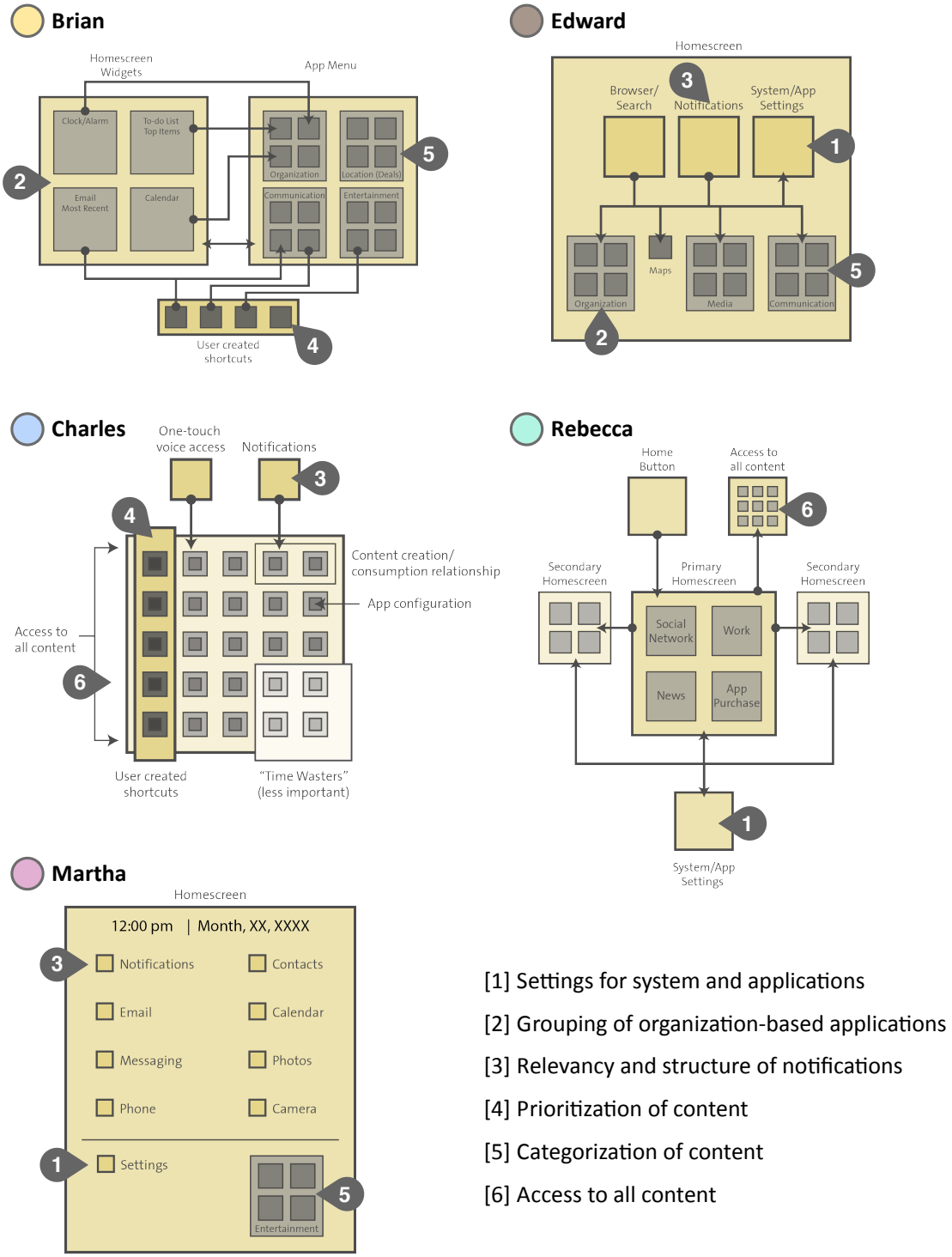
[3] Relevancy and structure of notifications;

[4] Prioritization of content;

[5] Categorization of content; and

[6] Access to all content.

In viewing the initial desired device home screen diagram for Brian, I indicate his desire for widgets [2] and an application menu [5]. In my abstraction, I also note how he desired to configure shortcuts to different pieces of content [4].



[1] Settings for system and applications

[2] Grouping of organization-based applications

[3] Relevancy and structure of notifications

[4] Prioritization of content

[5] Categorization of content

[6] Access to all content

Figure 5.4 - Iteration of desired home screen diagrams for first five participants.

From a process perspective, I determined that a consistent frame or structure should be used at the outset (e.g., rectangle representative of a screen). I also needed to establish symbols or consistent forms for representing themes and patterns in the diagrams. By constructing the final diagrams based on these premises, I was able to more easily recognize patterns and complete the intra- and inter-participant analyses.

5.3.2 Symbol Development and Analysis Template Update

I created vignettes and a final iteration of desired home screen diagrams for each of the nine participants (See Appendix A). During this process, I also conducted preliminary inter-participant explorations. These were based on the need to establish consistency in description and presentation of the vignettes and diagrams. Through this, I was also able to form an understanding of how participants' conveyed their needs and desires associated with touchscreen smartphone home screens. In developing the diagrams, I established a consistent platform, basing it on the form of a touchscreen smartphone (Figure 5.5). I also created a set of symbols for representing common elements across participants' needs and desires associated with touchscreen smartphone home screens (Figure 5.6).

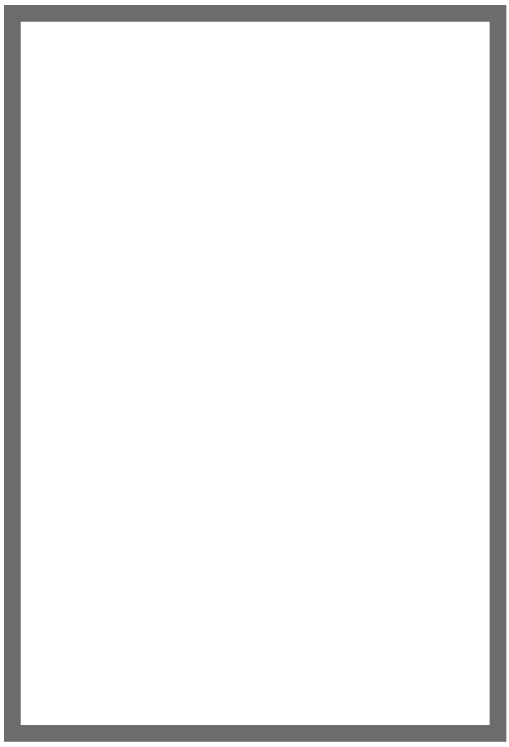


Figure 5.5 - Common platform used for each participant's desired device home screen diagram.

The identified symbols had direct implications on the analysis template's structure, leading to an updated version (Figure 5.7). In this section, I describe the symbols that emerged from the process of creating the vignettes and diagrams; connections between the symbols and analysis template; and updates that were made to the analysis template. I include letters in the text corresponding to areas of the symbol key (Figure 5.6) and numbers in the text corresponding to areas of the updated analysis template (Figure 5.7). I then present the final iteration of Brian's desired device home screen diagram, connecting the symbol key, updated analysis template and above discussion of his image analysis (See Figure 5.3).

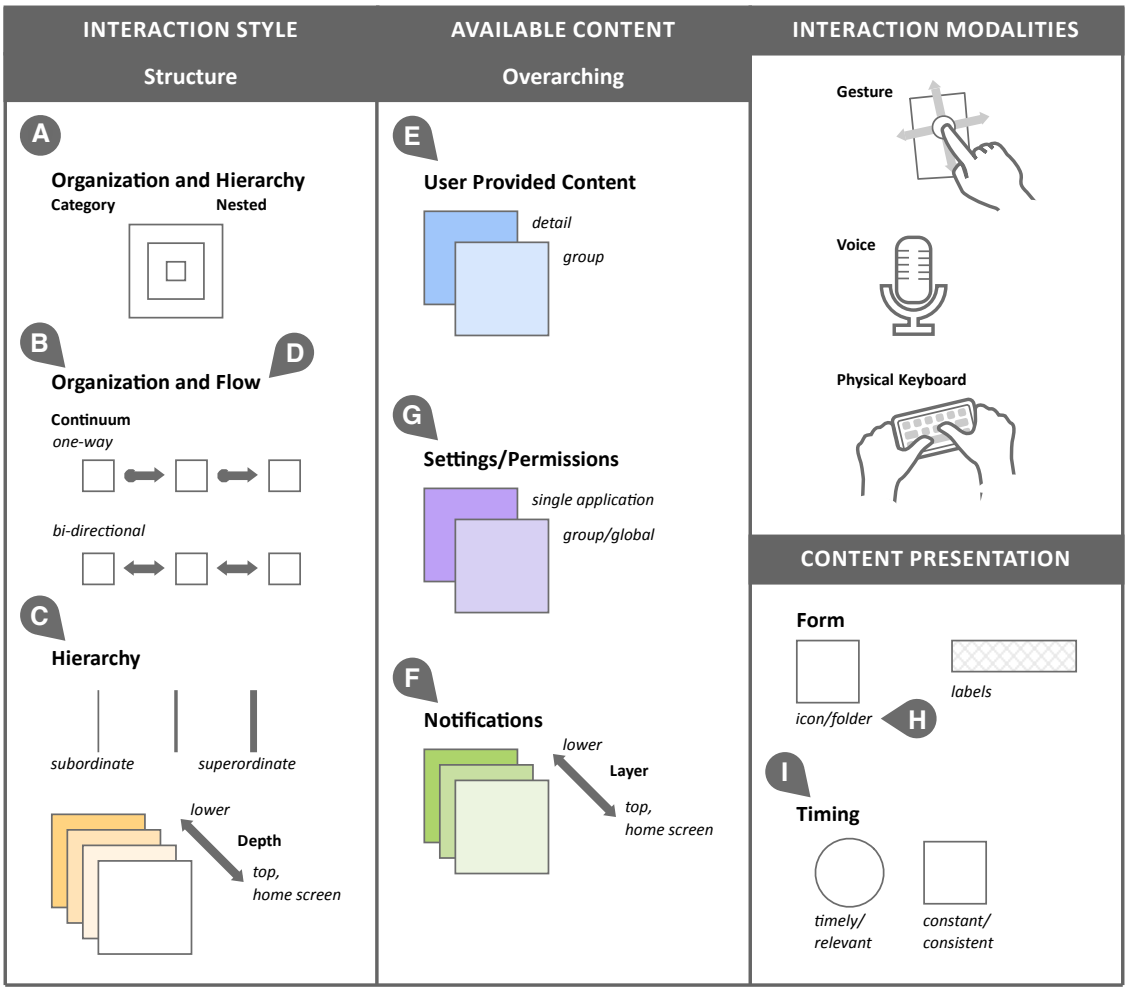


Figure 5.6 - Key for participants' desired device home screen diagrams.

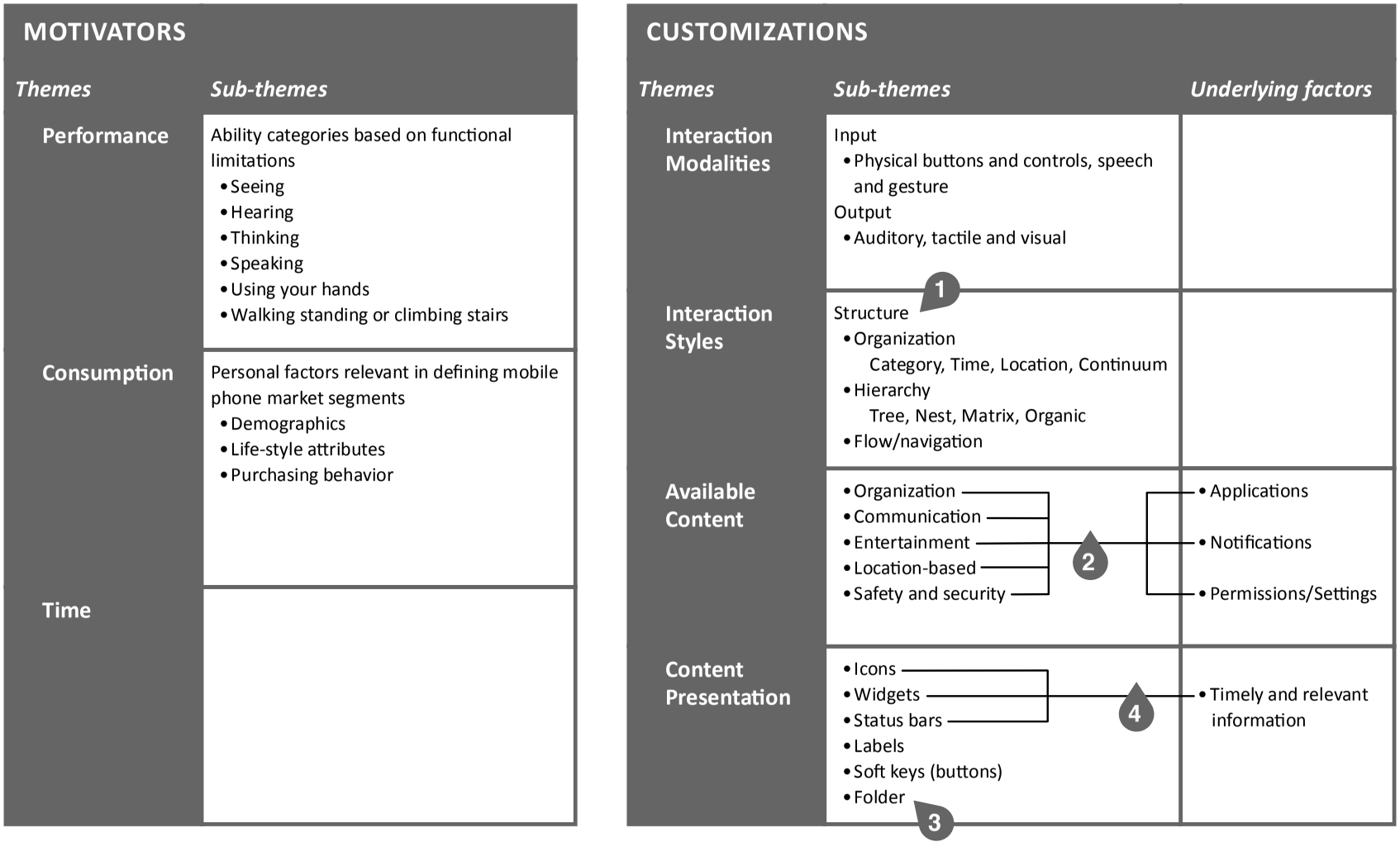


Figure 5.7 - Updated data analysis template.

5.3.2.1 Clarifying Interaction Styles

Participants described specific forms of interaction styles that they preferred. However, from a representation standpoint, I found the structure underlying the different types of interaction styles to be the common denominator [A]. By describing interaction styles in this manner, I established sub-themes as I had already done for interaction modalities, available content and content presentation (See Figure 4.5). I no longer had to base the description of interaction styles on specific designs or existing technology alone. Instead, I was able to center it on fundamental characteristics, allowing it to become an extensible approach to describing related customizations. It also placed heightened emphasis on how "parts" construct a "whole," connected to users' mental models. Through the participant study, I identified three areas related to interaction styles and structure [1]. Not all areas were identified as symbols for the desired home screen diagrams.

Organization [B] is the ability to group elements based on one or more of the following areas (Jones & Marsden, 2006; Tidwell, 2005):

- Category: Relating elements based on underlying, similar properties or characteristics;
- Time: Relating elements based on when they are accessed (user sought) or desired (system presented). It can involve elements of duration and sequence as well as event-based triggers;
- Location: Relating elements based on spatial characteristics including position on a single plane, with or without the use of reference points (e.g.,

corners, edges) and placement on layers where elements can be hidden or revealed in a linear (progressive) or non-linear manner; and

- Continuum: Relating elements through establishing a mechanism for linear ordering that is based on an underlying structure or common measure (e.g., alphabetical, date).

Hierarchy [C] is usually established in parallel with organization. It centers on establishing the relationship between elements as a function of their superordinate and subordinate relationships and is often established based on patterns and/or repetition (Geven, Sefelin, & Tscheligi, 2006). In the context of this effort, I define it in reference to the structure of content, not visual hierarchy, which is a manner of using graphics or visual design to drive focus towards prioritized elements. It is linked to aspects of layers (organization) and has four primary forms (Garrett, 2003; Lidwell et al., 2010; Simon, 1962):

- Tree: Placement of child elements below or to the right of a parent element;
- Nest: Placement of grouped elements fully or partially inside each other;
- Matrix: Creation of relationships where multiple pathways and links exist between elements establishing a web of relationships between elements; and
- Organic: Placement of elements based on sequences of actions, resulting in flat, peer-based relationships and minimal feedback about location within an interface.

Flow (also navigation) [D] centers on how the user can move and progress through content including how it is revealed and hidden. The possibilities are based on the interconnections of content, time-based factors (e.g., processing speed, data transmission) and interaction modality (Garrett, 2003).

Based on data associated with available content, I added an additional sub-theme grouping associated with the larger heading [2]. While the categories I described in Chapter 2 remained relevant, I found participants to discuss customizations related to available content based on the underlying factors of applications, notifications and permissions/settings. I reviewed the role of applications in touchscreen smartphone use in first presenting available content. However, I did not represent it in the analysis template, nor did I describe the inclusion and exclusion of specific applications as key forms of customization. I describe the three aspects of available content that participants framed based on their role in customizations. In association with the diagrams, there is also the distinction between content that is initiated or provided by users versus by the system [E].

Applications, frequently shortened to "apps," are designed to enable users to perform desired activities that can be associated with one or more of the identified categories. Touchscreen smartphones have pre-installed applications that are available on devices out-of-the-box. There are user-installed applications that individuals add through "app stores" or "marketplaces." I found the decision to add or remove applications to be a primary form of customization associated with home screens. It impacts interaction styles and content presentation.

Notifications [F] are the content that is surfaced to the user to provide information about alerts and recent activities. They are associated with different applications as well as device status. Depending on device capabilities, users can select the notifications that are given. Users often have the ability to modify their format(s) and frequency, linking notifications to content presentation.

Permissions/Settings [G] are associated with two levels of granularity. They can be overarching, affecting all content areas. These are typically related to modifying attributes of interaction modalities (e.g., volume of auditory output, form of text input) or modifying levels of user or system connection to specific system or device data (e.g., connecting to mobile network operators and wireless networks). They can also be associated with specific applications. This includes the direct tie to customizing notifications as well as modifying specific interaction modalities (e.g., turning sound on and off when playing a game) and interaction styles (e.g., viewing detailed content as a list or image thumbnails). Permissions/settings can also control levels of access individual applications have to specific system or device data (e.g., a device's location) (Au, Zhou, Huang, Gill, & Lie, 2011).

For content presentation, I identified an additional form impacting what is displayed on home screens. The folder allows participants to group multiple applications together [3, H]. If a user selects a folder, the screen refreshes to show applications that are contained within it. Another factor I found participants to associate with content presentation is timing [I]. I identified that individuals differentiated between omnipresent content, content they manually updated and content that was automatically updated with timely and relevant information. The

presentation of timely and relevant information is primarily associated with icons, widgets and status bars. Therefore, I placed it as a related characteristic and associated it with these three areas [4].

5.3.2.2 Desired Device Home Screen Diagram (Brian)

In creating the desired device home screen diagrams, I combined elements from the symbol key (See Figure 5.6) to represent participants' desires associated with interaction modalities, interaction styles, available content and content presentation. To describe this execution, I present a synopsis of Brian's vignette (See A.1 Brian) in association with his desired device home screen diagram (Figure 5.8). I include a description of how the symbols were applied in visualizing Brian's key findings. The numeric markers in the paragraph below refer to (Figure 5.8).

Brian would like to interact with his device using gestures [1: pictogram of interaction modality] and a physical keyboard [2: pictogram of interaction modality]. Brian desired to have widgets that would notify him of timely and relevant information [3: circles and green shade]. He indicated how the depth of insight associated with each widget should vary based on the type of content it is providing [4: nested circles and green shades]. Brian desired quick access to priority applications using his thumb [5: squares, orange shade, thicker line weight and placement]. Brian desired to have an application menu [6: second platform with orange shade as background]. Brian did not want to be restricted to an ordered grid as he is on his current iOS device [7: vacant space surrounding the various symbols]. Brian desired some applications to be placed in labeled folders [8: nested squares,

orange shade and crosshatch] and others of greater hierarchy to be represented by their icons alone [9: squares and orange shade].

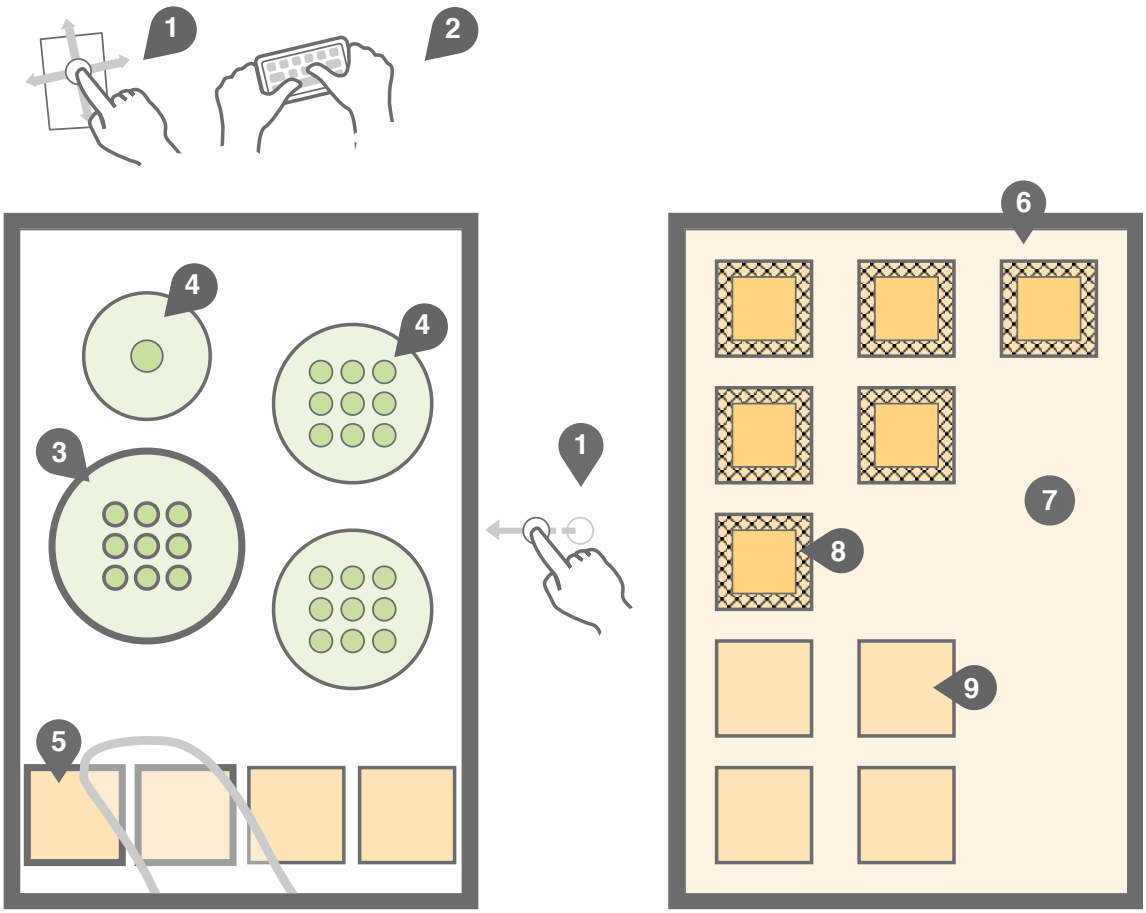


Figure 5.8 - Final iteration of Brian's desired device home screen diagram.

CHAPTER 6

MEETING DIVERSE USER NEEDS AND DESIRES THROUGH CUSTOMIZATION

Through the intra-participant analyses I narrowed participant data into vignettes and diagrams summarizing each individual's needs and desires associated with touchscreen smartphone home screen customization. Based on this output, I determined that a design research approach centered on exploring changing device states was appropriate for discovering user needs and desires. However, additional inter-participant analyses were required to fully address the study questions. This included whether the collective set of findings, stemming from a customization focus in inquiry, could help identify opportunities for addressing diverse users in mobile phone design and development. To conduct this assessment, I sought patterns across participants' findings. I used the updated analysis template as a platform (See Figure 5.7). I looked for commonalities related to the factors of customization. I explored motivations behind those customizations, seeking connections between the two that occurred across multiple individuals. Through this effort, I found five core types of connections between motivations and customizations. They were based on the following statements and descriptions:

1. *Participants desired customizations that were directly motivated by their abilities.* (Relates to functional limitations, Figure 5.7)

I reflected paired findings against current universal design regulations and recommendations, using the resources from outlining the forms of available content and content presentation as reference (See 2.2 Available Content). I identified points

where existing knowledge successfully addressed participants' needs and desires. I discovered areas where current knowledge fell short. With ability factors at the core, these findings remained associated with narrow design decisions versus the higher-level problems more apt to have greater impact on addressing diverse user needs and desires.

2. *Participants desired customizations that were associated with abilities that they, themselves, did not experience.* (Relates to functional limitations, Figure 5.7)

I once again referenced findings against current universal design regulations and recommendations using the noted resources. I discovered instances where participants introduced the same concerns as individuals with disabilities but were not focused on their abilities in doing so. I found these participants to provide a fresh perspective on potential design solutions versus those promoted by the current universal design knowledge base.

3. *Participants desired customizations that aligned closely with current market offerings.* (Relates to personal factors, Figure 5.7)

I considered findings in the context of current products based on their projected target markets. I identified points where the mobile phone industry was successful in addressing participants' needs and desires. I also discovered points where their execution fell short. I found these insights to support the current consumption-based perspective while also noting its shortcomings.

4. *Participants desired customizations other than ones indicated by their technology adopter profiles or personal factors.* (Relates to personal factors, Figure 5.7)

I looked at findings in reference to products currently available in the marketplace. I found that existing offerings were available, but were not necessarily known or designed appropriately for participants indicating interest. I discovered potential solutions for adjusting these offerings to reach a more inclusive audience. This supported consumption-based efforts while reinforcing their shortcomings.

5. *Participants desired customizations that were motivated by factors of time.* (Relates to Time, Figure 5.7)

Through the focus on device customization, rather than performance or consumption, I found participants' motivations for customizing their devices to center on scenarios of situational- and extended-device use. In these instances, I identified factors associated with time as the dominant reasons for participants making changes to their devices. I did find elements associated with functional limitations or personal factors to be present as well as influence these decisions. However, I noted that functional limitations and personal factors are not as dominate when dealing with time (i.e., connections 1-4).

I distinguished situational- and extended-device based on factors of time. I identified situational device use as event-based where a clear start and stop can be described and/or observed. I associated it with short-term interactions where physical and social environments play influential roles. I classified customizations related to situational device use as primarily short-term modifications (e.g., going

into a meeting and turning off auditory alerts). I also found participants to be motivated to customize their devices based on an accumulation of knowledge they gained as they used their devices over time. I classified these actual and desired changes as outcomes of extended-device use. I noted that these changes typically resulted in device modifications that are or would be maintained for longer periods of time.

In Figure 6.1, I convey the relationships between the five types of motivation-customization connections I outlined (i.e., connections 1-5). While I include all three themes of motivation (performance, consumption and time), I focus on time and its two scenarios, situational- and extended-device use [1]. I partially overlap time with performance and consumption [2]. I did this to indicate how functional limitations and personal factors were considered in, yet not central to, the primary theme emerging from this effort. I then show how each of the forms of motivation connects to customizations. I note that findings related to performance- and consumption-factors tended to maintain a narrow focus and reveal short-term solutions [3]. I note that findings related to time-based motivators centered on higher-level problems and led to the identification of a long-term design strategy for addressing diverse user needs and desires [4]. I classify long-term design strategy as an overarching approach that requires additional research and deeper analysis in order to resolve the associated higher-level problems.

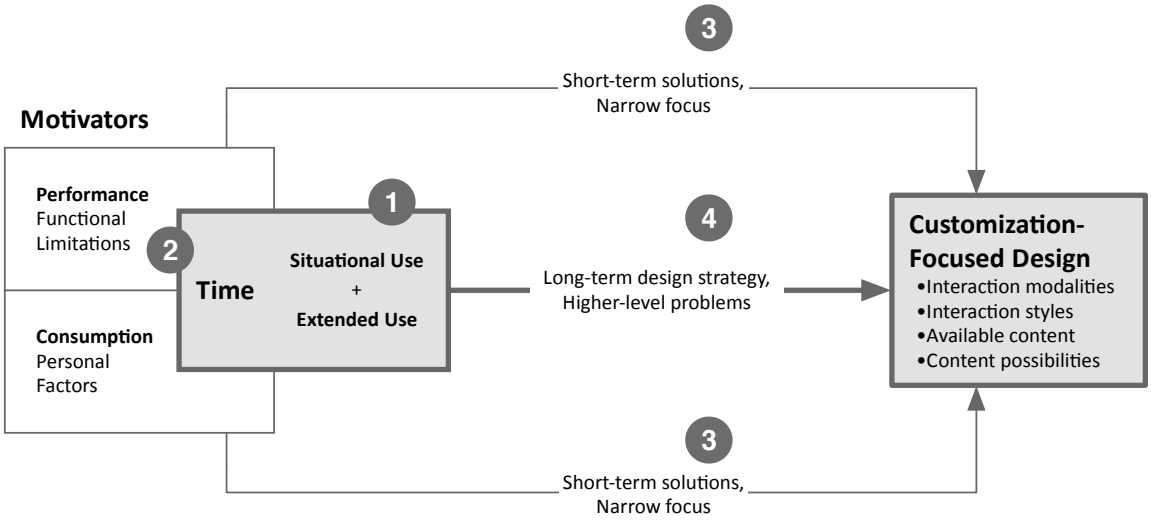


Figure 6.1 – Connections between motivators and customization-focused design, indicating points of short-term solutions and long-term design strategy.

In the remainder of this chapter, I present findings that emerged from the four forms of relationships between motivators and customizations associated with short-term solutions and narrow focus. I focus on customizations associated with interaction modalities and interaction styles. I note those I felt were immediately actionable towards improving the design of touchscreen smartphones to better address a diverse user population. I end this chapter reflecting on the impact of situational- and extended-device use, particularly in respect to hierarchy and flow.

6.1 Interaction Modalities

6.1.1 Input

6.1.1.1 Physical Buttons and Controls

I found participants who previously used mobile phones with physical keyboards to express interest in having this option of input modality again (See A.1 Brian, A.7 Sally, A.8 Wendy and A.9 Jack). They missed the tactile feedback and did not like the extent of visual focus required to use their onscreen keyboards. Based on these findings, I identified the need to provide users with an improved form of text entry. The ideal solution needs to provide appropriate feedback and reduce users' reliance on their vision. It also needs to address the shortcomings of the physical keyboard, mainly the small size of keys that frequently present barriers for individuals with physical limitations and/or larger fingers (Zheng & Ni, 2006). A potential option for text entry is voice input. Prior research studies have identified this modality as helpful for people with disabilities and it continues to be explored (Pires, Pinto, Rodrigues, & Dias, 2011). Unfortunately, there are limitations to voice input's ability to interpret what users have said (dialect, speech patterns, etc.). There may be privacy concerns with this input modality as well (e.g., composing personal email in a public environment) (Shaun K. Kane, Jayant, Wobbrock, & Ladner, 2009). Projection keyboards have been explored as alternate means of text entry. With this form of input, a virtual keyboard is illuminated on any surface. These still rely on visual attention (no tactile feedback) and introduce an additional

requirement: the need for a flat surface on which to rest the device (Roeber, Bacus, & Tomasi, 2003).

6.1.1.2 Gestures

In reviewing participants' data, I identified short-term solutions related to increasing use of multi-touch and spatial gestures as a primary interaction modality. In implementing designs that leverage physical motions, participants suggested using spatial reference points, including screen edges or device coordinates (e.g., tilting device vertically) as guides. They noted that this would shift their interactions from relying on vision to involving the senses of touch and kinesthesia. Gestures may improve performance by reducing the amount of attention required in interactions and utilizing muscle memory (Bragdon, Nelson, Li, & Hinckley, 2011). I found participants to reveal how increasing the use of gestures in interacting with touchscreen smartphones would impact other customization themes (e.g., interaction styles and content presentation) and their sub-themes (e.g., hierarchy, flow and soft keys) (See Figure 5.7). I identified that providing a greater link between aspects of the physical, mechanical and digital worlds could improve the design of interaction styles and create stronger alignment with users' existing mental models. This connection has previously been explored in efforts focused on tangible user interfaces. See the works of Ishii and Ullmer and Wensveen, et. al. for further description (Ishii, 2008; Ishii & Ullmer, 1997; Ullmer & Ishii, 2001; Wensveen et al., 2004). I also identified how increasing the use of gestures would impact available content and content presentation towards addressing diverse user

needs and desires. For example, one participant expressed the desire for augmented reality functionality. He described scenarios where he would direct his smartphone at points in his environment and contextual information would be displayed on his screen.

6.2 Interaction Styles

6.2.1 Organization

6.2.1.1 Category

Currently on both iOS and Android OS platforms, many device settings associated with universal design regulations and recommendations are categorized and labeled as "Accessibility." An example identified by a participant with a hearing impairment was the option to change auditory output from stereo to mono (See A.2 Edward). This study's findings suggested eliminating this categorization. Instead, I noted that each option should be aligned with the primary interaction modality it affects. For example, changing output from stereo to mono should be assigned to "Sound" settings instead of "Accessibility." I found shifting the terminology and association to place these settings in the context of device design rather than users' abilities. This integrated approach has the potential to minimize confusion on where the settings are located in a menu structure. It also may increase the likelihood that people without disabilities will discover the customization capabilities and explore their potential benefits, making it more inclusive.

6.2.2 Hierarchy and Flow

In reviewing the data, I discovered design shortcomings associated with device hierarchy and flow (or navigation). In examining the issues associated with the relationships between device content (hierarchy) as well as how users access and move through content (flow), I found barriers to users achieving their desired device states. I identified fundamental disconnects stemming from participants' needs and desires associated with prioritizing content. From an initial review, I noted short-term solutions to addressing hierarchy and flow shortcomings. I then conducted a more in-depth exploration aimed at discovering opportunities for greater design improvement. Through this second exploration I discovered a set of relative variables that appeared to relate to factors motivating participants to customize their devices while also indicating their desired hierarchy and flow customizations. I found them to be heavily dependent on both situational- and extended-device use versus functional limitations or personal factors. In this section, I present the findings associated with short-term solutions.

6.2.2.1 Prioritization and One-handed Use

Participants wanted to place prioritized applications in areas of the screen that are easy to differentiate. They wanted to select or manipulate options easily with one hand, usually using their thumbs. This desire aligns with universal design recommendations. However, the five participants that expressed this desire did not do so based on their abilities. Rather, this solution for improving interactions

stemmed from the desire to multi-task as well as to engage with other things or people in the environment simultaneously.

For example, in his desired primary home screen, Charles aligned icons vertically along the left edge. He wanted to easily access the applications he used frequently with his right thumb. To him, this was comfortable based on how he positions the device in his hand. Sally placed icons horizontally towards the middle of the screen based on the same premise. Both Charles and Sally's primary desired home screens are shown in Figure 6.3, indicating these prioritized areas[1].

[1] The symbol key used for all desired device home screen diagrams is presented in Figure 5.6 and described alongside the updated analysis template in 5.3.2.1 Clarifying Interaction Styles. I include the same symbol key in Figure 6.2 to assist with reviewing the diagrams in this chapter.

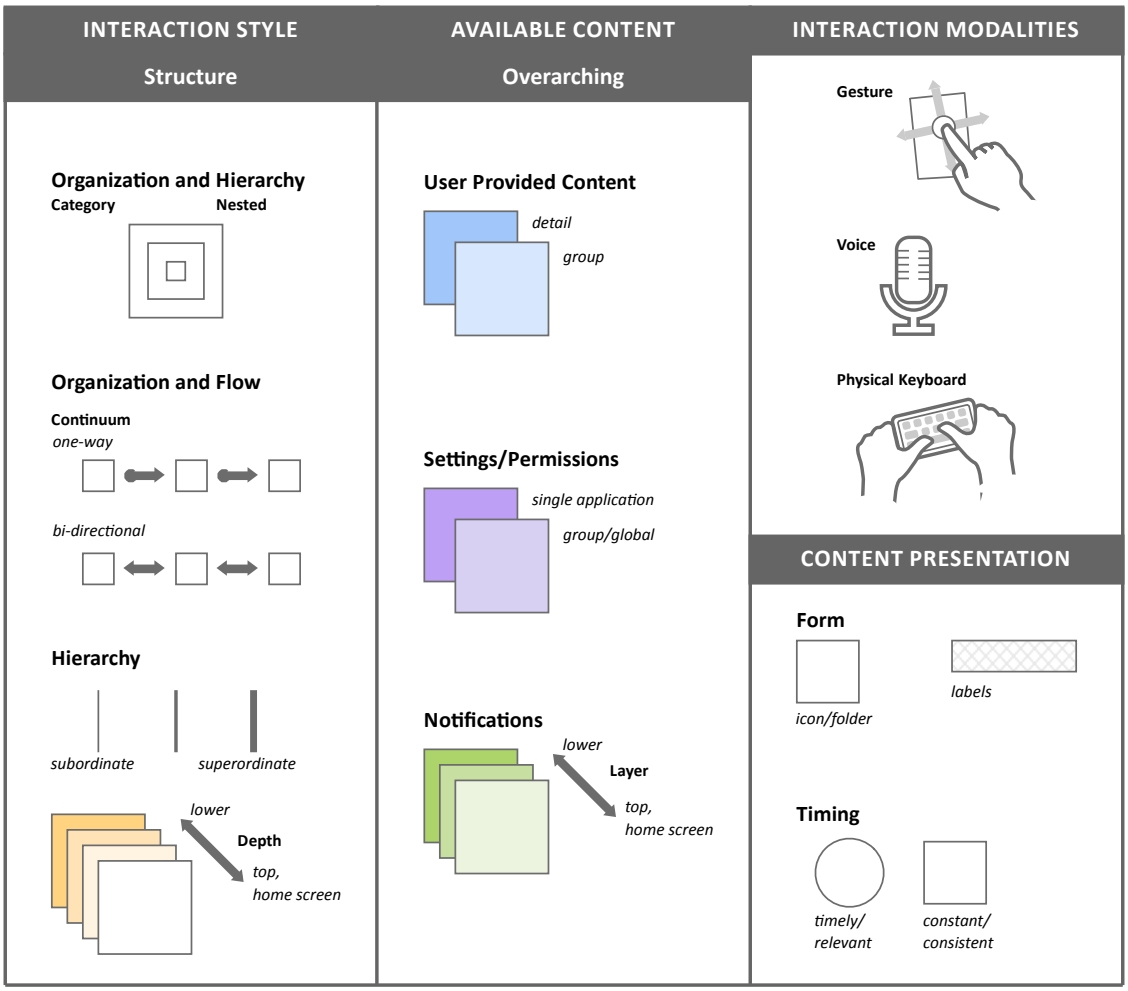


Figure 6.2 - Key for participants' desired device home screen diagrams.

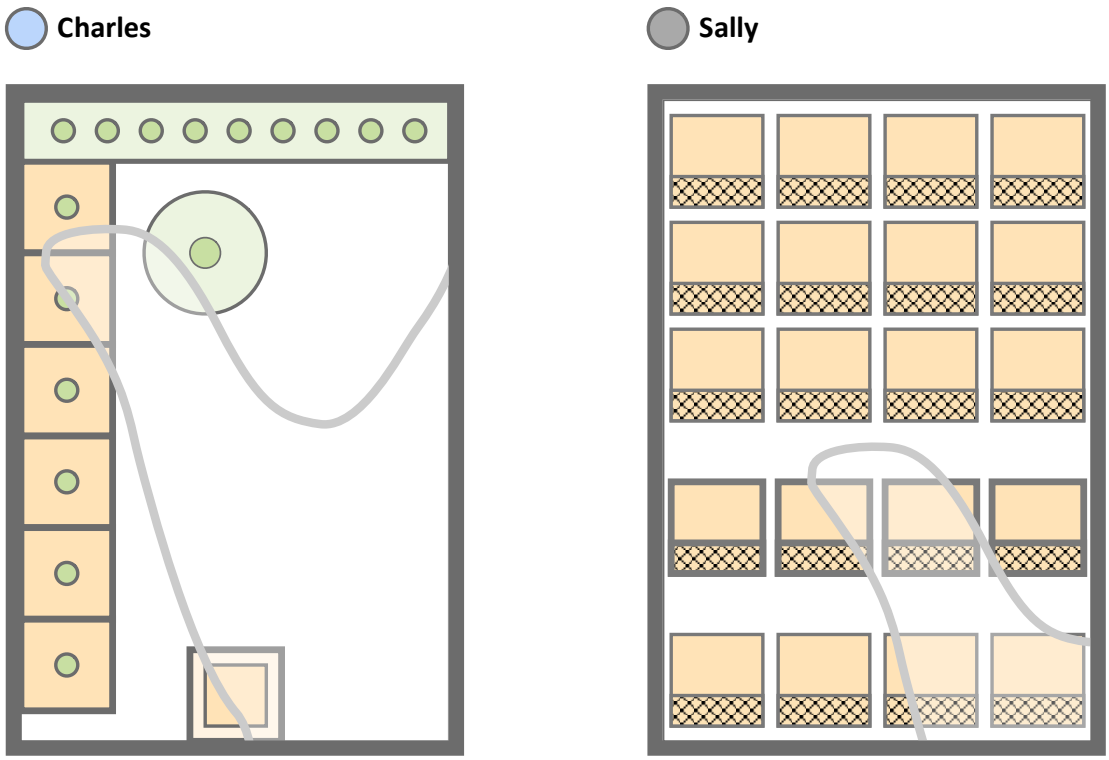


Figure 6.3 - Icon placement reflecting Charles and Sally's desired prioritization, indicated by heavier line weight.

I identified the short-term solution to provide users with a configurable area where they can place prioritized applications based on their preferred hand placement. Additional inactive white-space around these selection points would help prevent accidental activation of other applications or functions. Current iOS and Android OS devices do provide prioritized areas at the bottom of their screens; however, I discovered that participants found this to be an awkward location based on their hand placement. I noted how this tied findings from this effort to the smartphone's industrial design and how factors of the physical form can improve or

inhibit use (e.g., balance/center of gravity, screen placement and intended grip placement and texture).

Placing links to prioritized applications on a primary home screen establishes an organic hierarchy where elements are placed based on sequence of actions. However, I found all participants to desire a combination of at least two, if not all four forms of hierarchy (i.e., tree, nest, matrix and hierarchy)(See 5.3.2.1 Clarifying Interaction Styles). This is exemplified by Charles' full desired home screen diagram (Figure 6.4). He infused nest and matrix forms of hierarchy along with organic. The inclusion of multiple home screens represents flat, peer-based relationships that are indicative of organic hierarchies [1: primary platform linked to two secondary ones]. The grouping of applications on the second home screen indicates a form of nest [2: nested squares and orange shade]. The assignment of settings and permissions on an application versus system basis also shows a nested hierarchy [3: nested squares and purple shade]. A matrix hierarchy is represented by multiple access points to the same content, including the

- Prioritized icons [4: squares, orange shade, thicker line weight and placement],
- Scrollable application menu [5: pictogram and bottom platform with orange shade as background]
- Dedicated notification area [6: green shades and placement of circles in square grouping],
- Application-based notifications [7: placement of circles in squares], and
- Widget-based notifications [8: nested circles and green shades].

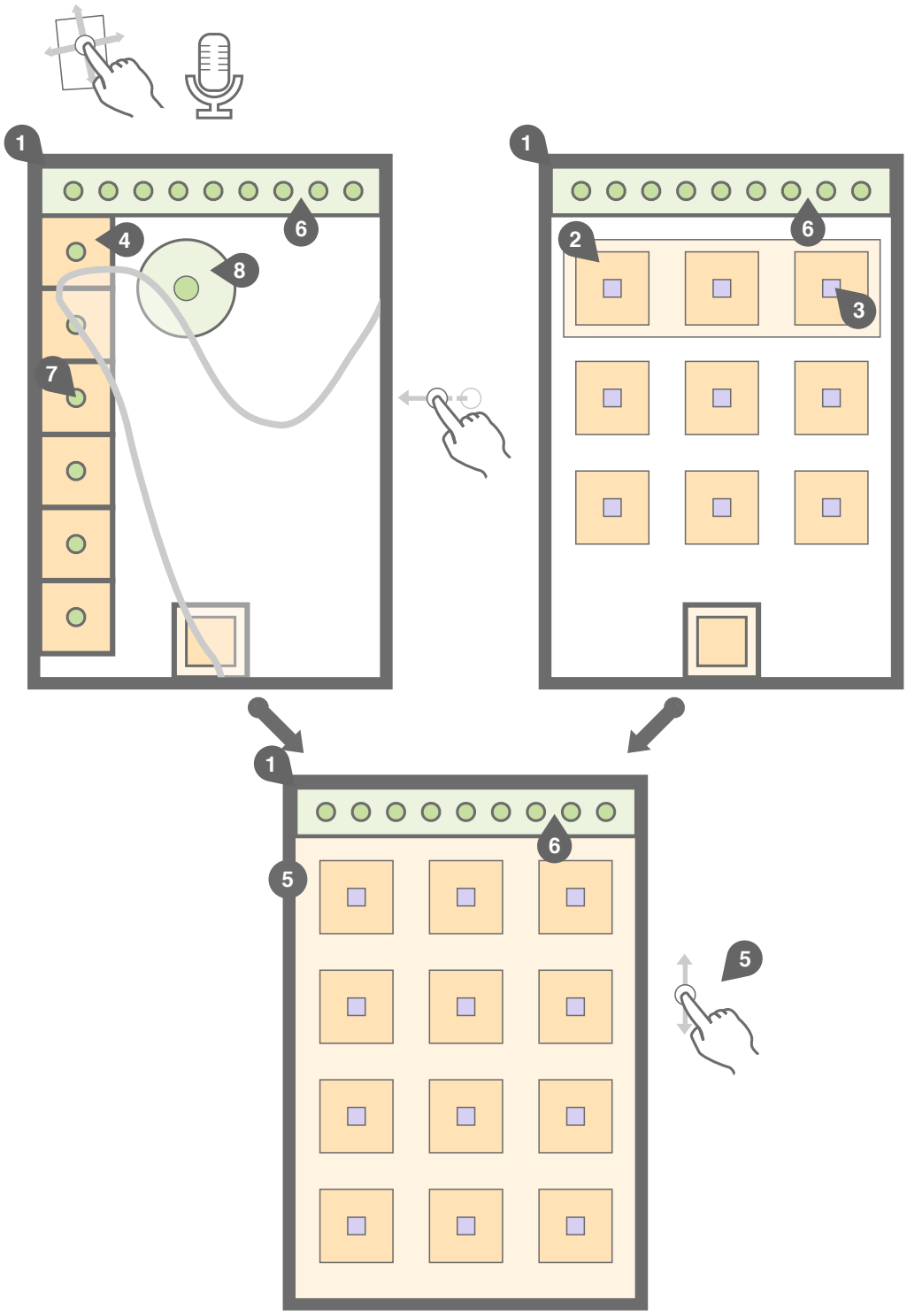


Figure 6.4 - Charles' desired device home screen diagram showing multiple forms of hierarchy and manipulation.

6.2.2.2 Search Functionality

Edward identified search functionality as a way to expand his use of organic hierarchy, placing it prominently on his desired home screen (Figure 6.5) [1: circle, blue shade, thicker line weight and placement]. He desired the ability to enter text and have results returned and displayed dynamically [2: nested circles], eliminating the need to navigate to find specific content. Edward noted that the search would return both device-based and World Wide Web results. He liked that this would help streamline his navigation by minimizing his cognitive load associated with remembering where he located applications on his home screens.

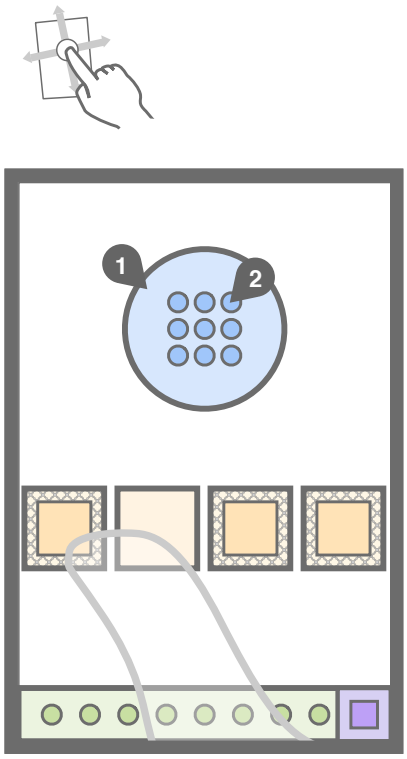


Figure 6.5 - Edward's desired home screen diagram indicating prominent search functionality.

In reviewing participants' stories, I found others who would likely benefit from this type of search functionality. Rebecca also mentioned having search capability as an integral part of her primary home screen. However, she only emphasized her need to search the World Wide Web. Both Brian and Charles expressed interest in having multiple ways to access information, allowing them to do so in a manner appropriate for their current situation. I identified the possibility that an improved search option would provide Brian and Charles with an unobtrusive yet powerful additional approach.

Search functionality is currently available on devices running iOS and Android OS. In reviewing current implementations, I found neither operating system's design to be fully successful. Neither option provides an adequate alternate means of device navigation for the diverse user population. In the current iOS design, the search feature is not visible from the primary home screen (Figure 6.6). To access it, users have to swipe the opposite direction than they usually do to navigate to their other home screens and associated applications. I suspect the need to deviate from primary behavior "hides" this option. While it is technically available, it appears to be underutilized.

Figure 6.6 - Current iOS search implementation (Apple Inc., 2011).

Android OS includes the search capability as a widget (Figure 6.7). It is located on users' primary home screen out-of-the-box. As users start typing, the screen refreshes to show dynamic search results. It indicates that there are multiple sources that can be searched. While I find this design to promote the functionality better than iOS, I find the placement of "Google" in the text field to improperly communicate that the search returns results only from the World Wide Web. Based on this review, I identified the short-term solution to improve the implementation of search as a means for navigating content on touchscreen smartphones.

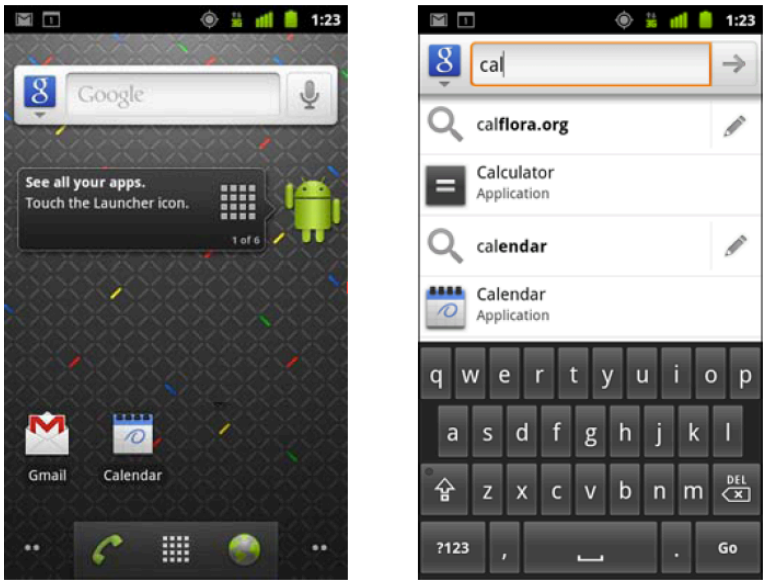


Figure 6.7 - Current Android OS search implementation (Google Inc., 2010).

6.2.2.3 Emerging Impact of Situational- and Extended-Device Use

By comparing participants' desired home screen diagrams (Figure 6.8), I was able to identify additional similarities in their desires for multiple forms of hierarchy. Through these analyses, I gained additional insight into how participants wanted to navigate through content on their devices. I supported these findings by reviewing participants' stories gathered during the research sessions.

Figure 6.8 – Collective illustration of all participants' desired home screen diagrams.

To establish a baseline for the inter-participant image analyses, I applied the symbol key (See Figure 6.2) to create diagrams representative of the general out-of-the-box states for iOS and Android OS. In Figure 6.9 I show the iOS out-of-the-box diagram, including an out-of-the-box image as a reference point. The diagram presents:

- The ability to use gesture and voice interaction modalities [1: pictograms];
- The capability to have more than one home screen [2: multiple platforms];
- The use of icons and labels to identify individual applications [3: squares, orange shade and crosshatch];
- The availability of folders with labels to group (i.e., nest) multiple applications [4: nested squares, orange shades and crosshatch];
- The prominent placement of four icons/labels to access prioritized applications [5: squares, orange shade, thicker line weight, crosshatch and placement]; and
- The use of a grid to arrange icons/labels [6: white space stemming from the lower right area of the screen].

Representative Diagram

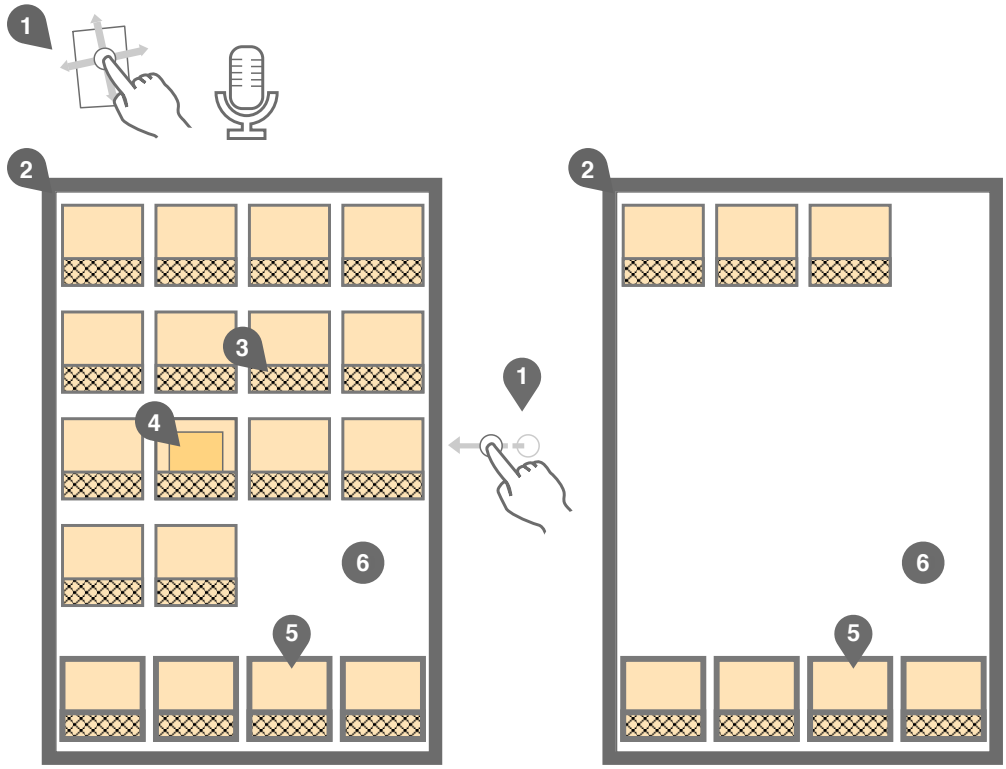


Image from iOS User Guide

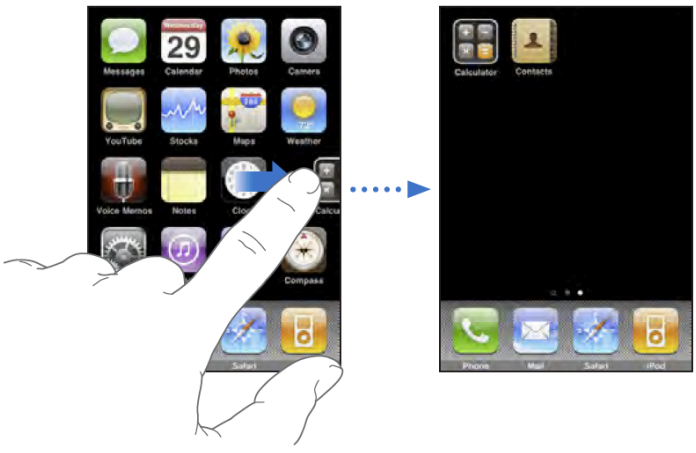


Figure 6.9 - iOS out-of-the-box home screen diagram in the context of out-of-the-box image from user guide (Apple Inc., 2009).

In Figure 6.10, I show the Android OS out-of-the-box diagram, including an out-of-the-box image as a reference point. The diagram presents:

- The ability to use gesture and voice interaction modalities [1: pictograms];
- The capability to have more than one home screen [2: multiple platforms];
- The availability of a vertical scrolling applications menu [3: lower platform and pictogram];
- The placement of two primary icons at the bottom of the screen [4: squares, orange shade and placement];
- The placement of a search area on the primary home screen [5: nested circles, blue shades and placement];
- The ability to include widgets on home screens that provide relevant and timely information [6: nested circles and green shades];
- The use of a flexible grid to arrange icons/labels and widgets [7: white space surrounding elements]; and
- The availability of an omnipresent notifications area [8: nested circles, green shades and placement].

Representative Diagram

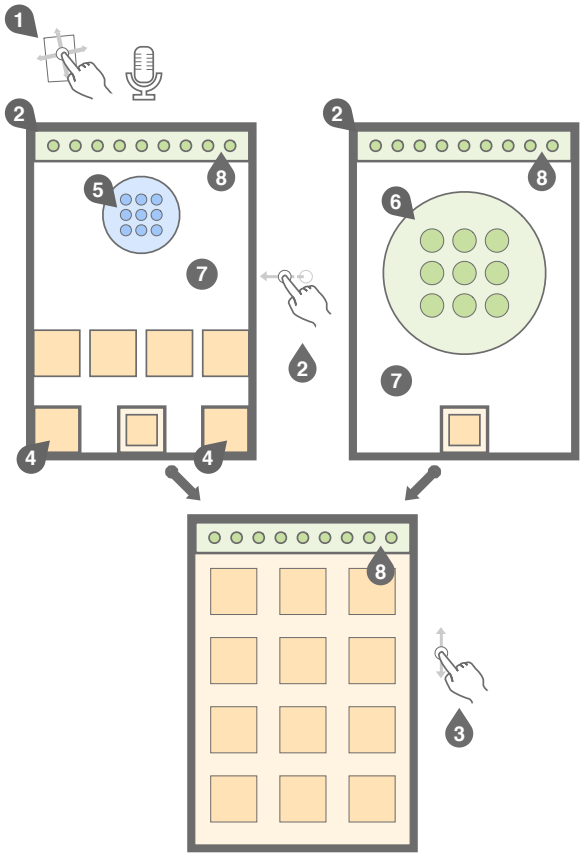


Image from Android OS User Guide

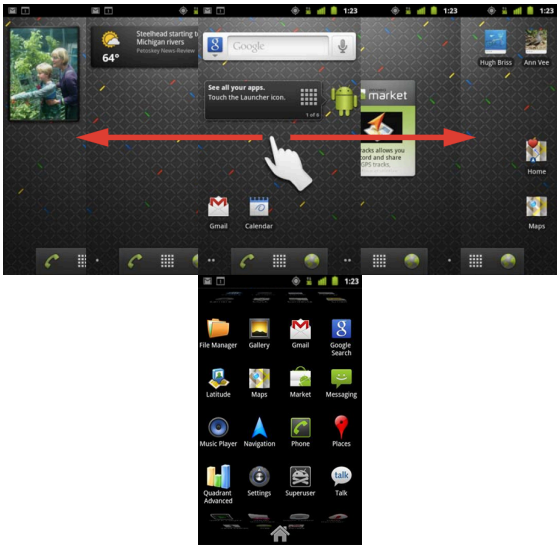


Figure 6.10 - Android OS out-of-the-box home screen diagram in the context of out-of-the-box image from user guide (Google, Inc., 2010).

I was interested in determining the impact of known factors on participants' desired device states, starting with understanding their impact on hierarchy and flow. I began by exploring the relationship between participants' current hierarchies and flow and their desired device states. I then reviewed the data to identify potential impact of functional limitations, gender and age. Finally, I looked at the output of the generative research activity and the influence it had on gathering data reflective of participants' desired states. I used the desired device home screen diagrams as the primary reference for these assessments. I supported the diagram comparisons with session notes. Figures representing the desired device home screen diagram comparisons are included in Appendix D. While these reviews started with hierarchy and flow, I progressed to examining other areas of customization.

I anticipated a level of correlation between users' desired device states and their out-of-the-box states stemming from their prior knowledge, use and comfort. I aligned the desired home screen diagrams based on operating systems. I found similarities in the desired states from participants who currently have an iOS device (See Figure D.2). I also found similarities in the desired states from participants who currently have an Android OS device (See Figure D.3).

I highlight examples in Figure 6.11 and Figure 6.12. In Figure 6.11, I show desired device home screen diagrams for two iOS users, Martha and Karen. Both indicated future devices that had organic hierarchies similar to their current operating system. However, instead of flicking sideways to access multiple home screens, they desired to have all applications available via a vertically scrolling list

[1: pictogram]. They both preferred the use of labels to icons to indicate the top level of content access [2: crosshatch]. Karen added one level of depth by noting the desire to nest applications (i.e., create folders) in association with each label [3: nested squares and shades of orange]. Both Martha and Karen desired to order the list based on priority, placing the primary applications/folders at the top [4: thicker line weight].

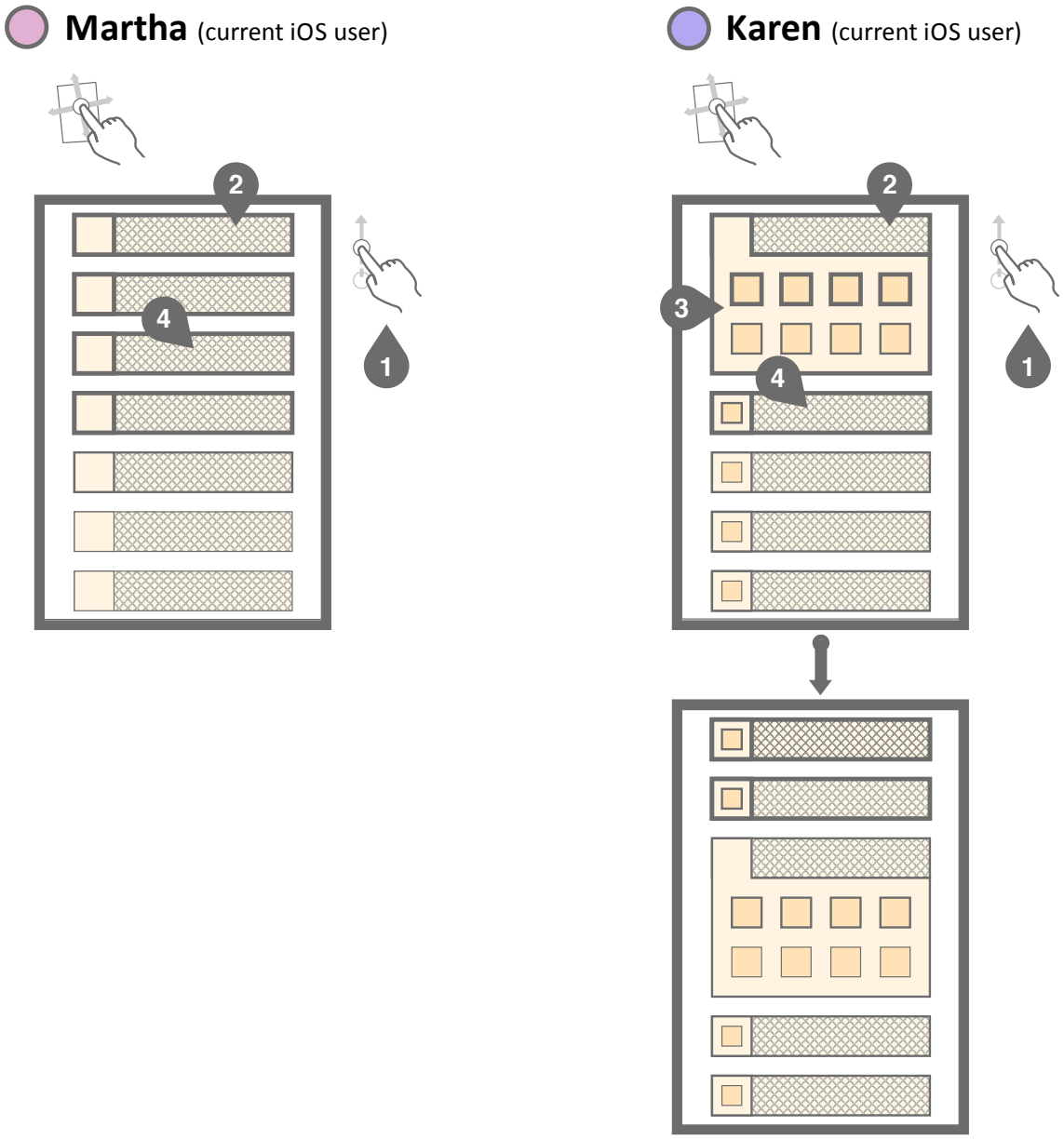


Figure 6.11 - Operating system-based comparisons, iOS focused.

In Figure 6.12, I show four participants' desired device home screen diagrams. Three currently used Android OS devices (Wendy, Rebecca and Charles). The fourth, Edward, currently uses an iOS device but has prior knowledge of the

Android OS. Therefore, I included him in this comparison. All four of these participants, desired to have an omnipresent notifications area [1: nested circles and green shades]. I noted that two of them also desired a prominent search [2: nested circles, blue shades and placement]. In addition, I found two of them to desire a scrollable application menu [3: pictogram, lower platform, nested squares and orange colors].

Figure 6.12 - Operating system-based comparisons, primarily Android OS focused.

While I noted the impact of participants' out-of-the-box states on their desired states, I found varying levels of deviation between the two. I was unsure the driver behind the extent of change, so I explored four possibilities.

- *Functional limitations*: I compared the three participants indicating limitations associated with thinking (ADHD and remembering) (See Figure D.4);
- *Gender*: I compared the four male participants (See Figure D.5) to the five female participants (See Figure D.6);
- *Age*: I compared participants younger than forty to those that were older than forty. I selected the age groups based on a delineation I found was currently used by the mobile phone industry in describing their market segments. All participants that were over 40 were female and grouped together (See Figure D.6); and
- *Generative tool activity*: I compared the participants who had difficulty using the generative research activity artifacts to describe their desired device states, including the three that were unable to complete the activity at all and the one who struggled but completed it (See Figure D.7).

With the small number of participants I was unable to determine if any of the areas explored was an underlying factor of desired hierarchies and flows. This inability is illustrated by comparing Rebecca and Jack's device states and stories.

Rebecca's full vignette can be found in A.4 Rebecca. Female and 32 years of age, Rebecca noted having thinking limitations based on ADHD. I found Rebecca to align with the "early majority" (See 3.2.4 Current Touchscreen Smartphone Market

Segments). However, as she described the device customizations she made, I discovered she had greater technology comfort and interest than she indicated. Therefore, despite initial perceptions, she may align more with early adopters. I also noted that Rebecca was one of the participants who struggled with the generative research activity.

Her current device had twenty pre-installed applications that she wanted to remove. However, device restrictions prevented this, motivating her to research how to "hack" her device in order to remove them. Five of the applications she removed were on the initial out-of-the-box home screen. This change can be viewed by comparing images of her out-of-the-box state and current state in Figure 6.13. With the level of technology comfort and know-how these actions indicate, I expected her desired device home screens to deviate further from her existing states. However, as indicated by comparing images of her current state and generative research artifact in Figure 6.13, they remained fairly similar.

Figure 6.13 - Rebecca's out-of-the-box, current and desired device states.

I present Rebecca's desired device home screen diagram in Figure 6.14. This representation also indicates the minimal design changes she desired from her out-of-the-box state. Similar to the current Android OS (Figure 6.10), Rebecca desired a prominent search area [1], navigation bar [2] and application menu [3]. However, within the application menu, she desired to group prioritized applications at the top versus have the full menu in alphabetical order [4: nested squares, orange shades and thicker line weights]. Rebecca also wanted to place important applications on her home screen in a staggered manner to prevent accidental selection while maintaining a visual balance [5: orange shade, thicker line weight and placement].

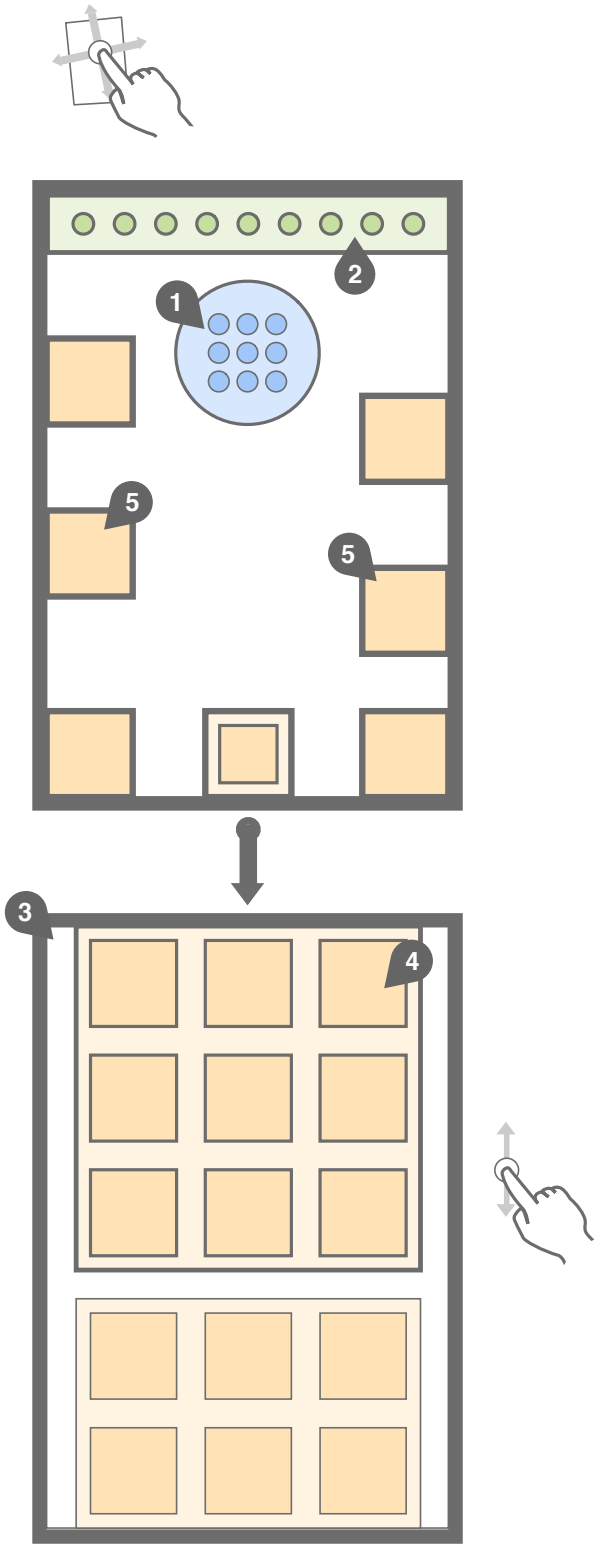


Figure 6.14 - Rebecca's desired device home screen diagram.

Jack's full vignette can be found in A.9 Jack. Male and 30 years of age, Jack self-reported having problems remembering things but did not tie his limitation to an official diagnosis. I found that he would likely be considered an "early adopter" and potentially an "innovator or experimenter" (See 3.2.4 Current Touchscreen Smartphone Market Segments). As indicated by the comparison between his out-of-the-box state and current state (Figure 6.15), he was overwhelmed by iOS's rigid four by four grid of icons and/or folders that provided the only direct access to content. He desired greater white space around items. At the time of the study, iOS prevented this. It forced an ordered placement of objects from top left to bottom right. As a result, on his current device, Jack "hacked" his device so that he could remove all icons and folders from his primary home screen other than those linked to the four applications he used most. These were located at the bottom of the screen and were omnipresent on all home screens. This configuration gave him a simple, clean view for the majority of his device interactions involving the home screens.

Figure 6.15 - Jack's out-of-the-box and current device states.

Jack was unable to use the artifacts in the generative research activity to construct his desired device. However, I used notes from his participant session to create his desired device home screen diagram (Figure 6.16). In describing his desired device state, Jack introduced an interface with multiple forms of hierarchy (See 5.3.2.1 Clarifying Interaction Styles)(Figure 6.16). He desired widgets that presented timely and relevant information [1: nested circles, green shades and placement]. He also wanted folders [2: nested squares and orange shades] and icons associated with important applications [3: squares, thicker line weight and orange

shade] to be present on a primary home screen. He noted that there should be ample whitespace between them [4: placement]. Jack wanted the ability to flick through the icons so that he could easily access additional important applications [5: pictogram and bi-directional arrows].

Jack also wanted to use gestures to reveal overlays [6: pictograms] that would give him:

- Greater insight into multiple applications' current states [7: nested circles and squares and orange shades]; and
- Quick access to device settings [8: nested squares and purple shades].

Jack's ideal state ranged from a primarily organic hierarchy in the out-of-the-box state to one that he described as a "Frankenstein" of mobile phone interfaces he has encountered in the past (e.g., iOS, Android OS, Microsoft Windows Mobile and HP webOS).

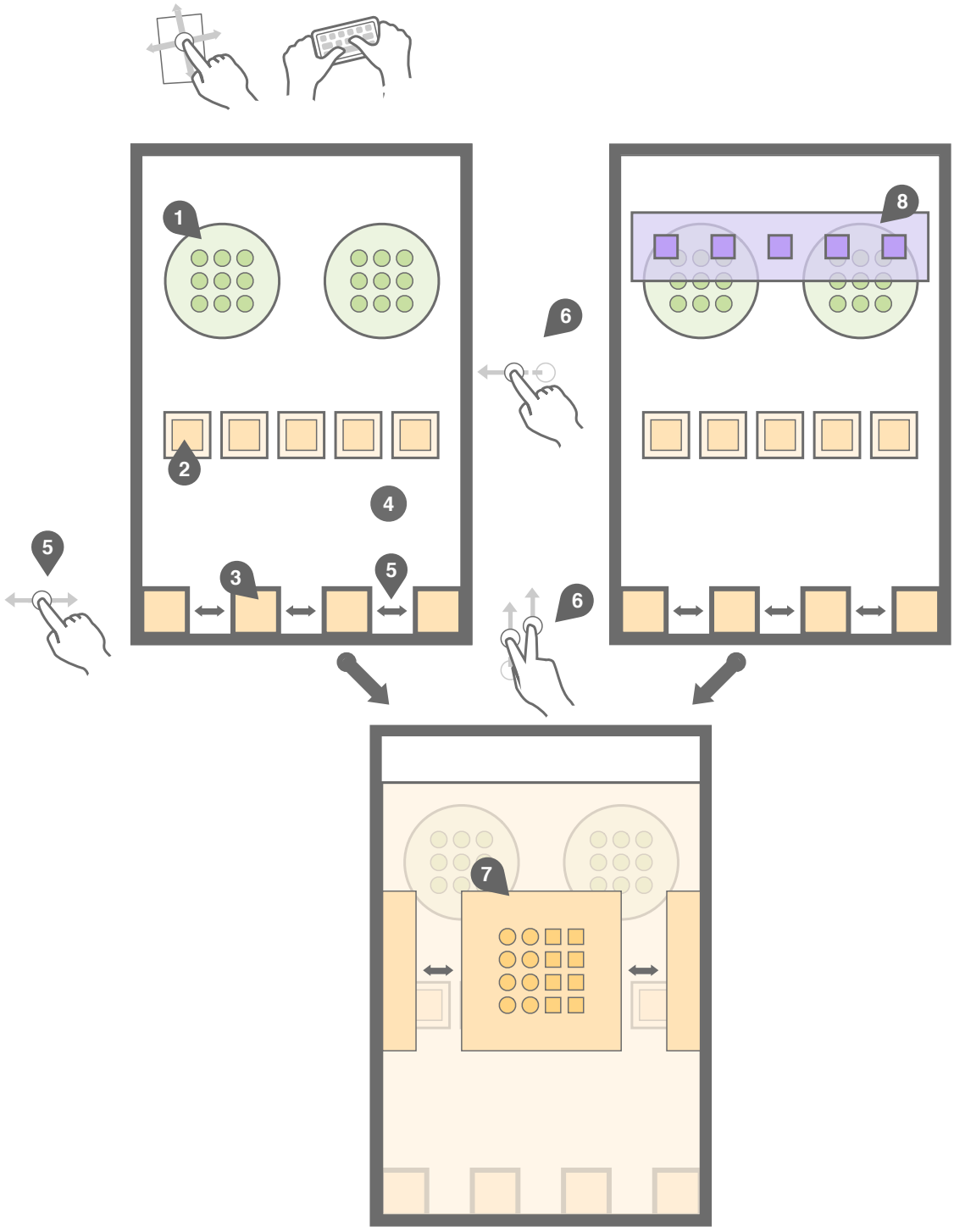


Figure 6.16 - Jack's desired device home screens indicating layered interface.

Rebecca and Jack are similar in age. They have thinking limitations, were comfortable with technology, and struggled with the generative research activity. However, I found that they had extremely different levels of desired changes between their current and desired states. Jack desired a greater shift than Rebecca from the hierarchies and flow, as well as interaction styles in general, presented in his current device to those in his desired.

I found prior operating system use, functional limitations, gender, age and success of the generative research activity to have limited impact on individuals' desired touchscreen smartphone customizations. I looked for additional themes and/or patterns to help explain the noted deviations exemplified by the comparison of Rebecca and Jack.

CHAPTER 7

FROM SHORT-TERM SOLUTIONS TO LONG-TERM DESIGN STRATEGY

By reflecting all participant data against the areas of interaction styles, I identified four variables reflective of participants' desired changes. The variables stemmed from individuals' situational- and extended-device use. I found each variable to be a continuum or spectrum. Collectively, individuals' alignment along these "spectra" appeared to indicate their inclination towards customizing factors associated with interaction styles. I present each of the relative variables within the context of motivators and interaction styles. I explore spectra in the context of Rebecca and Jack, demonstrating their applicability beyond interaction styles to the other areas of customization: interaction modalities, available content and content presentation. For available content and content presentation, I also present potential short-term solutions, leading to the identification of a fifth spectrum. Finally, I leverage the collective set of findings and concept of spectra to outline a long-term design strategy for improving the design of touchscreen smartphones by addressing diverse users needs and desires.

7.1 Spectra

In Figure 7.1, I represent the relationship between spectra and motivators for customizations associated with interaction styles. I introduce the relative variables [1] into the initial diagram that describes the relationship between motivators and customizations in relation to the higher-level problems and long-

term design strategy (See Figure 6.1). I remove the connections from performance and consumption to customizations. In doing so, I emphasize how spectra are indicative of participants' motivations for customizations of interaction styles stemming from situational- and extended-device use [2]. With the spectra's placement, I also show how they suggest characteristics of individuals' actual or desired customizations.

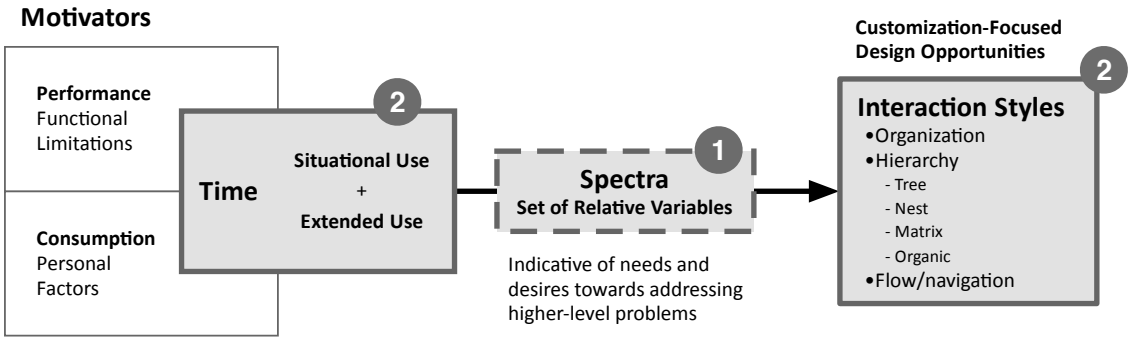


Figure 7.1 - Identified set of relative variables, or spectra, relating motivators and customizations of interaction styles.

Below are spectra I identified and how I defined them based on the review of participants' data:

Breadth vs. Depth is the continuum representing the relationship between hierarchy and the amount of content associated with each layer. Breadth indicates a shallow hierarchy with greater content associated with each layer. Depth indicates presence of more layers with less content associated with each one.

Separate vs. Unified is the extent to which a content or interface element is dependent on another. It can also be stated as the level to which users desire elements to be discrete or interconnected.

Push vs. Pull describes how content is surfaced. Push refers to the system automatically surfacing content based on pre-defined parameters. These are currently linked to settings/permissions as described earlier (See 5.3.2.1 Clarifying Interaction Styles). Pull refers to users actively seeking information on an as-needed or desired basis.

Signal vs. Noise is related to the surfacing of content based on factors of importance and time. Signal indicates the need for content to be presented only when known to be significant and relevant based on point-in-time and previously designated within the system. Noise indicates desire for content to be presented as the system receives or processes it regardless of its level of importance ("unfiltered").

I found breadth vs. depth and separate vs. unified to both relate to hierarchy. I found this to indicate the extent to which content forms a web across multiple applications and, therefore, how users are able to access and navigate the content. I noted that push vs. pull and signal vs. noise were linked, both addressing the surfacing of content. By exploring participants' stories behind their actual and desired customizations affecting interaction styles, I built an understanding of their inclinations toward one end of each spectrum or another. I also determined approximate placement along each spectrum for out-of-the-box iOS and Android OS.

This created a baseline for comparison. I formed two position maps to visualize how participants related to spectra.

In Figure 7.2, I show the maps and indicate the out-of-the-box placement for iOS and Android OS. I determined placement along each spectrum based on common knowledge of each platform; participants' reactions to their current devices; and my personal exposure to working with the operating systems. In the outlines below, I note examples of supporting evidence for the placement along each spectrum:

- iOS:
    - More *Breadth* because of the organic hierarchy restricting users to accessing applications via icons on multiple home screens and a single layer of nesting (i.e., in folders);
    - More *Separate* because of limited connectivity between organization-based applications;
    - A slight amount of *Push* because of the notifications some applications present to users; and
    - A balance between *Signal* and *Noise* because of users' ability to customize their notifications.
- Android OS:
    - A balance between *Breadth* and *Depth* because of the variety of methods for accessing content (e.g., widgets, application menus, icons and shortcuts) and the different levels of content granularity offered by each;

- More *Separate* because of limited interconnectivity between devices and their sources of content;
- A balance between *Push* and *Pull* because of the availability of a notifications window; and
- A balance between *Signal* and *Noise* because of the ability to include widgets on home screens.

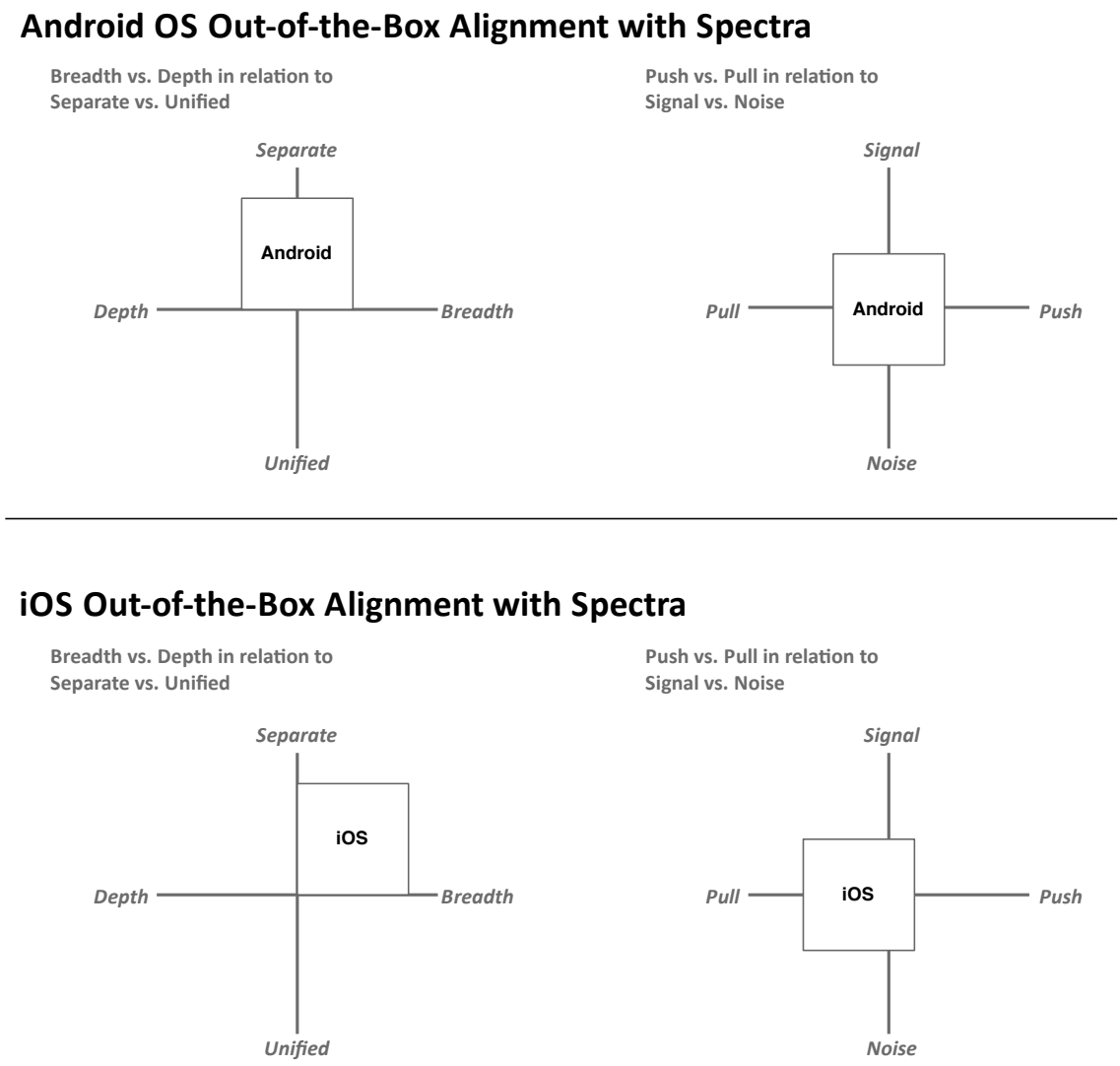


Figure 7.2 - Spectra related to interaction styles showing current iOS and Android OS placement.

Returning to the story of Rebecca and Jack, Figure 7.3 notes where I found each of them to sit along spectra based on their desired device states. I indicate their placement in comparison to their out-of-the box states (See Figure 7.2). In viewing these comparisons, I found Rebecca to remain closer to the current design of her

device. This aligned with what was indicated by her desired device state in Figure 6.13 and Figure 6.14. Based on the data I gathered, I placed Rebecca as wanting a balance of depth and breadth [1]. She wanted frequently used applications to be accessible from her home screens. However, she also wanted a full menu where she could differentiate between important and less important applications. The former would be placed at the top of the list with the latter organized alphabetically. I found Rebecca to always talk about her content as discreet and separate items [2]. In reviewing Rebecca's stories about customizations, I identified her desire to get updates about news, weather and communications, emphasizing social media. She did not appear to be concerned about the quantity of notifications she received [3]. I also found that Rebecca was more apt to seek information from her device (e.g., check updates on social media and read the news) than wait for her device to alert her of new content [4].

I found Jack's placement on the spectra to deviate much more from the current iOS placement. This aligned with his desired device state shown in Figure 6.16. Jack desired to integrate some, but not all, of his work-related content onto his personal device. I found this to give him a balance between having his device content separate vs. unified [A]. From both his current device and desired device states, I noticed that he preferred a lean top level of content access [B]. He desired home screen behavior where different gestures revealed alternate ways to access more granular levels of information. In concert with his desire for a clean initial home screen [B], I found Jack to want only key summary information [C] to be surfaced by the device [D].

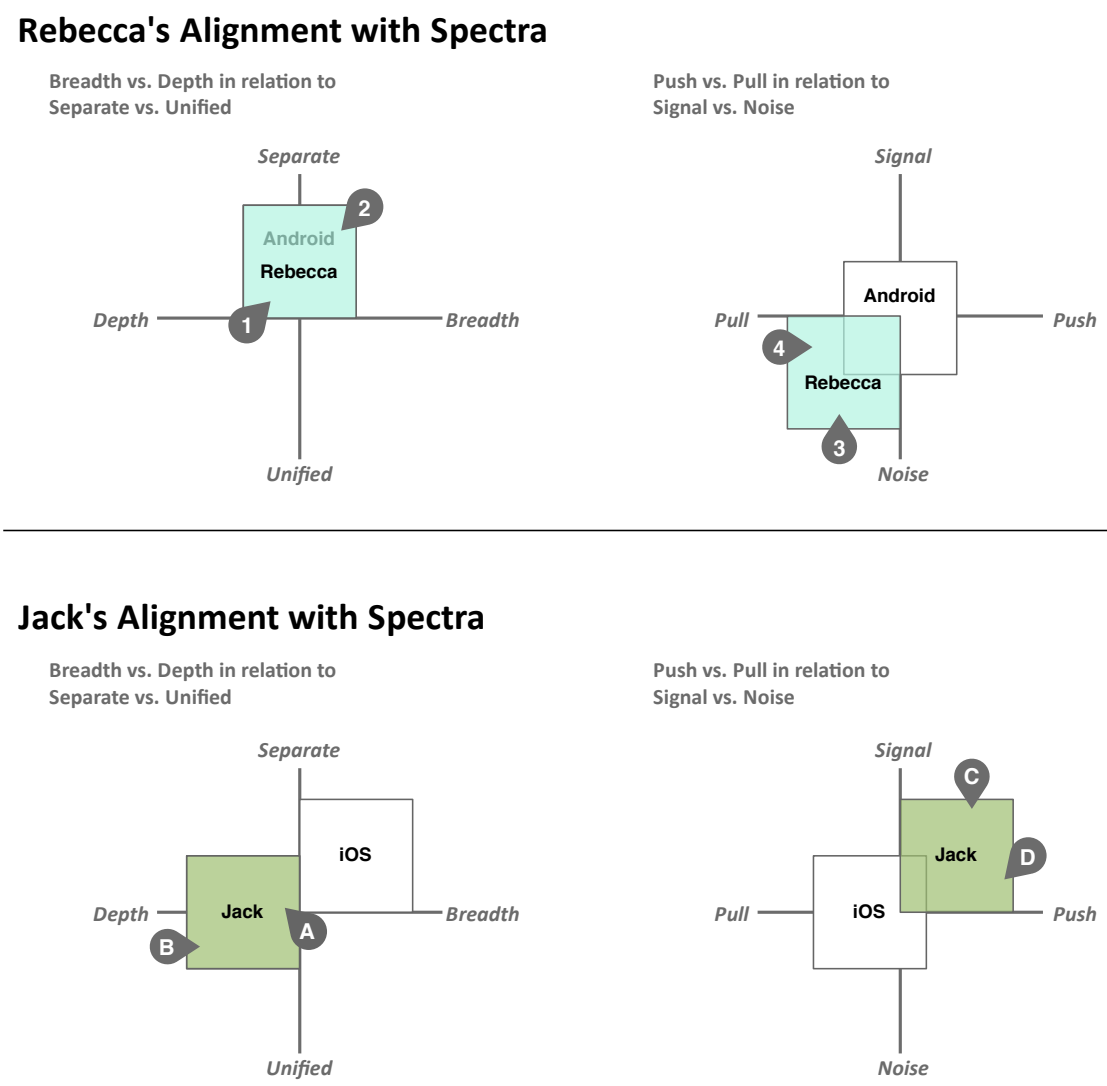


Figure 7.3 - Spectra related to interaction styles showing Rebecca and Jack's placement in comparison to their devices' out-of-the-box states.

7.2 Available Content and Content Presentation

After an initial review of the data, I determined that findings related to available content and content presentation could not be separated. I indicated this

dependency when first defining these areas (See sections 2.2 Available Content and 2.3 Content Presentation). Based on these interconnections, I chose to combine the presentation of my data explorations and findings associated with these areas.

Having identified spectra and their relationship to desired interaction styles, I decided to explore whether they were also indicative of participants' desires related to available content and content presentation. I also continued the inter-participant analysis process. This included using the updated analysis template to look for patterns between available content, content presentation and the motivation themes: performance, consumption and time (See Figure 5.7). Through these activities, I identified short-term design solutions that were primarily focused on the underlying factors of available content and content presentation: applications; notifications and settings/permissions; and timely and relevant information. I found participants' alignment along spectra to reflect their motivations for customizing aspects of these underlying factors. I also discovered another spectrum, practical vs. ornamental, related to visual design of home screens. As with the initial spectra, I found this relative variable to reflect participants' motivations and project their desired customizations.

In reviewing the data on available content and content presentation, I also noted bi-directional relationships between them and interaction modalities and interaction styles. Each tends to impact the other with a "ripple effect." Therefore, I updated the diagram in which I introduced the set of relative variables (See Figure 7.1). In Figure 7.4, I include the five spectra I identified through the data [1]. I expand customizations to once again include all of the noted themes [2](See Figure

5.7). I continue to show how spectra appear to be primarily associated with the time-based motivators of situational- and extended-device use versus factors of performance or consumption [3].

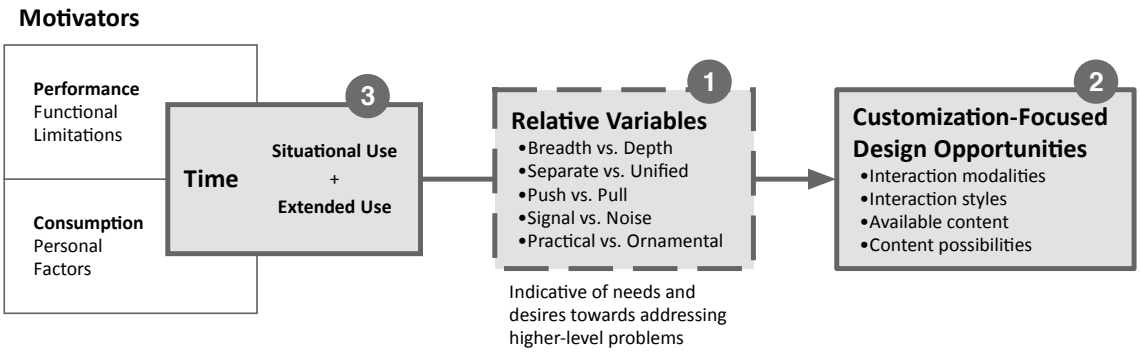


Figure 7.4 - Identified variables (spectra) connecting time-based motivators to customizations.

7.2.1 Applications

I discovered that participants created "work-arounds" to accommodate perceived device shortcomings. In multiple instances, individuals were annoyed by the pre-installed applications, and more so by their inability to remove them from their devices. This resulted in two participants "hacking" their devices to get rid of these applications. Another participant created a folder labeled "Random" to place the applications that he did not find useful. The mobile phone industry advertises these applications as "value added features (Vikas, 2010)." However, based on these

findings, I find the negative impact may be greater than the actual return of the "value added features."

In reviewing the data, I found that participants expressed desires by noting specific applications as well as describing content within those applications. I determined that communication- and entertainment-based applications were frequently discussed by name, whereas those associated with the sub-theme of organization were typically discussed based on forms of content. For communication, I discovered social media applications (e.g., Facebook and Twitter) were frequently prioritized. I noted that participants frequently referred to entertainment applications as "time wasters." Both Charles and Karen indicated they would like to partially organize their devices around this premise. In reviewing existing devices, I found industry efforts to promote this capability including "game centers (*iPhone User Guide*, 2011)."

I identified organization as a content area where participants hoped for more unified content relationships. For example, both Edward and Charles wanted their shopping lists to be supported by contextual information. This included details on product availability, pricing and reviews as well as recommendations of potential alternatives. Additional content they suggested included store hours and locations as well as maps for directions.

I also found several examples of participants wanting to use their touchscreen smartphones to replace current "paper-based" approaches. I discovered examples of positive outcomes. This included Martha using her camera to capture information she needed on occasion and found difficult to remember

(e.g., her license plate number, paint chip colors and light bulb types). However, I also discovered limitations. For example, the calendar functionality did not suit Karen's needs. She continued to carry around a paper version along with her touchscreen smartphone.

To address frustration points and content interconnectivity, I find data to suggest the need to review how individuals complete activities "on paper" in order to help design an appropriate solution. I identified that knowledge gained through this form of inquiry should supplement insight gathered from users about shortcomings to existing applications that aim to help with the same or similar tasks. From the findings, I also identified the importance of not designing a single application that incorporates multiple complex features. Rather, I found participants to want multiple applications with possibilities for interconnectivity and compatibility. In providing these solutions, participants would be able to customize which components they include on their devices and remove ones they feel to be unnecessary. It is of note, that I have found industry practices to potentially limit these proposed solutions due to their tendencies towards proprietary formats (Kenney & Pon, 2011). The effort to address this may exceed the benefits, requiring alternate approaches such as those I propose in 7.3 Long-term Design Strategy.

7.2.2 Notifications

I found participants to want a centralized notifications area that places messages from multiple applications, as well as device status updates, in a single location. This capability was available on Android OS at the time of the research

study. It became available on iOS during the time data were being processed. Both operating systems provided the ability to modify notification settings, including frequency and form. However, with their current designs, participants found the process of modifying and selecting the content to be displayed cumbersome. I found that participants had to tolerate misalignments with their preferences for signal vs. noise.

7.2.3 Settings/Permissions

Settings and permissions can be system-wide or application-based. System-wide settings and permissions include hardware (e.g., battery, screen brightness) and device-manufacturer software (e.g., font size, color themes). Application-based settings vary depending on authorship and capabilities (Au et al., 2011). I found participants to be confused about the differences. I found that participants want consistency in how the system-wide settings and permissions are modified and want clarity in what they control. For example, Martha changed the font size on her device in a general device settings area. She became frustrated when it did not change for all applications.

I found that participants wanted all application settings to be modified in the same manner across their device. I noted that some preferred having a central location to make changes, where others wanted each application to contain its own settings.

7.2.4 Timely and Relevant Information

As noted earlier, participants discussed the desire for the presentation of timely and relevant information. In aligning this with spectra, timely and relevant information parallels a desire for high signal and low noise. However, it is impacted by personal and situational factors. What is considered timely and relevant can change depending on circumstances. For example, Jack found his current device provided irrelevant insight into the status of his email application. iOS uses "badges" to display the number of unread messages (*iPhone User Guide*, 2009). To Jack, the significant number was the total of new messages that had arrived since he last glanced at his device, not the 747 messages he had failed to read (See Figure 6.15).

I also noted participants' increased desires for the push of timely and relevant information by their increased desires for widgets on their home screens. The ability to display widgets was only available on Android OS at the time of this study. All Android OS users expressed the desire to also have widgets on their future devices. Three iOS users, whose out-of-the-box devices did not have the capability to display widgets, desired to have them in their future devices. Reflecting on the data, I find it likely that the other two iOS users may be interested in having widgets on their device but were unaware of the capability.

I found participants to gravitate towards widgets because of their desires for gaining insight into application content before taking the step of opening the full application. Related concerns included ensuring the information presented in the widgets was of appropriate breadth and depth. For example, depending on individuals' preferences, a widget could display the current temperature, details on

the day's weather or a weeklong forecast. It could also tie to notifications by updating with specific details such as storm warnings. In tangent to proposing these capabilities, I found participants to express concerns about widgets pushing content only in appropriate intervals due to battery life.

7.2.5 Visual Design

I was surprised by the extent to which participants made decisions about what to put on their home screens and where to place it based on the aesthetic response it evoked. Multiple participants conveyed that their desired customizations were restrained by their current operating system's use of a forced grid to organize content on home screens. I mentioned this earlier in discussing Jack's device states. Three of the five iOS users were frustrated by the requirement to fill home screens with icons from top left to bottom right. They wanted more flexibility to allow for white-space or blank areas. Multiple participants also wanted the option of only showing icons on their home screens instead of also having to have a label associated as is required on current devices. They indicated that since they had placed the items on the home screens they knew what they were and, therefore, did not need to be constantly reminded. The majority of participants modified their home screen backgrounds (wallpapers) to reflect something of significance, primarily family or travel related. Based on these findings, I identified an additional spectrum and defined it based on the participant insight:

Practical vs. Ornamental is primarily related to content presentation. It is the level of detail assigned, starting with the core of what is needed to interpret the

message and moving towards layers of added elements (e.g., default wallpaper vs. animated series of family photographs).

7.3 Long-term Design Strategy

In exploring the collective set of participant data, I identified five spectra that I related to individuals' needs and desires for touchscreen smartphone customizations. Participants' tended toward one relative spectra data point or another based on situational- or extended-scenarios of device use with functional limitations and/or personal factors potentially playing a role as well. I found that participants' positions along these spectra were indicative of their desired device home screen states. Therefore, I have leveraged these spectra and relationships (See Figure 7.4) to help form and describe a strategy for improving touchscreen smartphone design and addressing the needs and desires for individuals diverse in age and ability.

I centered the strategy on providing users with devices where the out-of-the-box state aligns, to the greatest extent possible, with their desired states. However, as I found in this effort, discovering individuals' desired device states is difficult. Therefore, I have proposed addressing the higher-level design problems limiting the universal design of touchscreen smartphones by using spectra to guide both research and design efforts. I first describe how spectra relate to an overarching long-term design strategy and then extend their application to design research approaches. I also note how each relates to current performance- and/or consumption-based efforts.

In reviewing the potential spectra application, I identified two possible approaches. I found one to align with current consumption-based design and development practices (Figure 7.5). It centered on selecting positions in relation to the five spectra that collectively represent and define a user group (i.e., "Target Market A" and "Target Market B"). Research and design efforts would then aim to establish offerings that target that group. With its primary focus remaining on identifying and targeting specific populations, I determined it was not appropriate for arriving at solutions that meet the needs of individuals diverse in age and ability.

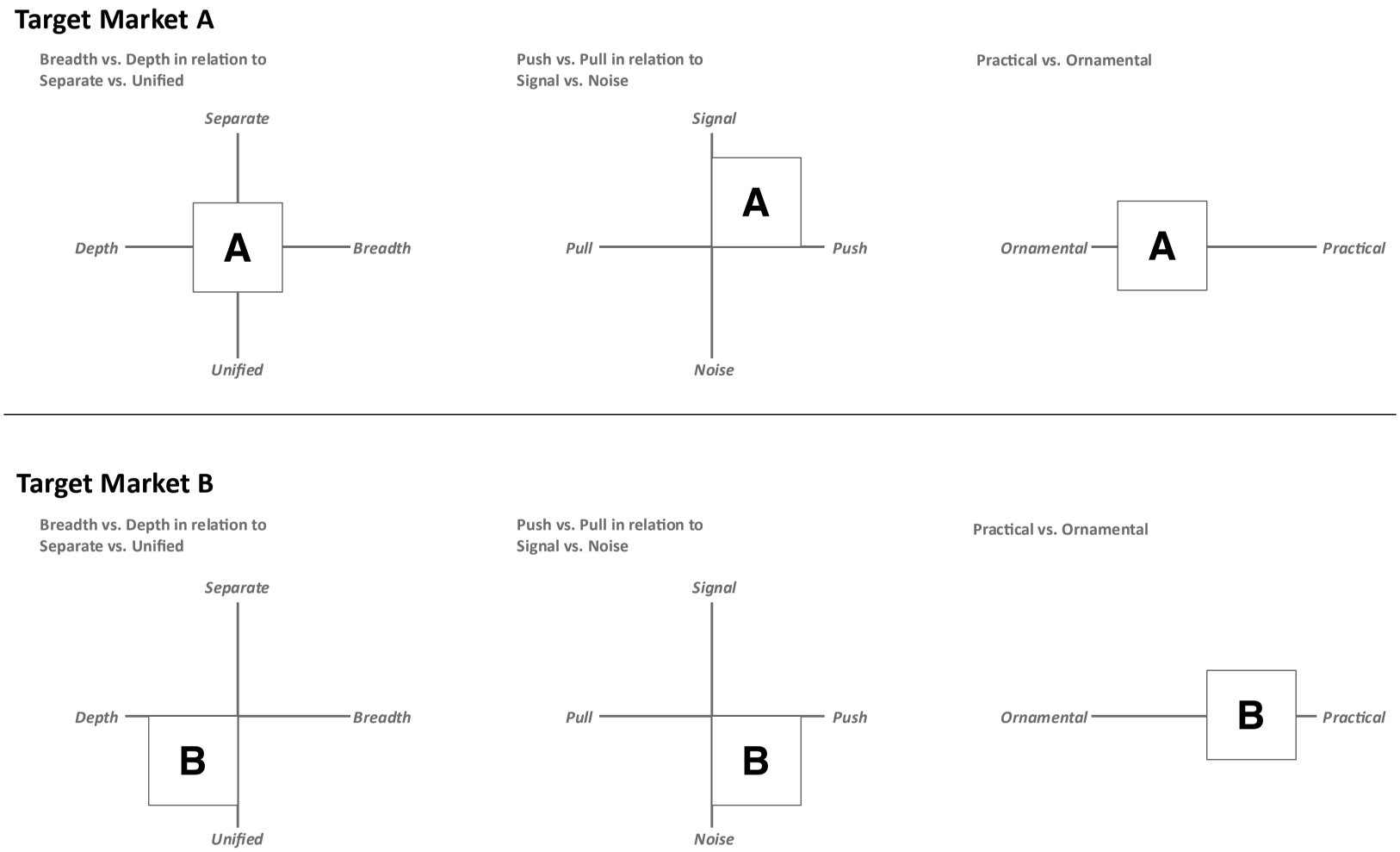


Figure 7.5 - Establishing target markets based on spectra positions.

The second approach I identified focused on addressing an inclusive population. It centers on designing devices that

- Address the range of the five identified spectra through their customization features and capabilities;
- Have an out-of-the-box (or "standard") state, determined through design research, that addresses a balanced position along each spectrum; and
- Allow users to customize their devices to better align current spectra positioning with the positioning indicative of their needs and desires.

I use the position maps to demonstrate the intention of this long-term design strategy (Figure 7.6). In the figure, I indicate an out-of-the-box state I feel aligns with this effort's findings and is, therefore, a balanced starting point based on the collective set of participant data. I designated:

[1] More breadth than depth in order to give users an initial overview of the content;

[2] More separate than unified content to allow users to easily add and remove applications and to determine what content connections they would like as well as when and how they would like them to be made;

[3] More push than pull to promote related device capabilities. I based this on the less technology-savvy participants being unaware of its potential to address their needs and desires. I also chose the position because I found it to align with the more technology-savvy participants' needs and desires;

[4] Balanced signal vs. noise to address the variety of participants' needs and desires related to the spectrum; and

[5] More practical vs. ornamental to emphasize participants' desires for "clean and simple" content presentation.

I use Jack's positioning (See Figure 7.3) to represent how users could customize their devices, evolving their states based on extended device use in order to better align it with their needs and desires [6]. To complete the representative example, I used study data to determine Jack's positioning on the ornamental vs. practical spectrum. I placed Jack towards practical [7] based on his desire for less clutter and more white space, as indicated by the visual contrast between his out-of-the-box and current device states (See Figure 6.15).

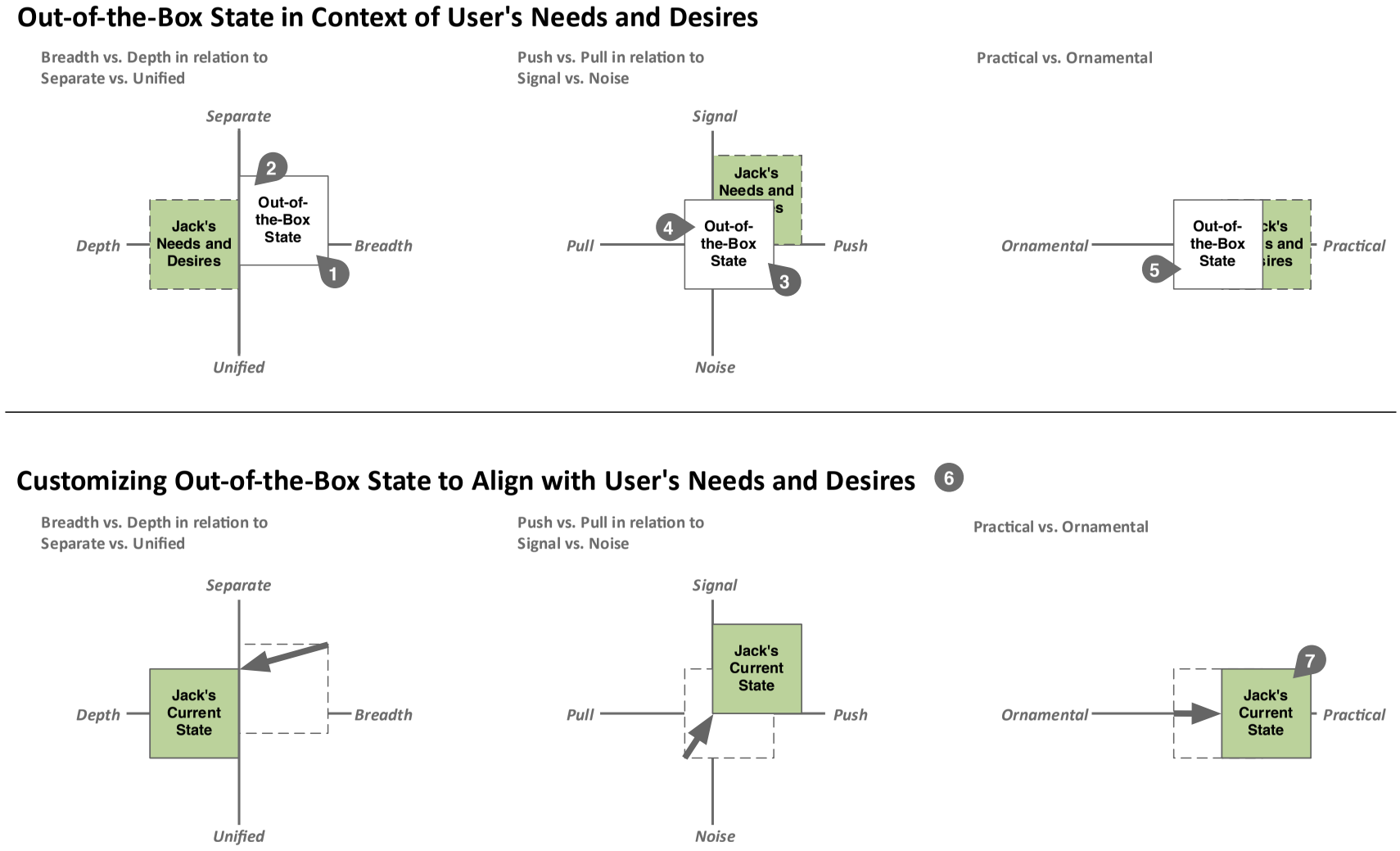


Figure 7.6 - Aligning out-of-the-box state to user needs and desires as indicated by spectra.

In addition to enabling users to establish a primary device state, as demonstrated with Jack in Figure 7.6, I identified the potential for users to create situational states. Users could activate these secondary states through methods they pre-determine in a settings/permissions area. In reviewing this effort's findings, I identified three potential scenarios. These include:

- An "entertainment state," initiated to improve the experience of waiting for children, at airports, for appointments, etc.;
- A "task state" implemented to hide content that distracts from accomplishing noted activities and goals; and
- A "travel state" applied when traveling to promote local information as well as reduce emphasis on work-related content.

In Figure 7.7, I once again use Jack as the example. I indicate how the design of customization-related elements (See Figure 5.7) would shift to reflect the alternate spectra positions. I based the entertainment, task and travel states' spectra positions on the collective findings from this effort.

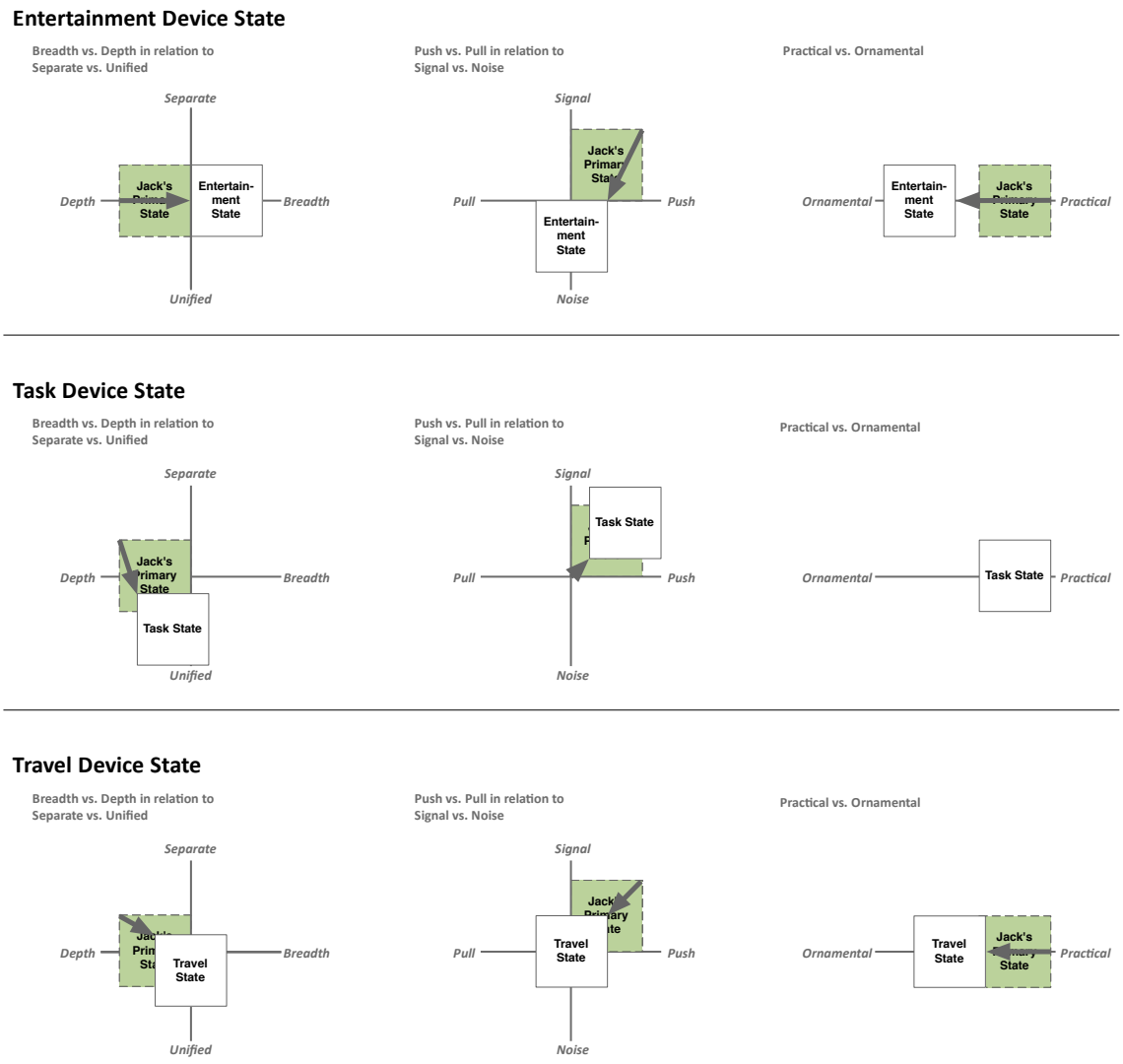


Figure 7.7 - Examples of alignment along spectra for entertainment, task and travel scenarios.

Through these examples, I illustrate alignment with consumption-based approaches. A device's standard out-of-the-box state could be based on the balance I show in Figure 7.6. In this form, a device could be promoted towards the market-at-large. However, the same device could be reconfigured to have additional out-of-

the-box states. For example, three additional versions could be packaged and marketed based on the entertainment, task and travel spectra positions I present in Figure 7.7. In the design strategy, I also provide a structure for addressing performance-based concerns. For example, in a "work" mode, interaction modalities associated with auditory output could have amplification capabilities to accommodate the need for conference calls and loud environments. This aligns with design recommendations and regulations associated with individuals with hearing impairments.

I identified the potential for personalization (system activated change) to automatically trigger the secondary states. However, based on initial discussions describing shortcomings of personalization, I feel it is important that this should not be implemented unless it can be designed in a manner that is transparent to users (See 2.4 Customization). I identified that research efforts exploring context-aware computing have potential to aid in this type of advancement (Hong, Suh, & Kim, 2009). However, prior works I found focused on approaches for pushing context-appropriate information and/or automatically changing specific device settings and permissions. I did not find efforts that addressed holistic changes to areas of touchscreen smartphone customization: interaction modalities, interaction styles, available content and content presentation (See Figure 5.7).

CHAPTER 8

CONCLUSION

8.1 Future Directions

To pursue the long-term design strategy towards meeting diverse user needs and desires, I found that additional design research is required. I identified two key areas:

- Understanding the relationships between users and spectra, from both situational- and extended-device use perspectives, and how the connections are indicative of individuals' touchscreen smartphone customization needs and desires (See Figure 7.4); and
- Understanding how to translate variability in spectra into executable designs for touchscreen smartphone customization.

I address the first by leveraging research and analyses methods I used as well as the lessons I learned through their execution. For the second, I realized that to affect change, the process is just as important as the end result. I find the following quote from *Design-Inspired Innovation* to eloquently capture my sentiment:

"When the next design problem is presented, the designer may be unable to apply the same answer, but may very well be able to apply expertly the methods and reasons learned from a previous exercise to find a creative new answer (Utterback et al., 2006)."

Therefore, I present a process for discovering design ideas through the spectra approach. I include a discussion of design research and analyses methods I find appropriate for identifying design opportunities and forming a design space to explore them. Finally, I present possibilities that emerge from extended application of the proposed approach.

8.1.1 Discovering Design Ideas through Spectra

The initial diagram I created relates the design research to the design space (Figure 8.1). It presents a structure for identifying and addressing higher-level problems. In the diagram, I combined motivators and customizations from the updated analysis template [1] (See Figure 5.7) and the diagram introducing the relationship between identified spectra and the motivators for customizations [2] (See Figure 7.4). I focused inquiry on factors of "time" versus "performance" or "consumption" [3] and, therefore, did not pre-suppose the user population or restrain the design space. I centered data gathering on understanding users needs and desires for touchscreen smartphone customization and the motivations behind them [4]. Rather than detailing the participants' needs and desires as design recommendations, I focused analysis on relating the data back to spectra [5]. My goal was to create a process where designers gain insight allowing them to construct an appropriate design space associated with the areas of customization towards improving touchscreen smartphone design for individuals diverse in age and ability [6].

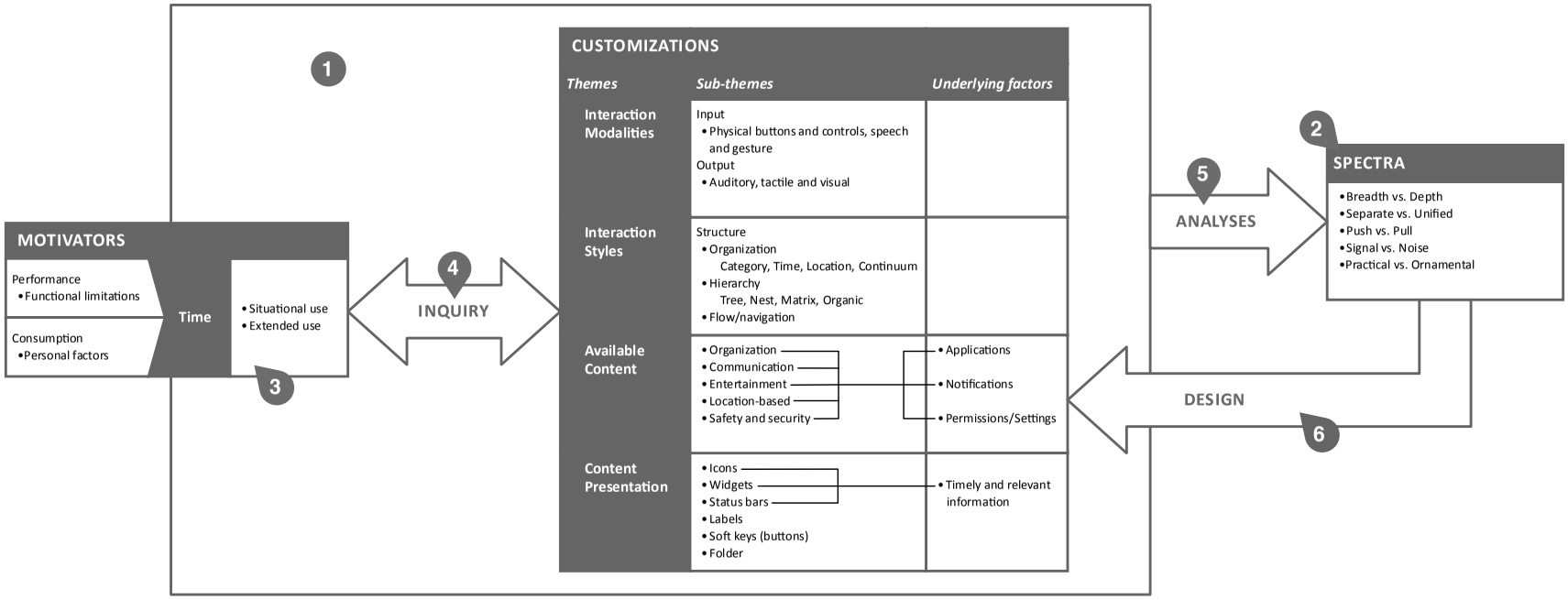


Figure 8.1 - Representation of connection between design research, analyses and design efforts towards addressing diverse user needs and desires.

8.1.2 Appropriate Design Research and Analyses Approaches

I proposed allowing users to establish a "primary" (See Figure 7.6) and multiple "secondary" (See Figure 7.7) device states. With the primary state associated with extended device use, I found individuals' alignment with each spectrum to remain constant. I found situational device use to cause alignment with each spectrum to shift. I found this to involve touchscreen smartphone users in perpetually iterative device modifications as they continually customize their devices. In reviewing this effort's processes and findings to determine applicable research and analyses methods for future direction, I kept both situational- and extended-device use scenarios in mind. I also noted that focus needed to shift from gaining insight into detailed needs and desires associated with the areas of customization (e.g., how users modified their device's wallpaper) towards understanding individuals' relationships to spectra. Without doing so, I feel results would remain focused on short-term solutions.

During this effort, I compared three device states: out-of-the-box, current and desired. I gathered details on participants' needs and desires for touchscreen smartphone home screen customizations. The information addressed participants' specific concerns and revealed short-term solutions. Through seeking patterns in data, I identified spectra as an underlying structure for framing the higher-level problems associated with universal design of mobile phones (See Figure 7.4). I determined that participants' alignment with the spectra could be identified through data I gathered during the participant sessions.

In retrospect, I found that two of the activities provided the greatest insight in doing so: comparing images of participants' out-of-the-box and current device states and reviewing conversations from the contextual inquiry. The generative research activity did not yield satisfactory results. Therefore, prior to future application, I recommend additional research be conducted to evaluate its appropriateness for gaining insight into users' desired smartphone customizations. To help refine the procedure, I suggest focusing on the materials that are provided to individuals to help them in constructing their artifacts; techniques for aiding participants in conveying ideas about dynamic device states; and/or approaches for encouraging participants to think beyond their level of technology awareness.

In the interim, I would counsel others to focus on the comparison between current and out-of-the-box device states. I feel this would be satisfactory as I did discover insight into participants' desired device states through the contextual inquiry portion of the sessions. It stemmed from reviewing conversations about where participants' current devices did and did not meet their needs and desires. Expanding the discussion topic of "thoughts on a new device" may allow increased understanding of desired device states to be gained through contextual inquiry.

In Figure 8.2, I summarize the future direction and application of this effort. I show how the scope of participant sessions focuses on out-of-the-box and current device states [1]. I include desired device states as an extension of the inquiry into current device states based on expanding the topics addressed in the contextual inquiry [2]. I indicate how the relationship between situational- and extended-device use and the areas of customization provide structure for developing

contextual inquiry research protocols [3]. I identify the types off data that lead to the image analyses [4]. I show how the updated analysis template (See Figure 5.7) continues to lend structure to exploring data gathered during participant sessions [5]. I note how the process of conducting the template analyses can inform the image analyses and visa versa [6]. Finally, I show how by reflecting the findings against the five identified spectra, higher-level design problems can be identified and structured towards creating solutions that address diverse user needs and desires [7]. In Figure 8.2, I intentionally removed references to touchscreen smartphones. I believe that this structure can be applied to other technology domains where users currently or could have the ability to modify standard out-of-the-box designs (e.g., computer operating systems and automobile entertainment and navigation systems).

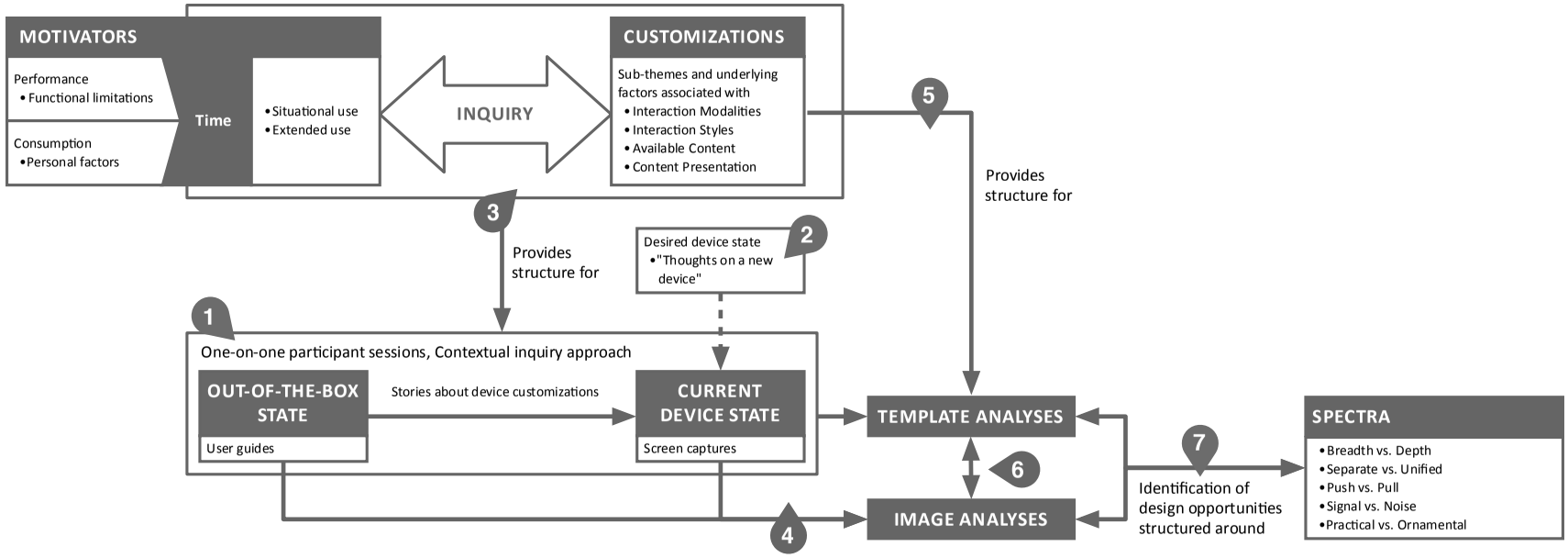


Figure 8.2 - Summary of applying proposed process for arriving at design opportunities.

8.1.3 Application of Spectra in Design

I identified extended application of spectra based on volume of data and change of industry. Increasing the frequency and use of spectra may support quantitative analysis. This could help in:

- Clarifying factors of situational- and extended-device use impacting individuals' alignment along each spectrum;
- Defining the extent of customization capabilities that should be offered; and
- Determining more precise placement of individuals along each spectrum.

With this insight, I envision devices being able to be designed so that they can guide users through the customization process. Design details could help users explore customization options and select appropriately. There is also the potential to apply the spectra visualizations (e.g., Figure 7.6) as an interaction style. Individuals could manipulate indicators within the quadrants or continuums and observe related changes to their devices. This approach could also be used to create scenario-based settings that facilitate device changes related to situational use.

8.2 Contributions

I explored focusing on the possibilities of touchscreen smartphone customization as a way to unite performance- and consumption-based design and development priorities towards universal design. Through this process, I found customization and, therefore, time to be central themes as individuals engaged in ongoing efforts to modify their devices to better meet their needs and desires. I

identified changes that participants made gradually over time through extended device use as well as ones that they made at different points in time based on situational factors. The motivations that drove changes based on situational- and extended-device use go beyond the initial scenarios of use that are stressed by both performance- and consumption-based efforts. I found this to support shifting design research activities towards exploring the theme of "time" and its impact on device use.

Through thematic analysis and analyzing participant session data against a template structure, I identified five spectra indicative of participants' needs and desires related to touchscreen smartphone customization. I found using these as a reference point to organize findings, rather than functional limitations or personal factors, can illuminate higher-level problems. As a result, I outlined a design strategy that applied the spectra to addressing the underlying factors and improving touchscreen smartphone design. In proposing the strategy, I provide insight into its practical application in future design and development efforts.

I found the effectiveness of the analyses methods I used in this effort to be an important contribution to future design research. I believe that template analysis was appropriate for exploring data and could prove effective in future design research efforts. I was able to verify and refine the themes that were part of the preliminary structure. I also added themes that were not identified through literature review or prior research efforts, showing its potential to grow to address new areas. This included revealing spectra that ultimately became a major focus of this work and approach for addressing disconnects and shortcomings of

performance- and consumption-based efforts. I feel the updated analysis template could be effectively applied in future studies exploring touchscreen smartphone design (or design of other technology with customization capabilities) and help streamline the efforts.

The image analyses provided a wealth of insight that I feel exceeded the resources required to complete them. I reflected on the process of the desired device home screen diagram development as an output of the image analyses. I identified that reducing the number of symbols and/or the graphic detail of each symbol could further increase the value of this approach. It would lessen the time required to create each diagram while still resulting in valuable visualizations. In situations where the domain of focus is similar to touchscreen smartphone home screens, the symbols I created could be applied and modified as appropriate. The success of the image analyses suggests the possibility of reviewing device states alone, without participant interviews. While this removes the stories that provide additional context, I feel the image comparisons would still provide insight into the customization themes I identified in this effort. With this approach, I recognize the possibilities of asking individuals to provide multiple screen shots at different points in time (e.g., one day, one week, one month and six months after purchase). This would incorporate factors of time to a greater extent.

8.3 Final Thoughts

My intention was to address two questions through my research, analysis and explorations:

1. Does comparing touchscreen smartphone device states (out-of-the-box, current and desired) identify opportunities for design improvements that address the needs and desires of individuals diverse in age and ability?
2. Does the approach identify design opportunities that would have remained unidentified or unassociated through performance- and/or consumption-based inquiry alone?

I feel I was successful. I went beyond outlining short-term solutions by introducing a complementary approach structured around identifying actionable long-term design opportunities.

My hope is that the explorations I describe in this document are thought provoking. I intend my work to encourage future design research on customization and factors of time, targeting findings towards practical and timely application. I reinforce aligning performance- and customization-based design and development approaches as an alternate and complementary perspective on universal design.

As you may have observed, there are key terms and phrases that I did not discuss in detail within the research portion of this work. This includes: user experience, emotion, meaning, desire, pleasure and framework. I refrained from doing so for multiple reasons. Each of these terms can inspire semantic arguments among experts; some use them as buzzwords while others dispute their meanings. I had no intention of using this dissertation as a forum to join those conversations. By

excluding these concerns, I remained focused on the fundamental issue of addressing the needs and desires of individuals diverse in age and ability.

"The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking." — Albert Einstein

APPENDIX A

PARTICIPANTS' VIGNETTES AND VISUALIZATIONS

I tied the final versions of each participant's vignette with their desired home screen diagrams. I present concrete connections between the two using corresponding alphabetical markers. The final versions for all nine (n=9) vignettes are included in this appendix with the diagrams for each following the text. The overview of all participants is included for reference (Figure A.1) as well as the symbol key (Figure A.2).

NAME	AGE	GENDER	FUNCTIONAL LIMITATIONS	INDUSTRY and POSITION	DEVICE	OS
Brian	27	Male	• None specified or observed	• Transportation, *Program Manager: eCommerce*	Apple iPhone 4	iOS 4.3*
Edward	28	Male	• Seeing, *colorblind* • Hearing, *total loss in one ear* • Broke bones, *collar bone dominant arm*	• Voice Communication, *Software Engineer*	Apple iPhone 3Gs	iOS 4.3*
Charles	37	Male	• Seeing, *corrected low vision*	• Education, *MBA Student*	HTC myTouch 4G	Android 2.2
Rebecca	32	Female	• Thinking, *ADHD*	• Beauty, *Hair Stylist*	Samsung Vibrant Galaxy S T959	Android 2.2
Martha	64	Female	• Seeing, *corrected low vision*	• Health and Insurance, *Geriatric Care Manager*	Apple iPhone 3	iOS 3.1
Karen	55	Female	• Seeing, *corrected low vision*	• Real estate, *Residential Realtor* • Nonprofit Organization, *Founder*	Apple iPhone 3Gs	iOS 4.3*
Sally	54	Female	• Seeing, *magnifying glasses for small print* • Hearing, *hard of hearing* • Thinking, *ADHD*	• Real estate, *Residential Realtor* • Entertainment, *Voice-over and On-camera Talent*	HTC Droid Incredible ADR6300	Android 2.3*
Wendy	34	Female	• None specified or observed	• Banking, *Commercial Loan Auditor*	Motorola Droid, 1st Generation	Android 2.2
Jack	30	Male	• Thinking, *Remembering*	• Computer: Web Services, *Systems Administrator*	Apple iPhone 4	iOS 4.0

*Latest version of operating system at time of participant session

Figure A.1 - Research Participants.

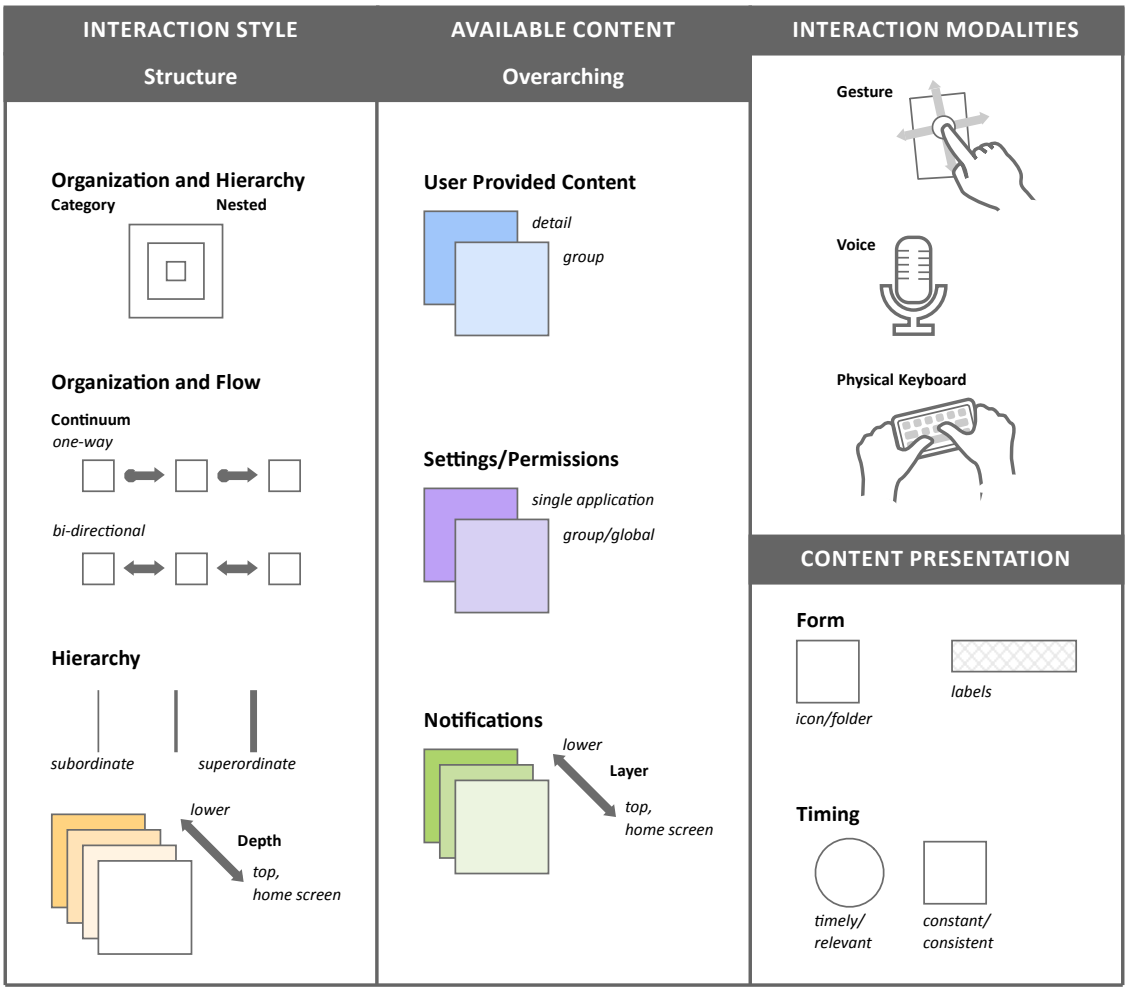


Figure A.2 - Key for participants' desired device home screen diagrams.

A.1 Brian

(Figure A.3)

- Gender and age: Male, 27
- Functional limitations: None specified or observed
- Industry and position: Transportation, Program manager (eCommerce)
- Device and operating system: Apple iPhone 4, iOS 4.3

The iPhone is Brian's constant companion. He has a (RIM) BlackBerry for work, but he usually ends up forwarding the phone calls and email to his iPhone. This is both for the convenience of carrying one device and because he "just likes it (iPhone) more." He does wish the iPhone had a physical keyboard like the BlackBerry. He finds having one makes composing email much easier. As one of the most important things on his smartphone, he would like to access email from the bottom left of the home screen [A], giving him the ability to open it quickly with press of his thumb.

Brian would also like widgets on his home screen, a capability currently unavailable on iPhones. He finds just showing the number of unread messages as an alert to be insufficient as it's difficult to remember from one glance to the next what the number was. He'd like to be able to view information such as the sender and subject for the most recent messages [B]. This would allow him to decide if he actually wants to open the application directly to a message or to view a complete list [A].

In general, he wants multiple ways to access things, including placing shortcuts on the home screen and having access to applications within a folder or

even multiple folders. Brian would like to organize (the interface) around the different ways he uses the applications, flowing from one to the next. As he discussed, the placement of items on his home screen, he voiced frustration about being restricted to a grid that requires him to fill screens with icons and labels from the top left to bottom right. He wants the freedom to place things on the screen and not be restricted to an ordered grid [C]. He also just wants to see icons, no labels [D].

When Brian first got his iPhone, he wasn't sure what to do with the pre-installed applications. He wished he could delete them. Instead, he created a "Random" folder on the primary home screen, placing them inside. He did change the home screen wallpaper to reflect his family's native country, with a sense of pride.

Brian talks with and messages friends and family frequently, also using his device to access Facebook. He organizes a local sports league and engages with the participants through different communication methods. He would like quick access to a to-do list and calendar to also help with this endeavor. He prefers to have these presented as widgets [E]. He noted that they would also facilitate a balance with work related activities. In talking about the widgets, he had knowledge that they are available on devices running Android OS; however he had a negative perception of the hardware on which it runs.

Brian finds it important to keep up with what is going on in the world, having multiple related applications, especially ones reflecting news and sports. He download approximately 1-2 applications per week, trying them out and removing those he does not like. He usually places ones that remain in a folder as they are

usually not accessed frequently, if at all, after initial uses. Brian has never paid for an application before, which is surprising based on his professional roll as a Program Manager for eCommerce. He has always found a free version that he perceives to have the same or similar value as a similar paid application. He has been unable to understand the significant advantages offered by those that cost money. If someone could convey this, he would probably be willing to purchase some.

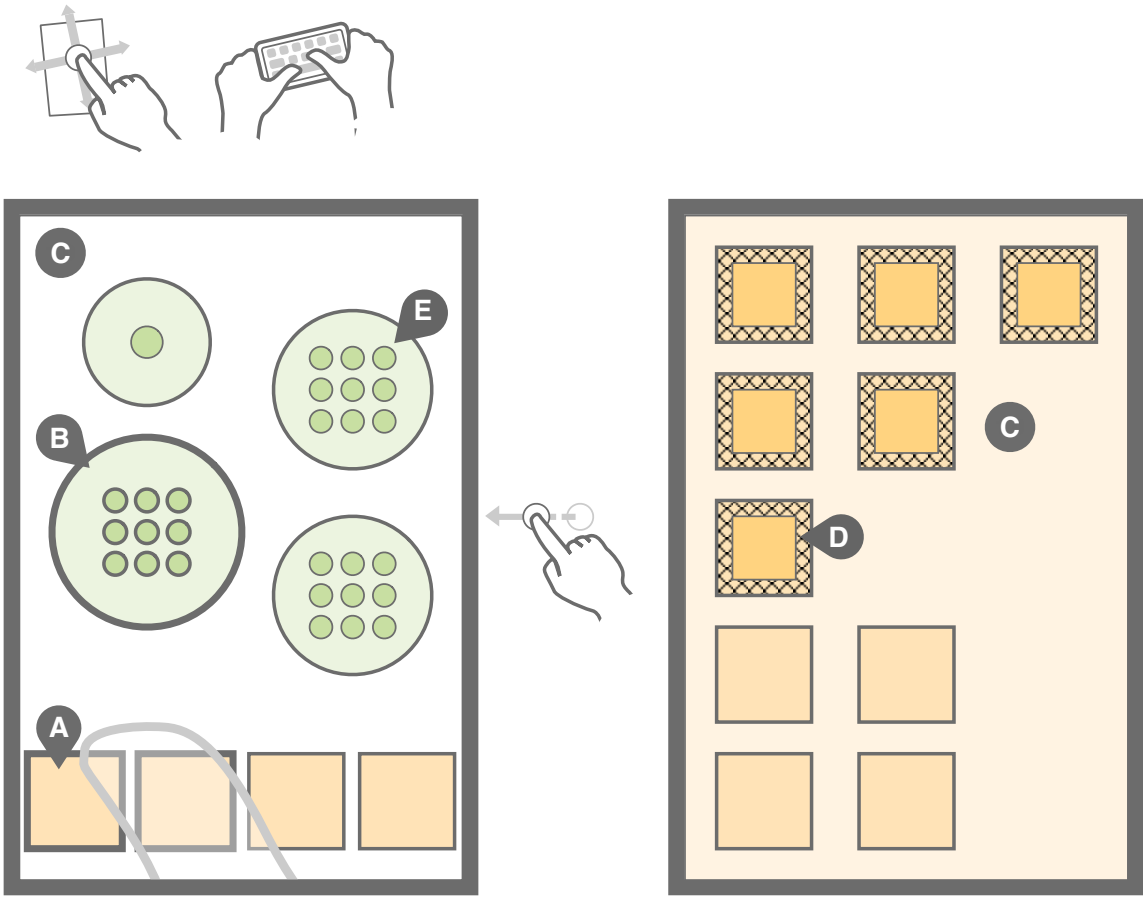


Figure A.3 - Brian's desired home screen diagram.

A.2 Edward

(Figure A.4)

- Gender and age: Male, 28
- Functional limitations: Seeing (colorblind), Hearing (total loss in one ear) and Broken bones (collar bone, dominant arm)
- Industry and position: Voice communication, Software engineer
- Device and operating system: Apple iPhone 3Gs, iOS 4.3

Edward has had an iPhone since they were first introduced in 2007. When he upgrades devices or the OS is updated, he likes that things transfer for him from the old to the new, pretty much staying the same. On the last OS update, the ability to create folders was introduced. He liked that it automatically suggested grouping "Utilities" on the main home screen, giving him an example. He kept this folder, adding one more for "Games." Access to "Settings" has been placed in the Games folder; although, he was not sure why this was done.

One of Edward's priorities for interface changes was associated with Settings, noting that it really needs improvement. He finds it frustrating that they appear to be centralized but are not. Device settings are located through the main point of access; however, the settings for some applications are found in this area and others are in the applications themselves. He doesn't like that he is made to guess, noting that he would like to be able to configure things all in one place [A].

One thing Edward did right out-of-the-box was to change the audio output from stereo to mono to address his hearing limitations. In reviewing with the researcher how he did this, he went to the "Sounds" area of General Settings, but

was confused when it was not there. He found it in the Accessibility section, puzzling to him as he was adjusting something related to auditory output. He felt it should be associated with the other auditory output options rather than a disability-related section.

Edward also stressed the importance of being able to modify the settings associated with notifications. He discussed how many applications want to provide different alerts, but do not give control over what is surfaced and when. He wants high signal, low noise. Half of those that currently appear are not important to him; however, there are several that are. To make it easier to differentiate between these, he would like to have greater control over them and have them located in a centralized area [B].

Edward stated that he doesn't use the media player enough to keep it in the prominent bottom bar, replacing it with a task management application that helps him organize projects and things he needs to do. Using his device to help him keep up with personal and professional things is important and related content should be easy to access with his thumb [C]. He relies on the task management application to give him event-based reminders and notifications but to also tell him about the ongoing events. Edward would like to see this application better integrated with other organization-related applications like calendar and note taking. He would also like it tied to maps, giving the example that if he was driving by a place with a related event, his device should alert him. In general, Edward would like maps to do two things, help him discover and help him navigate. Edward extended his desire to

combine application functions to communication-based ones as well. He would like to have email, SMS and MMS located in one central "Messaging" area.

To Edward, "search" should be front and center [D]. As he starts to type, he would like the device to filter content from the Internet and the device itself, giving him quick access to the knowledge he is seeking. To access an application he would like to start typing its name and select it when it appears in the filtered results list. This would allow him to not have to remember where applications are within the interface, swiping through several home screens to find them. This is what he currently does as three of his five current home screens have minimal organization, filled with applications from top left to bottom right that have little association from an external observer vantage.

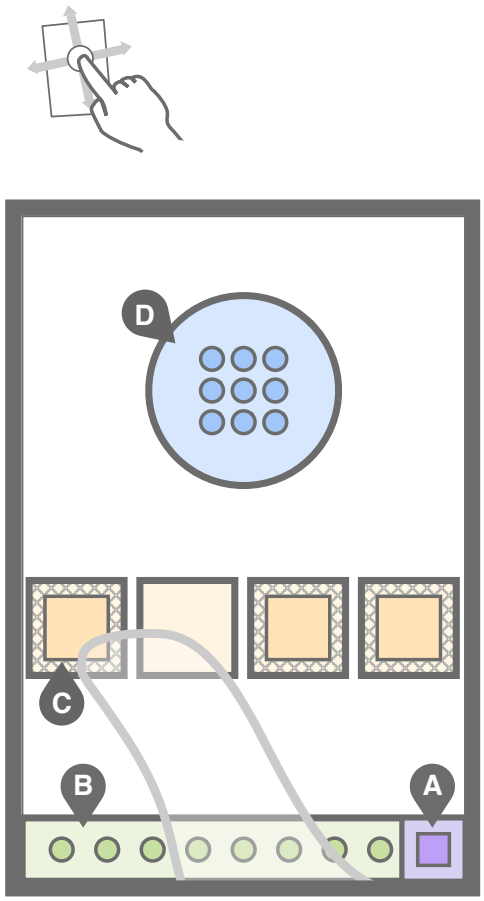


Figure A.4 - Edward's desired home screen diagram.

A.3 Charles

(Figure A.5)

- Gender and age: Male, 37
- Functional limitations: Seeing (corrected low vision)
- Industry and position: Education, MBA student
- Device and operating system: HTC myTouch 4G, Android 2.2

Charles is a self-described multitasker who desires the presentation and structure associated with his device to match the different ways and reasons he interacts with it. He described multiple interaction modalities and centered on a matrix-based organization with a lean top level and heavier bottom level of content access. He desires to use gestures, voice and physical controls to engage with his mobile phone. With his current device, he was annoyed by the fact that there were widgets on some of the home screens that he could not figure out how to remove.

Despite no self-reported or observed physical limitations, he emphasized his desire to use his MP with one hand. More specifically, he would like to be able to use it with just his thumb, accessing frequently used applications through shortcuts placed in a vertical row on the home screen [A]. He would like the row to be placed on the left side of the screen so that it would be comfortable for use with his dominant, right hand. He desired each shortcut to have a visual indicator if content had been updated with new, relevant information [B]. It's important to him that he has to do little to be informed. The most important application, email, would be placed at the top of the list, giving him the ability to use the physical form to help him locate the access point and reduce reliance on his vision [C]. He also desires a

"genius" button that provides one-touch access to using voice commands to make calls, send text messages, search the Internet and more.

Charles indicated the desire for the device to recommend applications that he uses frequently, replacing ones in the left column it noticed he doesn't use as frequently. Although, he did note that he wants this done in a non-obtrusive manner, suggesting that it appear in a centralized notification window that he chooses to access after it indicates that there is a message [D]. One shortcut he noted that he doesn't need on the home screen is text or multi-media messaging. The notification window would provide access to incoming messages that would then allow him to reply directly. In terms of communicating with others, he thinks about the person he wants to communicate with first and then the mode of communication. Therefore, contacts is the important application to have access to from the home screen. He desires only icons to represent points for application access. He doesn't need the redundancy because he was the one that added or moved them and should, therefore, know what they are.

Charles has a personal philosophy to never buy the first iteration of a technology. While he keeps up with the latest and is often intrigued and excited by new devices, he prefers to wait for the kinks to get resolved. His purchasing style is also reflected in his approach to applications. He has never purchased one, as none have demonstrated that level of worth to him.

Charles is concerned about battery life and that it will never be able to keep up with new device capabilities. Therefore, despite the potential for a device to be highly customizable to match his needs and desires, he wants to maintain control,

especially over the frequency of automatic application content updates. Charles noted that he would prefer this to be controlled on an application level [E], where he would access settings by selecting and holding an application's icon within a full application menu [F]. Doing so would activate a menu with an edit option.

Content selection is focused on accessing and receiving timely and relevant knowledge. A weather widget is important [G]. It would provide him with storm warnings so that he would know if one was approaching and be able to quickly dive deeper to determine its severity and when it's supposed to arrive. To him, this is especially relevant when he's riding his motorcycle around town. Charles desires to continue to use the device to research product information on the go, including reading reviews and where else he might be able to purchase an item locally or online to ensure he is getting a good deal.

While Charles is currently an MBA student and not working, he still desires to use his device to schedule meetings with peers and keep track of assignments and to-dos. The latter are placed in lists, an application he uses for more than just to-dos. He also maintains ones for reference including motorcycle parts and frequently made recipes so he knows ingredients to purchase. He'd like to be able to connect a location with appropriate lists. For example, next to a list of items to purchase at the hardware store, he would like the store address and hours of operation.

Charles also enjoys playing a word game with his brother. It's an ongoing social engagement. For this, a centralized notification area is helpful to indicate when it is his turn in the game. Also related to games, he would like an area that he calls "time wasters," giving him something to do when he has downtime [H].

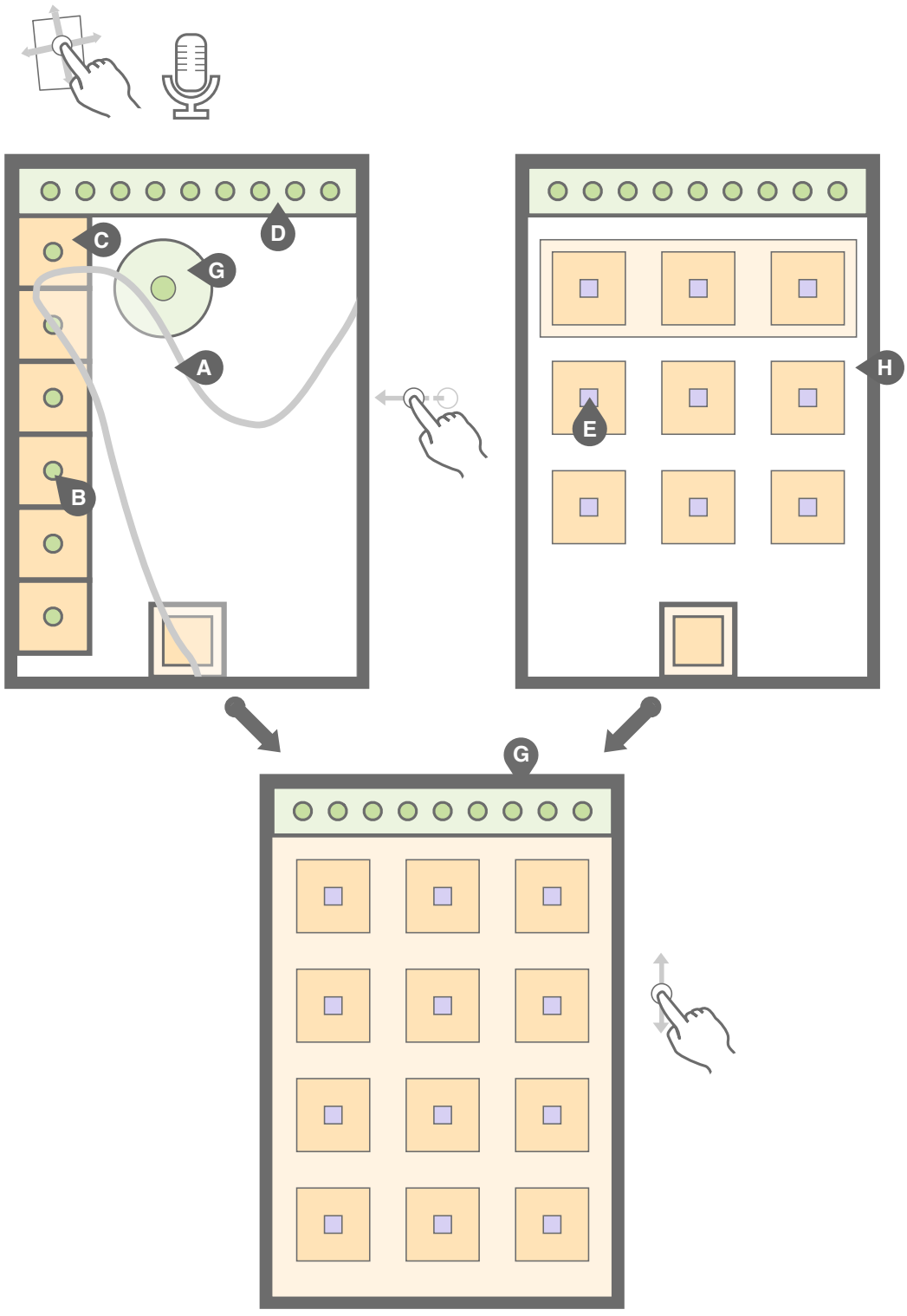


Figure A.5 - Charles' desired home screen diagram.

A.4 Rebecca

(Figure A.6)

- Gender and age: Female, 32
- Functional limitations: Thinking (ADHD)
- Industry and position: Beauty, Hair stylist
- Device and operating system: Samsung Vibrant Galaxy S T959, Android 2.2

Rebecca has pride that she has an Android device versus iOS. She appreciates the open software platform and flexibility it enables. Her current device had fifty pre-installed applications that were locked and could not be removed. She found this "bloatware" extremely annoying, especially the twenty applications that she had no desire to use. This motivated her to research online how to "hack" her device to be able to remove them. She has a sense of pride for having successfully completed this on her own, projecting technical capabilities that might appear greater than initially perceived. Since then, she has added twenty applications that she desired.

Rebecca's response to customizing her device is that she's "customized it so many times," ultimately, desiring a clean, simple interface with no excess. She desires prioritized icons to be placed in a diagonal pattern on the home screen because it looks better to her, clean and simple with no excess. As a calm pattern, she feels it allows her to easily recognize placement, seeing each item independently but still placed in a form of alignment [A]. Rebecca prefers the ability to place the icons where she wants on the screen versus being restricted as she's noted on iOS devices. She wants just icons, unsure as to why one would need both remarking that she should know what each one is having put them on the device [B]. All of the

applications, including those with access on the home screen, should be accessible via a full menu [C]. She doesn't like the idea of using folders to organize. The menu should be alphabetized except ones that she accesses more frequently should be able to be placed at the top [D].

The current capabilities of Rebecca's mobile phone have caused her to hardly use her laptop anymore. She uses her mobile phone to track personal health information, book clients, look at her work appointments, and check weather and directions. She used to use email frequently but finds herself replacing it with messaging through Facebook. Therefore, instead of having an application shortcut on the home screen, she accesses it from notifications that appear in an alert window [E]. Rebecca also wants to be able to have quick access to search the Internet [F].

As far as device settings, Rebecca rarely changes the ringtone. Although, she will change the typeface on occasion, mostly when she is in the mood to try something different. She doesn't like her device's capabilities to adjust brightness, so she has it set so she can manually adjust it.

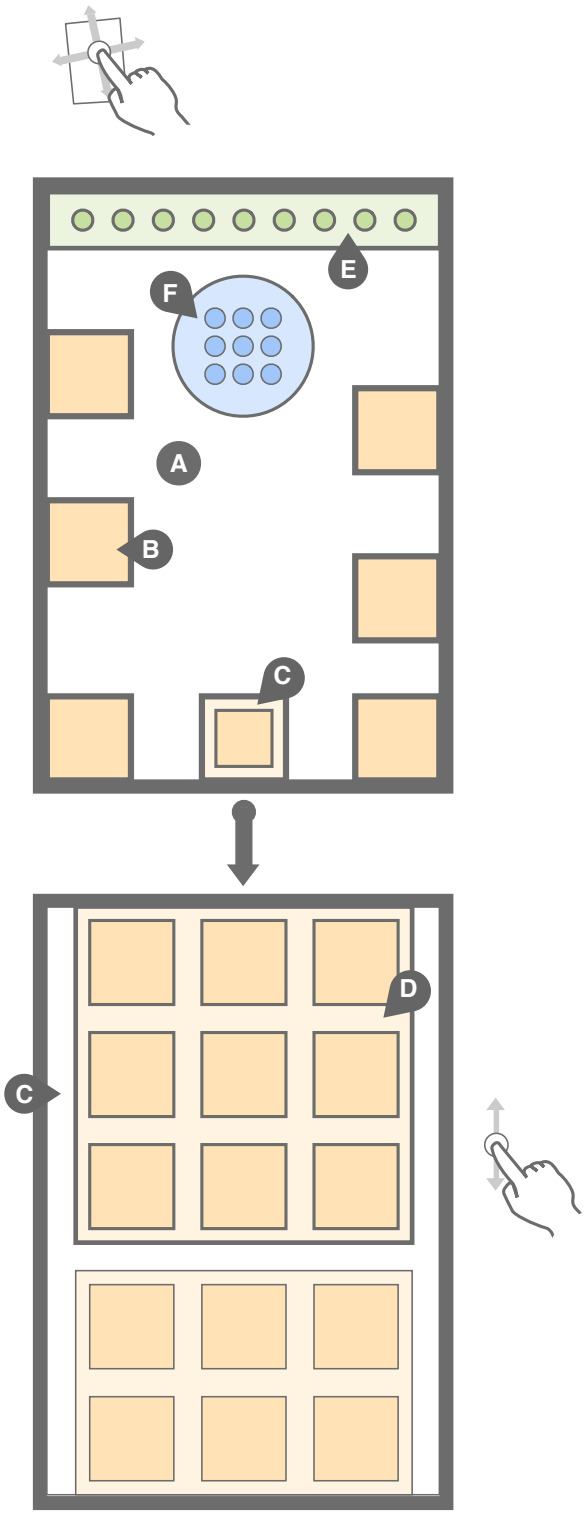


Figure A.6 - Rebecca's desired home screen diagram.

A.5 Martha

(Figure A.7)

- Gender and age: Female, 64
- Functional limitations: Seeing (corrected low vision)
- Industry and position: Health and Insurance, Geriatric care manager
- Device and operating system: Apple iPhone 3Gs, iOS 3.1

Martha got an iPhone at the urging of her son but also likes making sure she is keeping up with technology. It's her first smartphone; although, she's been a mobile phone user for over 20 years, since they were "car phones" and big boxes. She travels quite frequently to see clients and visit the family home in rural Georgia. In both instances, the phone provides invaluable connections. When she's out of town, it's a "lifeline." It allows her to keep up with the news and check email, which is how she receives referrals for potential new clients for her geriatric care management business. As a business owner, this connection is extremely important. Unfortunately, because of the security required to view medical information, her current device doesn't allow her to access the details she needs to complete the new client process. She has to go to the local library to use their computers. She'd really like it if she could complete the process just using her smartphone.

She likes that family can contact her day and night and is extremely excited when her children send MMS with pictures and video of her grandkids. Frequently, the women in her knitting group share pictures of their families with each other using their smartphones. She likes that she's able to do this as well. With no indication of cognitive limitation, she's also come to depend on the device as a tool

for reminders. Despite her minimal technology comfort and experience, she discovered on her own a convenient approach for doing so. She uses the camera to document things she may need (e.g., license plate numbers, paint chip colors, light bulbs she frequently needs to purchase, etc.).

Martha has to make sure her glasses are nearby if she's doing anything that requires reading or typing on her device. She doesn't really use the address book, having memorized most phone numbers or dialing clients and not wanting to keep their numbers.

About thirty years ago, Martha took a speed-reading course. This has given her the ability to quickly understand written text. With this in mind, she would like to minimize clutter and make labels much more prominent [A]. In regards to the arrangement of applications on her current device, she has made minimal changes. They are mostly, despite a few accidental changes, in the order in which they were added. She doesn't have a problem navigating as she's memorized where the primary apps are located. Therefore, her content organization is relatively flat. The ability to scroll through the ones she has with the ones used most frequently at the top would be ideal [B]. This works for her based on the fact that she desires few applications and doesn't need to push the limits of technology. The current one does so much more than she ever imagined that she finds it difficult to think about how else a smart phone could facilitate connections.

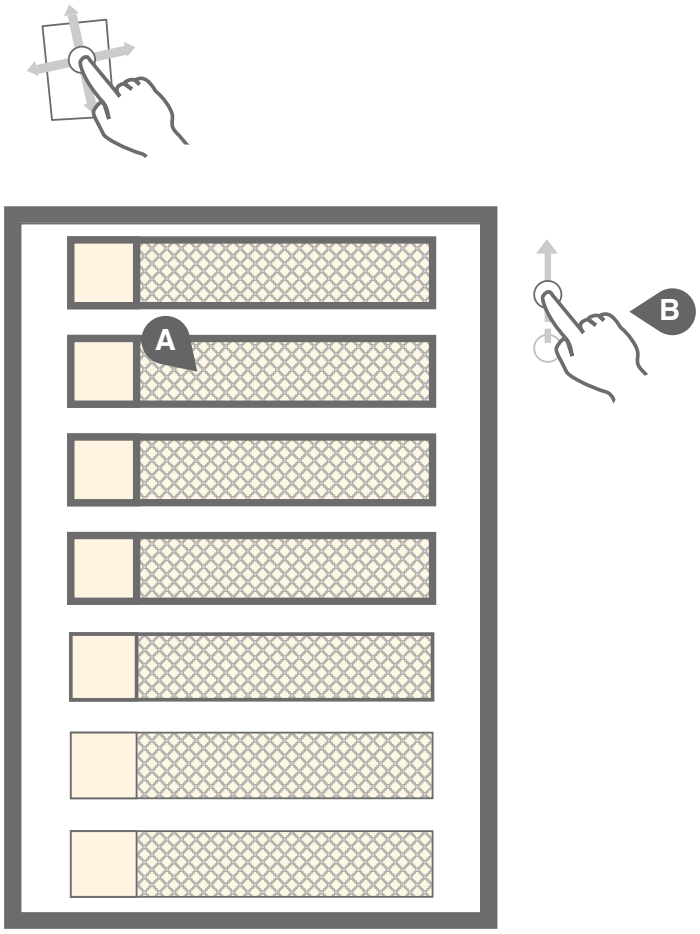


Figure A.7 - Martha's desired home screen diagram.

A.6 Karen

(Figure A.8)

- Gender and age: Female, 55
- Functional limitations: Seeing (corrected low vision)
- Industry and position: Real estate, Residential Realtor and Nonprofit Organization, Founder
- Device and operating system: Apple iPhone 3Gs, iOS 4.3

Karen stated, "the world changed, so I had to change with it." It was initially motivated by things she had to do for work as a real estate agent and was further prompted by the desire to keep up with the technology her children were using. High-school and college students, her kids do not have iPhones but like to grab hers and use it on occasion. They're actually the reason why several applications have been added to the device. She tries to make sure those are free or inexpensive. Karen will also add applications herself, mostly ones friends have recommended. She finds that she purchases and/or downloads them, tries them out and then rarely uses them again.

There is minimal structure related to the organization of the applications on her device. She finds it burdensome to arrange the icons on the device and has not bothered to use the computer interface to help. The primary home screen has minimal changes from the out-of-the-box state. All of the applications located on it were pre-installed.

She has tried to shift things she does on "paper" to the device. However, there are several areas where it does not suit her needs. One of these is the calendar

functionality. Karen still carries around a paper version, accessing the iPhone calendar only as a point of reference. One thing she has done is use the camera to take images and then upload them to a printing service and receive physical copies in the mail a few days later. She really likes that she gets to keep personal memories on the device and show them to other in frames and albums.

She'd like the device to help her more with her work needs. While the iPhone can act as a lockbox key to let her show homes to clients, the interface isn't as good as the "real thing." So she still carries around both. She is able to read through some of the contracts, but it isn't ideal. She also runs a charity/volunteer organization and would love to be able to figure out how the device could help facilitate things she has to do. At the same time, she'd like to be able to use it for fun as well, for example, when she's waiting for her kids.

Karen sometimes uses the notes application to help her remember things. She's made lists with things she purchases consistently but not frequently. An example she gave is light bulbs, much like Martha who takes photos of items like this to help her remember what to purchase. She also has a few applications that she uses to find restaurants, especially since she has special dietary restrictions. Karen changed the ringtones assigned to her "favorites" if she could think of a song or tune that reminded her of them.

Karen desires and interface based on accordions where there are labels [A] that when selected open to reveal related applications [B]. She described it as a theme based organization scheme. The most frequently used themes would be located at the top of the list [C]. She identified travel, games, work, home and

lifestyle as potential themes. She would like the themes to be system recommended and if you liked them, the system would suggest additional examples of applications related to that theme.

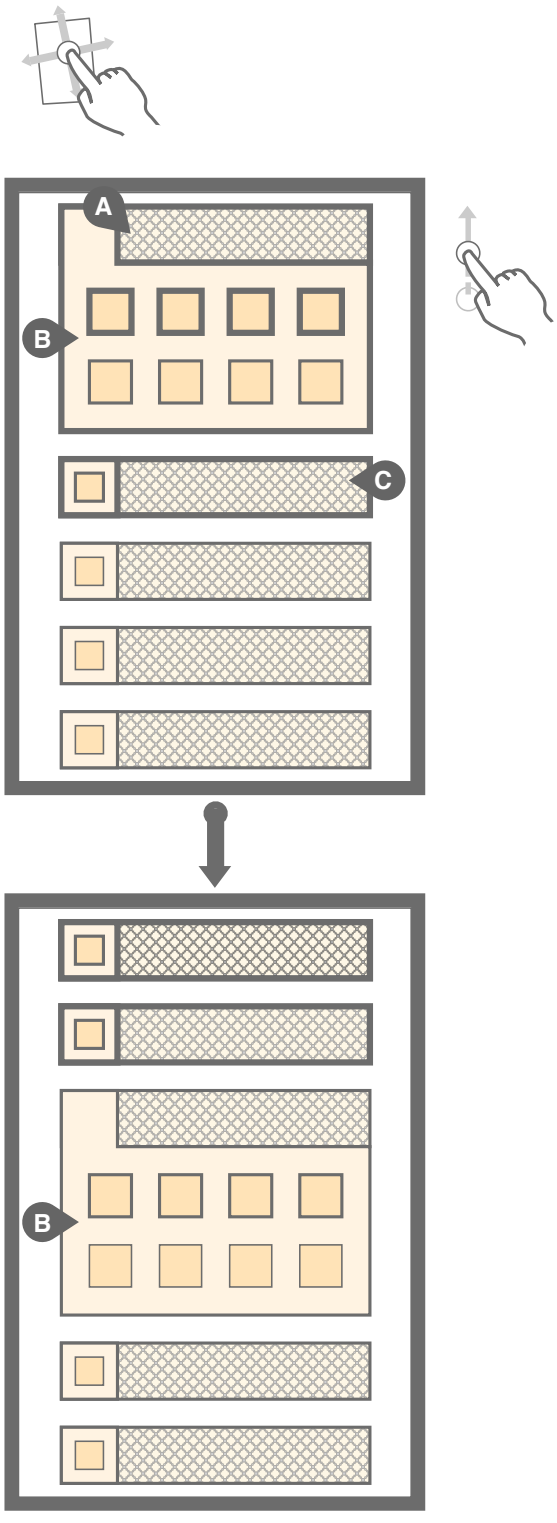


Figure A.8 - Karen's desired home screen diagram.

A.7 Sally

(Figure A.9)

- Gender and age: Female, 54
- Functional limitations: Seeing (magnifying glasses for small print), Hearing (hard of hearing) and Thinking (ADHD)
- Industry and position: Real estate, Residential Realtor and Entertainment, Voice-over and on-camera talent
- Device and operating system: HTC Droid Incredible ADR6300, Android 2.3

It's really important to Sally that it appear that she is up to date on the latest technology. She really wanted an iPhone; however, the carrier she was on and wanted to stay with didn't have it as an option when her last device, a BlackBerry, broke. She went to the store and selected the device they had available that most resembled the iPhone, a touchscreen smartphone running Android OS. She wasn't sure that'd she'd be satisfied with it, but she has been. She's impressed with all it can do and feels like she's fully capable of using it. However, after observing her during the contextual inquiry activity, she was not sure what many of the applications on her home screen were or how they got there. She also was not sure, when prompted by the researcher to talk through the applications she has on her device and the meaning they have for her, how to navigate to the full menu list. For future devices, she'd like everything she has to be available through the home screens [A] using both icons and labels [B].

In terms of figuring out how to use her device, she mostly focused on what she used to do on her BlackBerry and then discovered how to do those activities on

the Android. One thing she misses from the BlackBerry is the full keyboard. She doesn't like the virtual keyboard and finds that she mostly uses the device to consume content and not create or compose.

She uses the calendar frequently on her device, which can help with managing ADHD; although, she did not indicate this as a reason for using it. It helps her with her hectic schedule managing her two jobs as voice-over talent and real estate agent. She had not explored the potential of the device to help with her ADHD in other ways (e.g., notes, to-dos, reminder applications). While physical limitations were not self-identified or observed, she prioritized application access on the primary home screen so that she could reach those most frequently used with her thumb [C]. She uses an external magnifying glass sometimes to help her with reading small text. She desires to interact with the device while driving in a manner that is safe.

On her current device, Sally added a widget to one of the home screens that displays travel pictures. While these are stock images, she really likes that the device reflects her passion for travel and would like any future device to do the same. Although, she would like it if it showcased some of her own photos instead [D]. She would also like quick access to read travel-based reviews and add some of her own. She's currently a frequent contributor to a website centered on this.

She'd also like the device to reflect that she's a "word person." She has a dictionary application that she uses frequently. Her children recently introduced her to playing a social word game. Sally likes that it's an additional way she can connect

with them while they are away at college. She also uses video chat to stay in touch, including with her husband who frequently travels internationally for work.

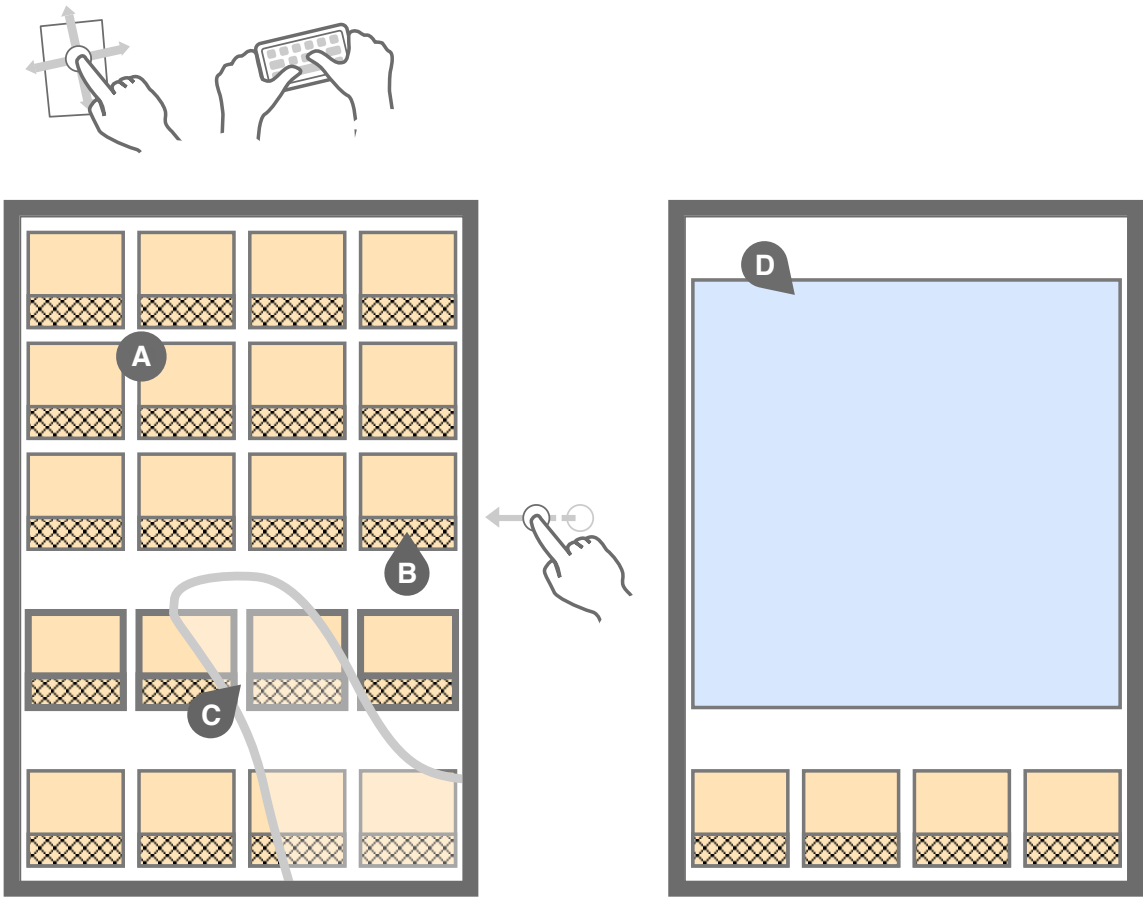


Figure A.9 - Sally's desired home screen diagram.

A.8 Wendy

(Figure A.10)

- Gender and age: Female, 34
- Functional limitations: None specified or observed
- Industry and position: Banking, Commercial loan auditor
- Device and operating system: 1st Generation Motorola Droid, Android 2.2

Wendy was an early adopter of the Android platform, having had her device for two years; although, she's not concerned about having the latest technology. She got her current device because her previous smartphone broke. Her dependence on the device has grown as the number of applications available has increased. Many of the applications she has added are entertainment based, with several of those also geared towards learning, including instructional videos and podcasts. She frequently uses the camera and wishes her device had a physical button that would allow her to quickly snap a shot.

She didn't like the way the interface looked and organized information from its out-of-the-box state. It took about a year of having the device, to be motivated enough to do something about it. She downloaded a new "launcher," or skin for the interface. Wendy found it was a way to change the interface without going to the extent of hacking. She also downloaded an application that helped her organize applications into nested folders where the top level is accessible from the main home screen [A]. She can then drill down to the other two levels [B]. While it took her quite a bit of time to customize her interface in this way, she's really happy with it. A central reason for why she organized things as she did was based on whether or

not she was okay if it took her a moment longer to open one application over another.

Applications she uses frequently also have shortcuts that are located on two primary home screens. The shortcuts she uses most frequently are placed in a location she can easily access with her thumb [C]. She likes visual balance in the presentation of the shortcuts, so on the second home screen she's added a few applications that are there only because she wanted the balance versus frequency of access.

She's added multiple communication-based applications to her device. This includes two email applications as she has two different accounts and didn't want to access them from the same shortcut. She also has added chat and social media applications. She has also made changes that are driven by concerns on battery life (e.g., eliminated live wallpaper).

Wendy's previous smartphone had a physical keyboard so when she selected the device she has now, that was something she wanted. Her device has a slide-out one. Over time she's been surprised about how little she uses it and has gotten used to the virtual one. However, she misses it being omnipresent and in a future device, she would like a physical piece to split the screen so that the bottom area shows a virtual keyboard by default [D]. She also wanted to locate notifications on the bottom screen [E].

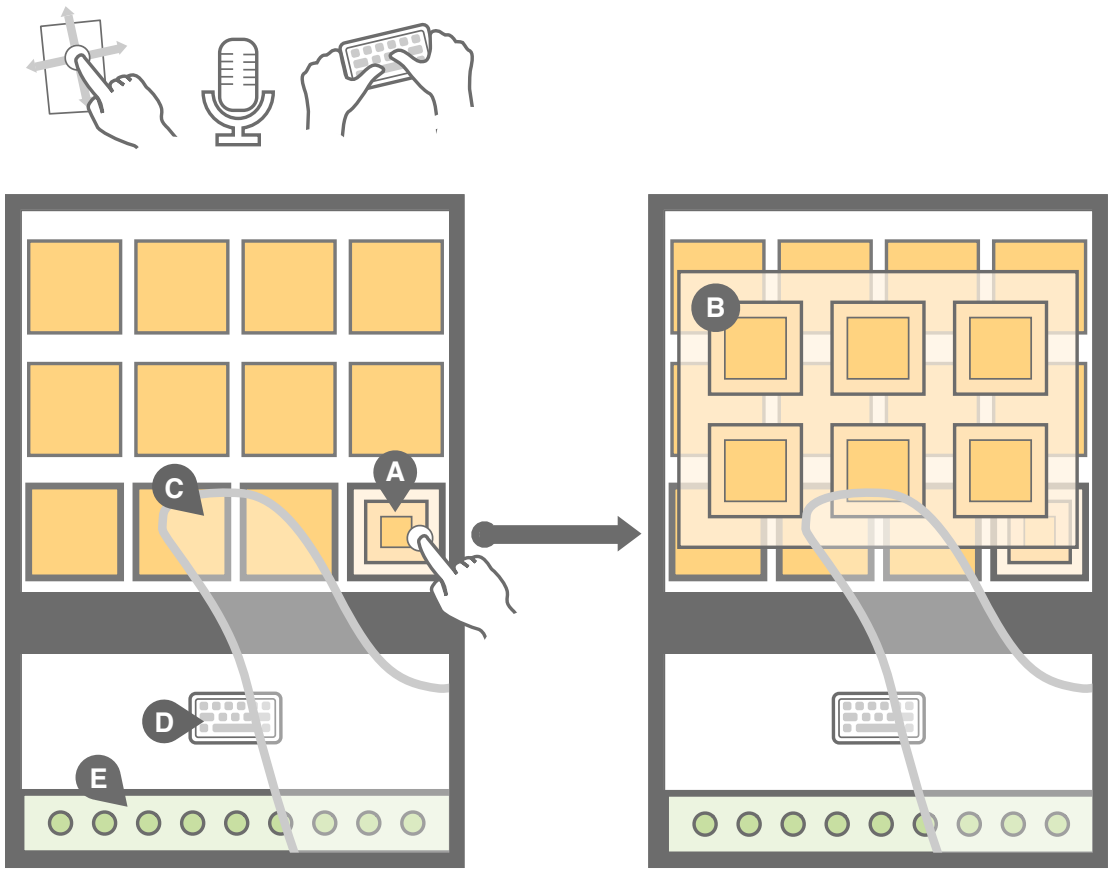


Figure A.10 - Wendy's desired home screen diagram.

A.9 Jack

(Figure A.11)

- Gender and age: Male, 30
- Functional limitations: Thinking (remembering)
- Industry and position: Computer (web services), Systems administrator
- Device and operating system: Apple iPhone 4, iOS 4.0

Jack lives in the world of technology as a systems administrator in the telecommunications industry. While he likes having the latest and greatest, he often finds himself overwhelmed by all of the gadgets and desires to simplify. He rooted his device in order to gain access to features yet to be implemented or currently prohibited in iOS. He also mentioned that after spending the amount of time and energy it took to customize in this manner, he likely doesn't use the device to the fullest extent. Another reason he hacked it was to help mange work and play. He currently has a BlackBerry for work and usually forwards it to his iPhone. One thing he needed to be able to do was gain access to his work servers. Initially, he could only do this on his BlackBerry. By hacking the iPhone, he was able to download an application that allowed him do this and shift into using one mobile phone versus two.

On his current device, he removed all of the applications on the main home screen except for the four omnipresent ones located at the bottom. This gave Jack a clean interface that he did not find overwhelming while still giving him quick access to the applications he uses most frequently. This can be viewed as aligning with his noted thinking limitation and tendency to feel inundated with irrelevant or

unimportant information. He added several applications to the other home screens on his device and has organized most of them into folders [A].

Jack desires a "Frankenstein" of mobile phone interfaces that he's encountered in the past, whether through actual use, playing with friends' devices or just reading up on the latest technology. Jack described it as a device that would be the best of the worlds he's experienced, yet still clean and elegant. One key thing for him is increased use of gestures to open different overlays on the main home screen [B]. He also desires to use gestures to scroll through prioritized application shortcuts located at the bottom of the screen [C]. The additional use of gestures would allow him to shift from his current reliance on vision as he flows through the interface.

It's important to him to have some insight into applications before he opens them, including widgets on the main home screen [D]. This is also important with applications with which he was previously engaged. He'd like to be able to swipe two fingers up from the bottom of the screen and have scaled down versions of those applications displayed, giving a visual capture of their actual state [E]. He could then swipe from left to right to view all of the different ones. This idea stemmed from the Palm Web OS. He also desires the ability to make quick changes to settings with the quick slide of a finger in the middle of whatever screen he's viewing [F].

Jack no longer addresses the "badges" that display on his device to indicate the number of new activities that have taken place within an application. This is based on the fact that he doesn't remember what the number was from one glance

at his device to the next so they become ineffective. Instead he desires contextually relevant information. Notifications should be primarily based on things he sets (e.g., multiple alarms to make sure he's on schedule getting ready in the morning). Alerts should be based on concrete, envisioned events. Jack also desires the ability to gather timely and relevant location-based information to help determine things he would like to do and/or gain knowledge about the area, environment and/or situation. He likes the idea of using virtual reality applications to do this, where he can move his device around and view information on the screen about what he is facing in real space.

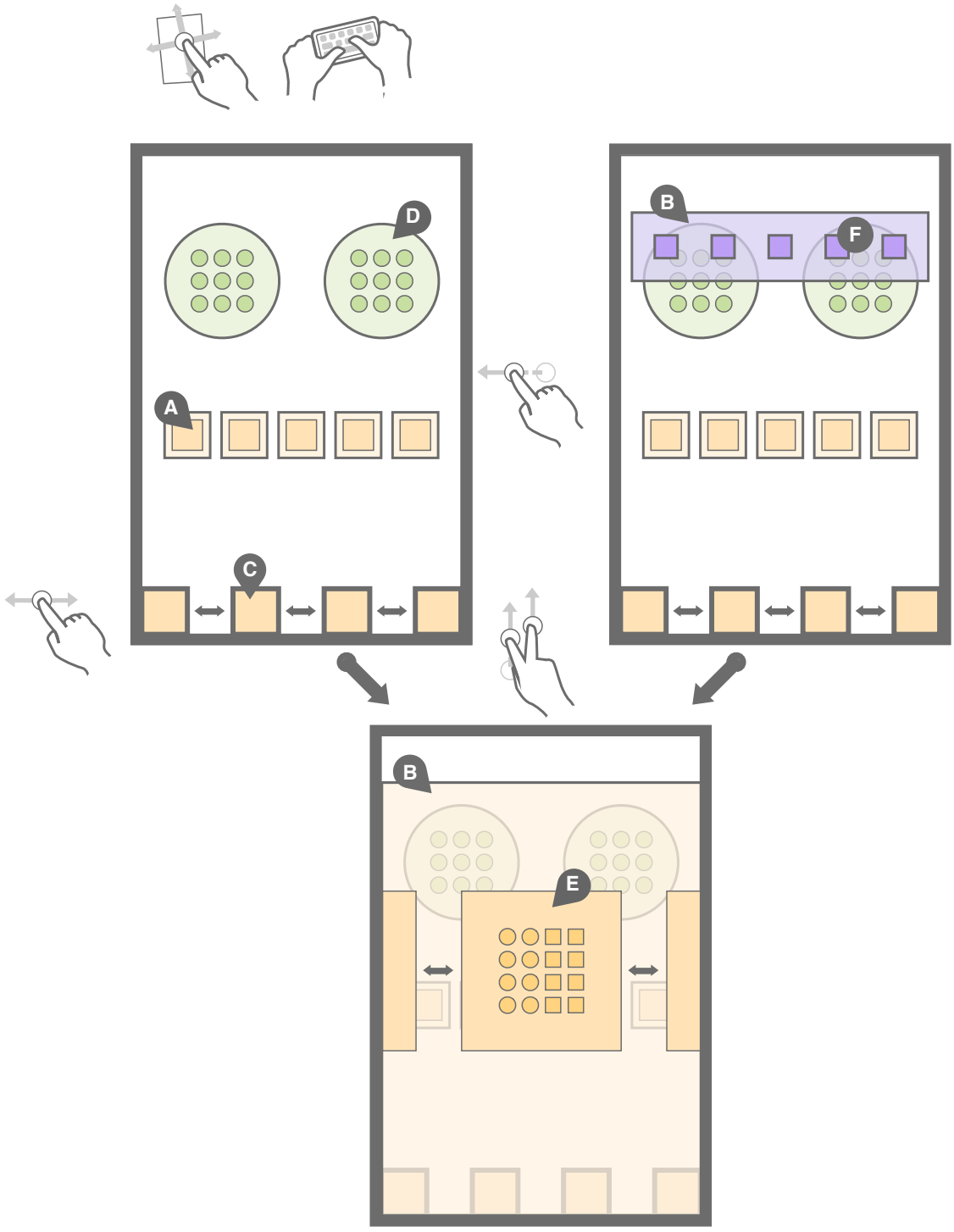


Figure A.11 - Jack's desired home screen diagram.

APPENDIX B

PARTICIPANT SESSION DISCUSSION GUIDES

Appendix B includes the discussion guides I used to conduct the participant sessions. I present the guide for the first five participant sessions. I follow this with the guide used in the remaining four sessions. I highlight the primary areas where changes were made based on findings from the first five participant sessions.

B.1 Discussion Guide for Participants 1-5

B.1.1 Introduction

1. Participant session overview
    a. Purpose of study
    b. Four sections of study
        i. Introduction and general participant information
        ii. Desired smartphone state (generative research activity)
        iii. Current smartphone state (contextual inquiry)
        iv. Conclusion/final thoughts and comments
2. Demographic questions
    a. Gender
    b. Age
    c. Job title and description

3. Abilities
    a. Difficulty with activities
        i. Seeing (blind, low vision or colorblind)
        ii. Hearing (deaf or hard of hearing)
        iii. Thinking (learning, remembering or concentrating)
        iv. Speaking
        v. Using your hands
        vi. Walking, standing or climbing stairs
    b. Conditions that cause difficulties (e.g., arthritis, broken bones, mental or emotional problems, learning disability, speech disorder, etc.)
    c. Use of assistive technology (e.g., screen reader, alternate input, hearing aid, etc.)
4. Current mobile device
    a. Mobile network operator/service provider
    b. Manufacturer
    c. Operating system

B.1.2 Generative Research Activity

1. Instructions
    a. Use of materials to help convey ideas about desired device, including wooden platform
    b. No right or wrong way to use the materials
    c. Ask participant to “think aloud”

2. Documentation
    a. Video recording
    b. Photographs of constructed artifacts

B.1.3 Contextual Inquiry

1. Description of section focus on current device state
2. Prompts
    a. Reason for initial purchase of devices
    b. Assistance obtained in purchasing, learning and/or modifying device
    c. Transition from prior device to current device, lending insight into whether customization behaviors are related to prior mobile phone use
    d. Motivations for including or not including different types of content
    e. Unmet needs and desires related to home screen customizations
    f. Customizations performed related to earlier modifications they made, including instances where after making a change they later returned the device to its initial state
    g. Thoughts on obtaining a new device
3. Documentation
    a. Video recording
    b. Photographs (screen captures) of current device home screen(s)

B.2 Discussion Guide for Participants 6-9

B.2.1 Introduction

1. Participant session overview
    a. Purpose of study
    b. Four sections of study
        i. Introduction and general participant information
        ii. Current smartphone state (contextual inquiry) [order changed]
        iii. Desired smartphone state (generative research activity) [order changed]
        iv. Conclusion/final thoughts and comments
2. Demographic questions
    a. Gender
    b. Age
    c. Job title and description
3. Abilities
    a. Difficulty with activities
        i. Seeing (blind, low vision or colorblind)
        ii. Hearing (deaf or hard of hearing)
        iii. Thinking (learning, remembering or concentrating)
        iv. Speaking
        v. Using your hands (grasping, rotating, pressing/pushing, two-handed actions/coordination or numbness) [additional prompts]
        vi. Walking, standing or climbing stairs

b. Conditions that cause difficulties (e.g., arthritis, broken bones, mental or emotional problems, learning disability, speech disorder, etc.)
c. Use of assistive technology (e.g., voice input, screen reader, alternate input, hearing aid, eyeglasses/contacts, gloves, etc.) [additional prompts]

4. Current mobile device
    a. Mobile network operator/service provider
    b. Manufacturer
    c. Operating system

B.2.2 Contextual Inquiry

[order changed]

1. Description of section focus on current device state
2. Prompts
    a. Reason for initial purchase of devices
    b. Assistance obtained in purchasing, learning and/or modifying device
    c. Transition from prior device to current device, lending insight into whether customization behaviors are related to prior mobile phone use
    d. Motivations for including or not including different types of content
    e. Unmet needs and desires related to home screen customizations

f. Customizations performed related to earlier modifications they made, including instances where after making a change they later returned the device to its initial state

g. Thoughts on obtaining a new device

3. Documentation

a. Video recording

b. Photographs (screen captures) of current device home screen(s)

B.2.3 Generative Research Activity

[order changed]

1. Instructions

c. Use of materials to help convey ideas about desired device, including wooden platform

d. No right or wrong answer or way to use the materials

e. Ask participant to "think aloud"

2. Prompts [additional content]

a. Reflect back on discussion of current device and things like/don't like

3. Documentation

a. Video recording

b. Photographs to constructed artifacts

APPENDIX C

GENERATIVE RESEARCH ACTIVITY TOOLKIT

The generative research activity toolkit used for all participant sessions included the following items:

1. Materials to aid with construction
    a. Scissors
    b. Single-sided tape
    c. Double-sided tape, pre-cut into squares
2. Colored markers in two line weights: broad line, fine line
3. Wooden platform approximately the size of a touchscreen smartphone, 2.625” x 5.375” (Figure C.1)

Figure C.1 - Wooden platform.

4. Foam shapes with adhesive backing

    a. Bright colors (Figure C.2)

        i. Shapes including: triangles, ovals, squares, rectangles, hearts and circles

        ii. Sizes ranging from .25” x .25” to 1.5” x 1.5”

Figure C.2 - Bright color foam shapes.

    b. White

        i. Circles, .25” diameter

        ii. Smaller squares, .25” x .25” and larger squares, .5” x .5” (Figure C.3)

Figure C.3 - White square foam shapes.

5. Small alphabet stickers (Figure C.4)

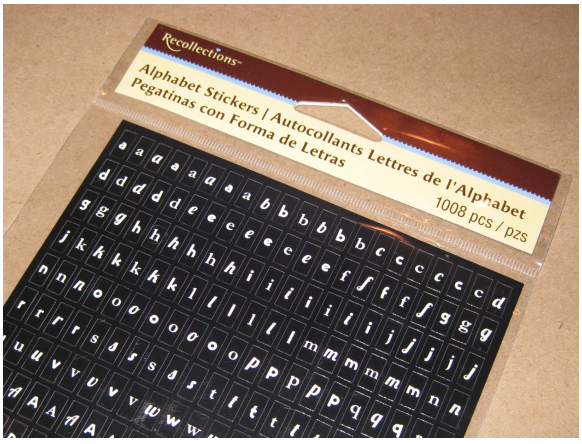


Figure C.4 - Alphabet stickers.

6. Small dimensional objects

    a. Wooden button, .25” (Figure C.5)

Figure C.5 - Wooden button.

    b. Colored rhinestones (Figure C.6)

        i. Shapes including: triangles, ovals, squares, diamonds and circles

        ii. Sizes ranging from .125” x .125” to 1” x 1”

Figure C.6 - Colored rhinestones.

c. Colored jingle bells, approximately .4” diameter (Figure C.7)

Figure C.7 - Colored jingle bells.

d. Googlie eyes, approximately .75” diameter (Figure C.8)

Figure C.8 - Googlie eyes.

e. Adhesive domes, silver and multi-colored, .125” diameter (Figure C.9)

Figure C.9 - Adhesive domes, silver and multi-colored.

7. Office paper

a. Plain white, 8.5” x 11”

b. Printed with touchscreen smartphone related symbols (Figure C.10)

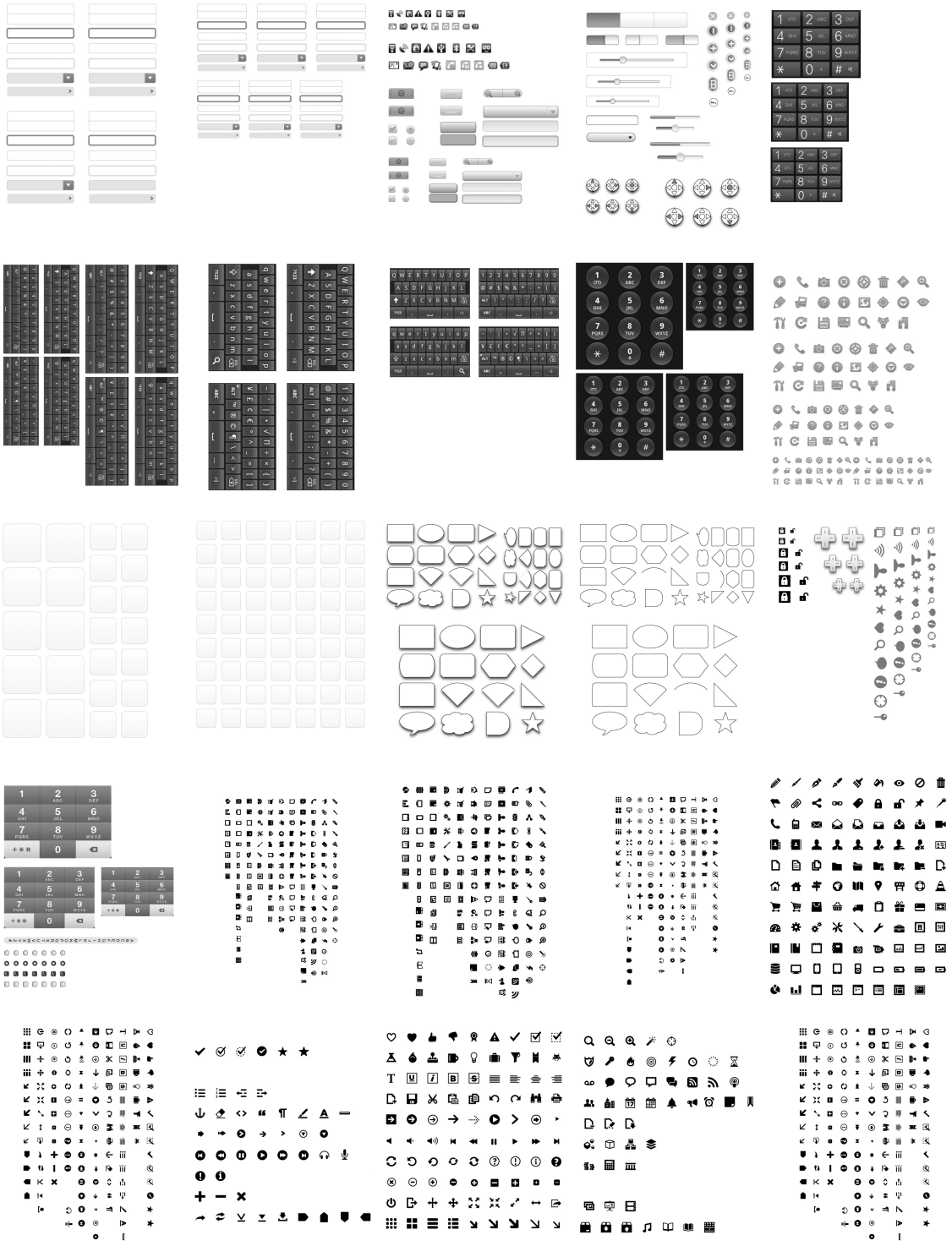


Figure C.10 - Paper with symbols associated with touchscreen smartphones.

APPENDIX D

INTER-PARTICIPANT IMAGE ANALYSES

Appendix D includes the sets of desired device home screen diagrams I used to explore common drivers for customizations as described in 6.2.2.3 Emerging Impact of Situational- and Extended-Device Use. The symbol key is included for reference (Figure D.1).

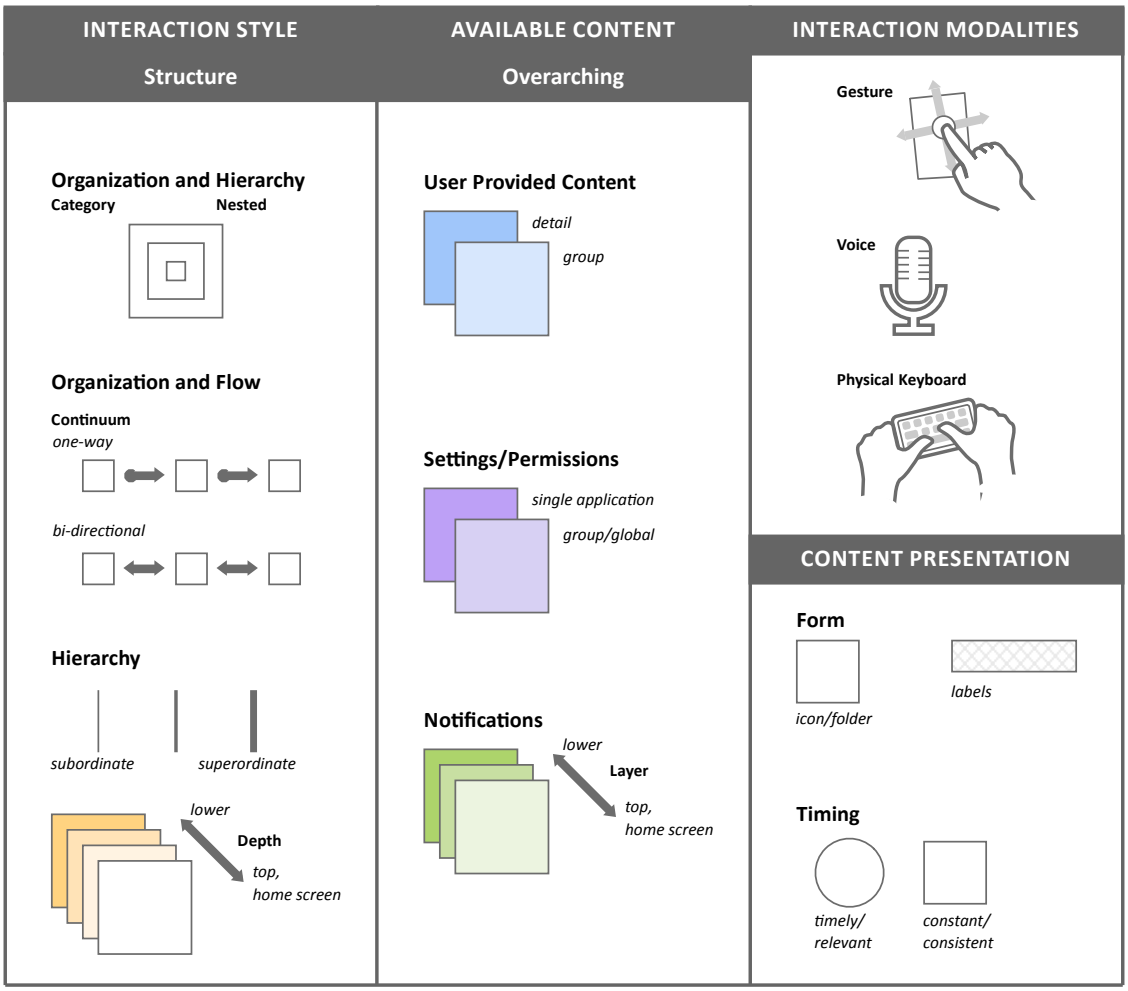


Figure D.1 - Key for comparison and translation of participants' desired device home screen diagrams.

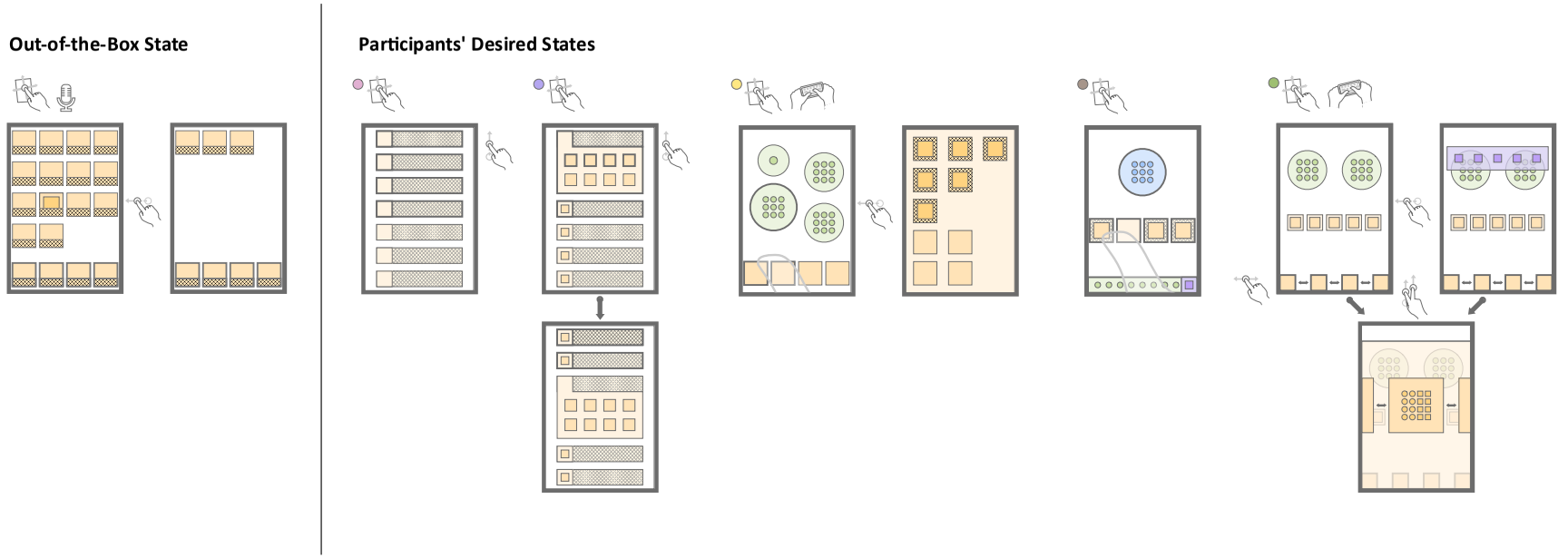


Figure D.2 - Comparison of desired device home screen diagrams, current iOS users.

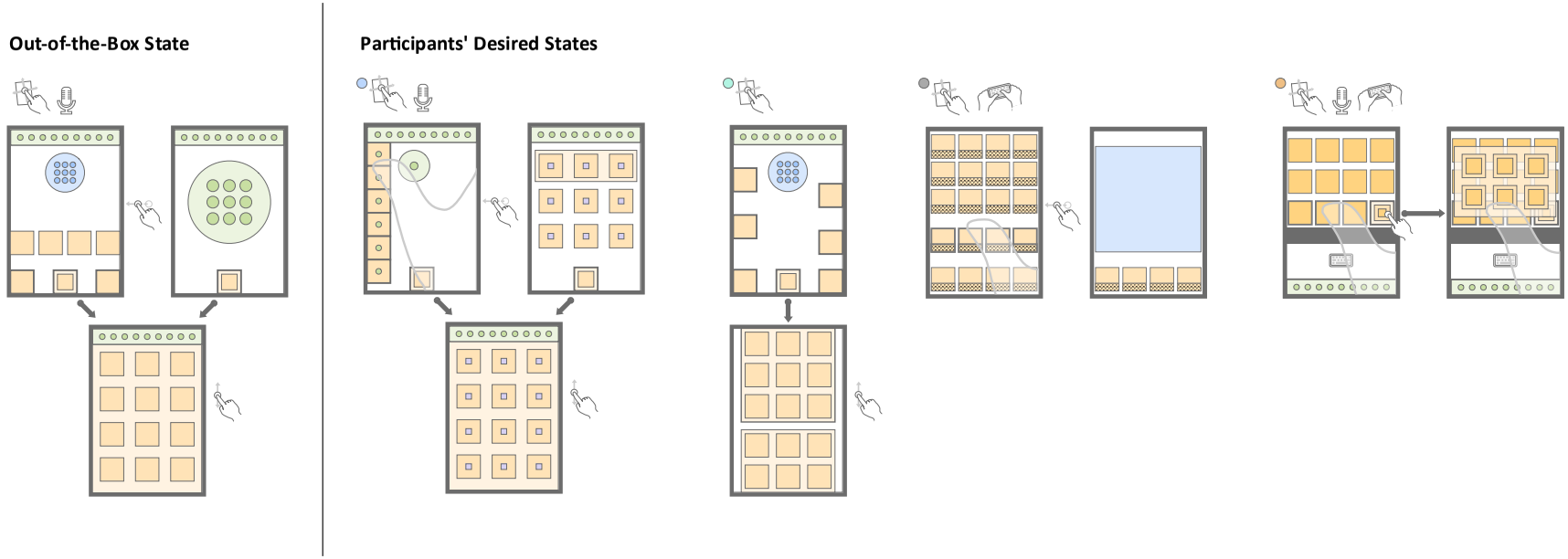


Figure D.3 - Comparison of desired device home screen diagrams, current Android OS users.

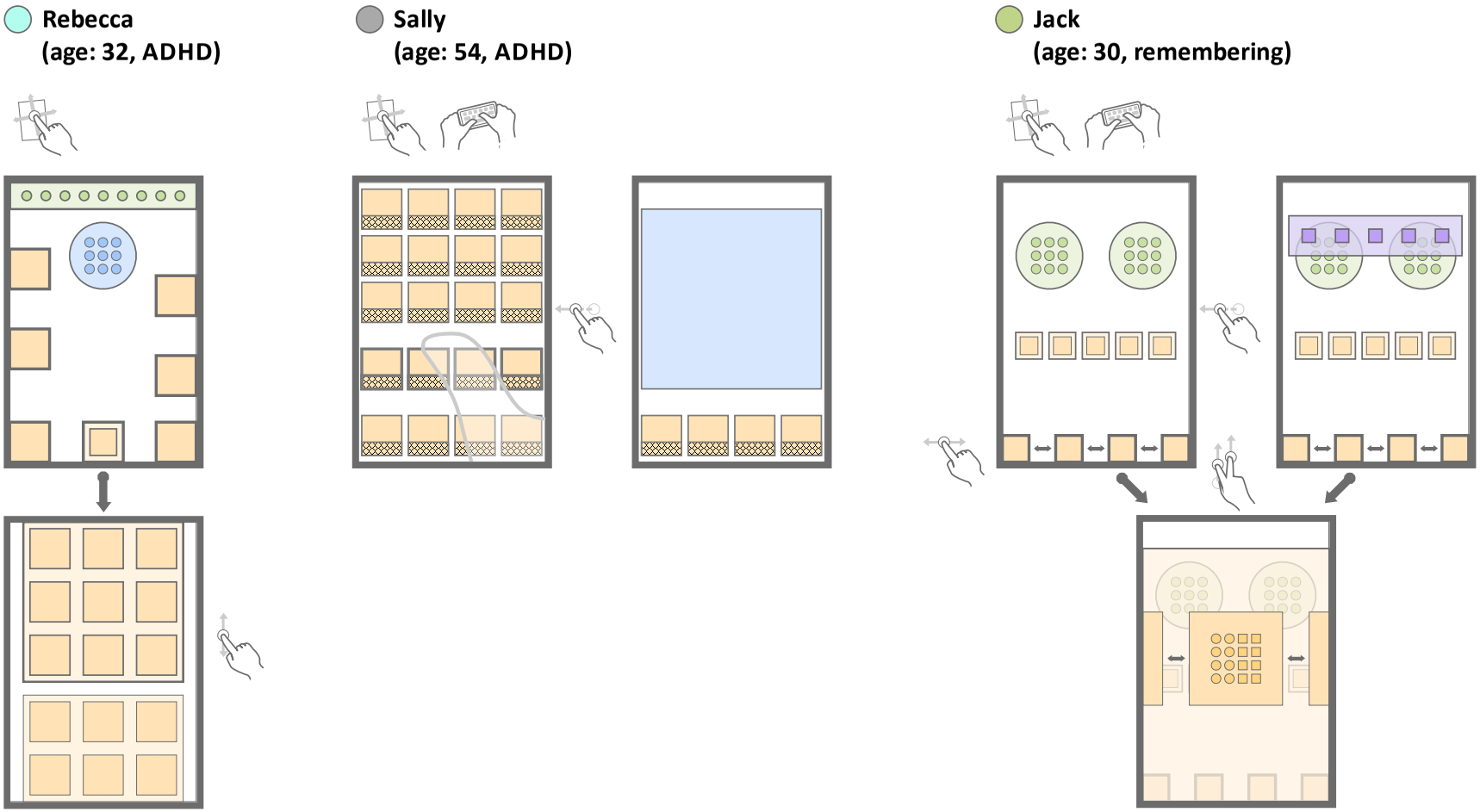


Figure D.4 - Comparison of desired device home screen diagrams, participants with thinking limitations.

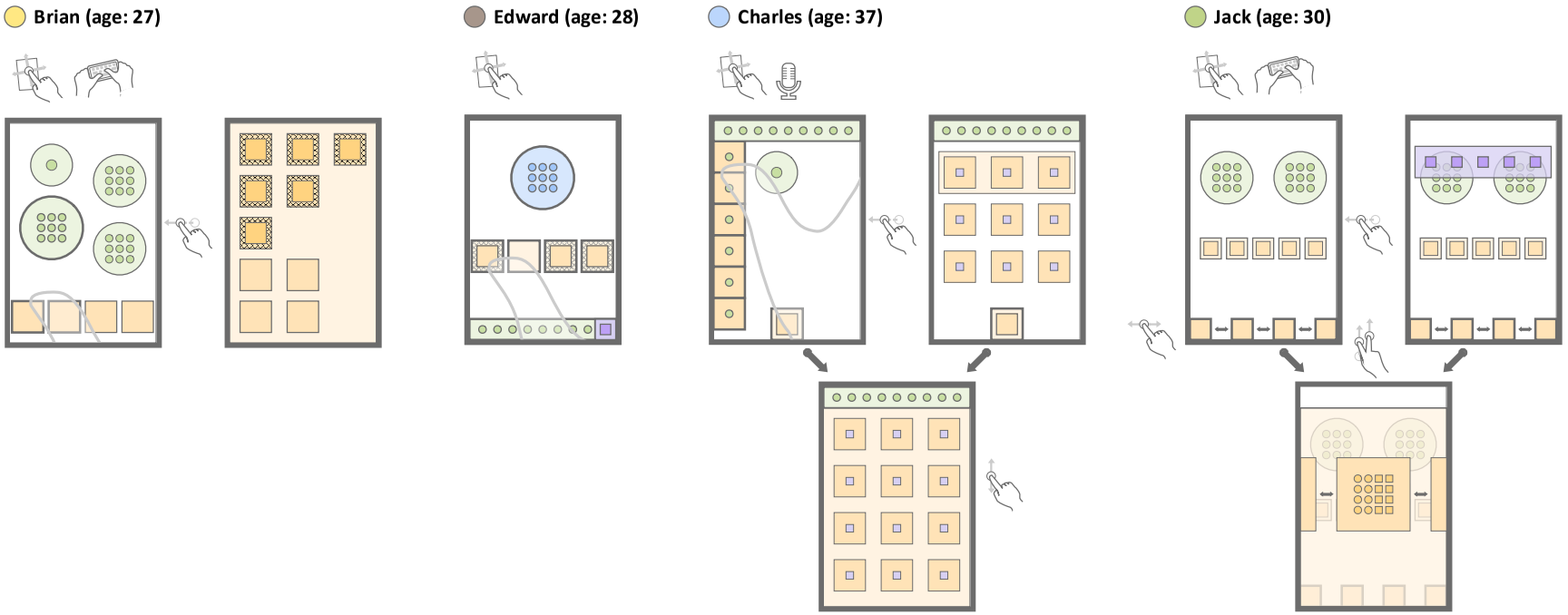


Figure D.5 - Comparison of desired device home screen diagrams, Male - Under 40 years old.

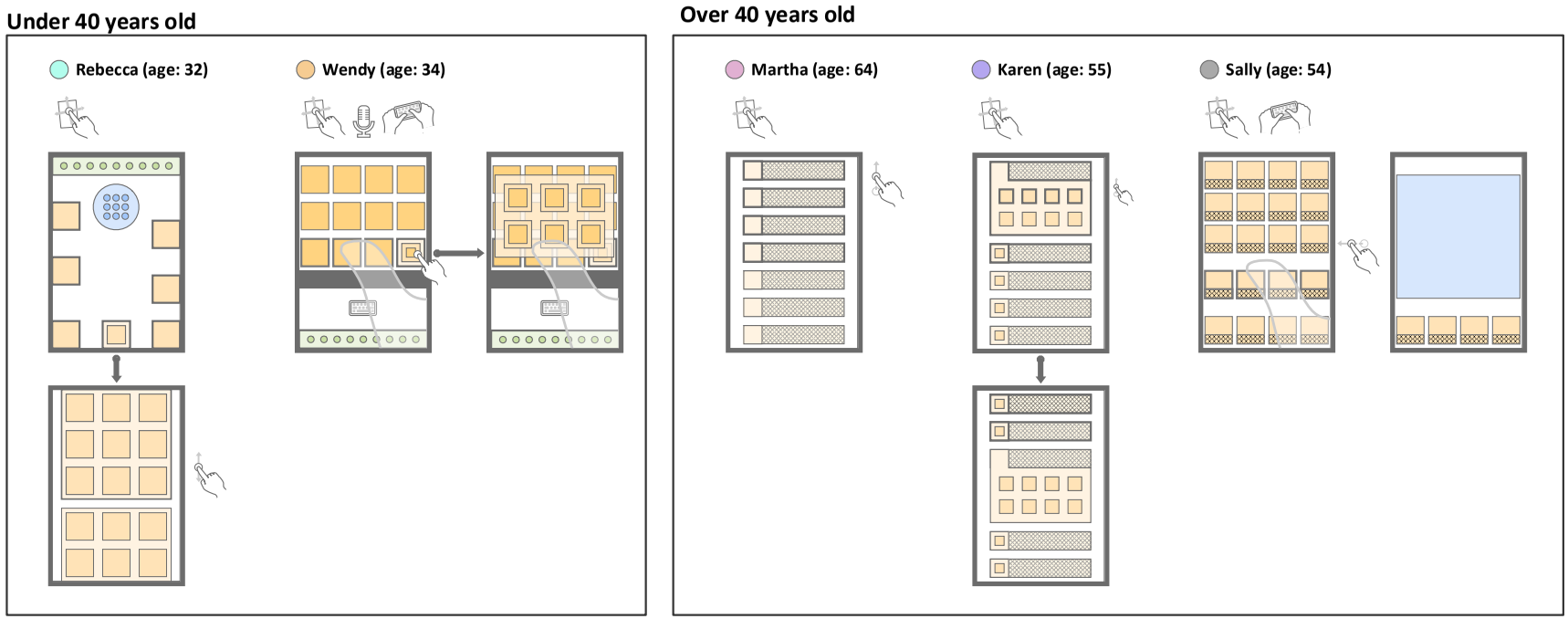


Figure D.6 - Comparison of desired device home screen diagrams, Female - Noted ages.

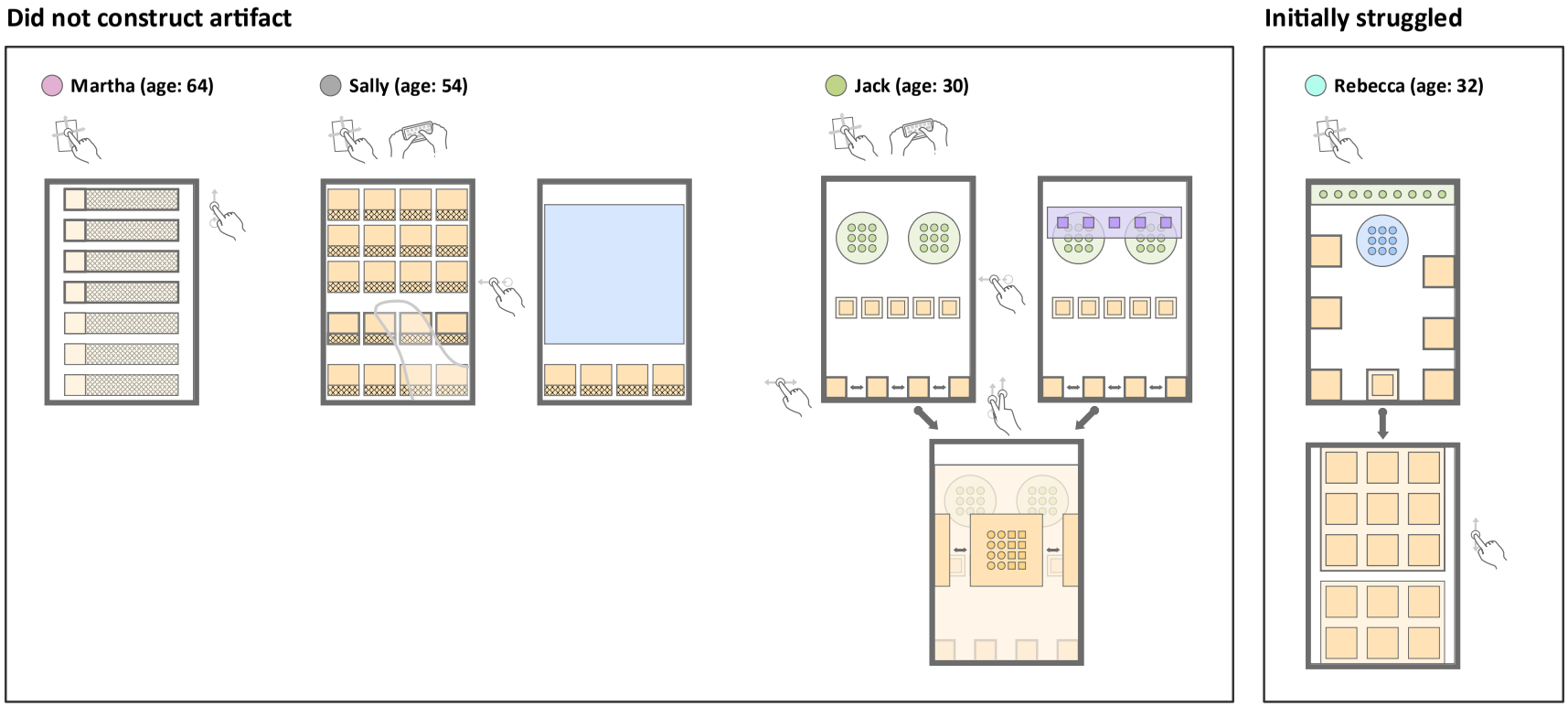


Figure D.7 - Comparison of desired device home screen diagrams, based on generative research activity limitations.

REFERENCES

Abascal, J., Arrue, M., Garay, N., & Tomás, J. (2003). USERfit Tool . A Tool to Facilitate Design for All. *Universal Access Theoretical Perspectives, Practice, and Experience* (pp. 141–152).

Abascal, J., & Civit, A. (2001). Bridging the gap between design for all and assistive devices. *Universal access in HCI: towards an information society for all*, *3*, 1.

Apple Inc. (2009). *iPhone User Guide for iPhone OS 3.1 Software*.

Apple Inc. (2011). *iPhone User Guide for iPhone OS 4.2 and 4.3 Software*.

Ariely, D., & Carmon, Z. (2000). Gestalt characteristics of experiences: the defining features of summarized event. *Journal of Behavioral Decision Making*, *13*, 191–201.

Ariely, D., & Zauberman, G. (2000). On the making of an experience: the effects of breaking and combining experiences on their overall evaluation. *Journal of Behavioral Decision Making*, *13*(2), 219–232.

Au, K. W. Y., Zhou, Y. F., Huang, Z., Gill, P., & Lie, D. (2011). Short paper: a look at smartphone permission models. *Proceedings of the 1st ACM workshop on Security and privacy in smartphones and mobile devices*, SPSM '11 (pp. 63–68). New York, NY, USA: ACM.

Baines, P., Fill, C., & Page, K. (2008). *Marketing* (Pap/Psc.). Oxford University Press, USA.

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The case research strategy in studies of information systems. *MIS quarterly*, *11*(3), 369–386.

Bevan, N. (2009). International Standards for Usability Should Be More Widely Used. *Journal of Usability Studies*, *4*(3).

BlackBerry Storm Series User Guide. (2009). Research In Motion Limited.

Blom, J. (2000). Personalization: a taxonomy. *CHI '00 extended abstracts on Human factors in computing systems* (pp. 313–314). The Hague, The Netherlands: ACM.

Blom, J., Chipchase, J., & Lehikoinen, J. (2005). Contextual and cultural challenges for user mobility research. *Commun. ACM*, *48*(7), 37–41.

Bohnsack, R. (2008). The interpretation of pictures and the documentary method.

Bragdon, A., Nelson, E., Li, Y., & Hinckley, K. (2011). Experimental analysis of touch-screen gesture designs in mobile environments. *Proceedings of the 2011 annual conference on Human factors in computing systems*, CHI '11 (pp. 403–412). New York, NY, USA: ACM.

Buchanan, M. (2008). The Magic Behind Touchscreens. *Gizmodo*. Retrieved December 23, 2011, from http://gizmodo.com/5036516/giz-explains-the-magic-behind-touchscreens

Bühler, C. (2008). Design for All – from Idea to Practise. *Computers Helping People with Special Needs* (pp. 106–113).

CTIA - The Wireless Association. (2011). Consumer Guide to Wireless Accessibility Features. *AccessWireless.org*. Retrieved January 2, 2011, from http://accesswireless.org/Find/Guides-How-Tos.aspx

Carter, J. (1999). Incorporating standards and guidelines in an approach that balances usability concerns for developers and end users. *Interacting with Computers*, *12*(2), 179–206.

Charlesworth, A. (2009). The ascent of smartphone. *Engineering & Technology*, *4*(3), 32–33.

Coleman, R. (2008). Inclusive design: an introduction to inclusive design. *Design Council*. Retrieved November 15, 2008, from http://www.designcouncil.org.uk/en/About-Design/Design-Techniques/Inclusive-design/

Constantiou, I. D. (2009). Consumer behaviour in the mobile telecommunications' market: The individual's adoption decision of innovative services. *Telematics and Informatics*, *26*(3), 270–281.

Cooper, A. (2004). *The Inmates Are Running the Asylum: Why High Tech Products Drive Us Crazy and How to Restore the Sanity* (1st ed.). Sams - Pearson Education.

Courage, C., & Baxter, K. (2004). *Understanding Your Users: A Practical Guide to User Requirements Methods, Tools, and Techniques* (1st ed.). Morgan Kaufmann.

Crerar, A., Benyon, D., & Wilkinson, S. (2001). Individual differences and inclusive design. Book Section. Retrieved February 9, 2009, from http://researchrepository.napier.ac.uk/1823/

Curwen, P. (2010). Is your smartphone smarter than mine? *info*, *12*(2).

Darzentas, J., & Miesenberger, K. (2005). Design for All in Information Technology: A Universal Concern. *Database and Expert Systems Applications* (pp. 406–420).

Desmet, P. (2004). Measuring Emotion: Development and Application of an Instrument to Measure Emotional Responses to Products. In M. A. Blythe, K. Overbeeke, A. F. Monk, & P. C. Wright (Eds.), *Funology: From Usability to Enjoyment* (1st ed., pp. 111–123). Springer.

Dong, H. (2007). Shifting Paradigms in Universal Design. *Universal Acess in Human Computer Interaction. Coping with Diversity* (pp. 66–74).

Dong, H., Keates, S., & Clarkson, P. J. (2004). Inclusive Design in Industry: Barriers, Drivers and the Business Case. *User-Centered Interaction Paradigms for Universal Access in the Information Society* (pp. 305–319).

Dourish, P. (2004a). What we talk about when we talk about context. *Personal and Ubiquitous Computing*, *8*(1), 19–30.

Dourish, P. (2004b). *Where the Action Is: The Foundations of Embodied Interaction*. The MIT Press.

Dumas, J. S., & Redish, J. C. (1999). *A Practical Guide to Usability Testing* (Rev Sub.). Intellect Ltd.

Eaton, K. (2012, February 23). The Smartphone Revolution Is Over (For Now). *Fast Company*. Retrieved February 24, 2012, from http://www.fastcompany.com/1819197/is-the-smartphone-at-an-evolutionary-dead-end-yup

Economides, A. A., & Grousopoulou, A. (2009). Students' thoughts about the importance and costs of their mobile devices' features and services. *Telematics and Informatics*, *26*(1), 57–84.

Ely, M. (1997). Chapter 3: Creating Forms; Informing Understanding. *On writing qualitative research: living by words*. Psychology Press.

Erickson, F. (1985). *Qualitative Methods in Research on Teaching.* (Occasional Paper No. 81). Michigan State University.

Experian Simmons. (2010). Experian Simmons Reveals New Insights on Mobile Consumers. Retrieved July 31, 2011, from http://press.experian.com/united-states/Press-Release/experian-simmons-reveals-new-insights-on-mobile-consumers.aspx

Fain, W. B. (2004). *Design for Inclusion: Creating a New Marketplace - Industry White Paper*. Washington, DC: National Council on Disability.

Federal Communications Commission. (1998). *Section 255 of the Telecommunications Act of 1996: Access to Telecommunications Services Telecommunications Equipment, and Customer Premises Equipment by Persons*

with Disabilities (p. 149). Retrieved from http://www.fcc.gov/Bureaus/Wireless/Notices/1998/fcc98055.pdf

Fenwick, K., Massimi, M., Baecker, R., Black, S., Tonon, K., Munteanu, C., Rochon, E., et al. (2009). Cell phone software aiding name recall. *Proceedings of the 27th international conference extended abstracts on Human factors in computing systems*, CHI EA '09 (pp. 4279–4284). New York, NY, USA: ACM.

Findlater, L. (2009). *Supporting Feature Awareness and Improving Performance with Personalized Graphical User Interfaces*. The University Of British Columbia, Vancouver. Retrieved from http://faculty.washington.edu/leahkf/pubs/findlater-phd-thesis.pdf

Fortunati, L. (2002). The Mobile Phone: towards new categories and social relations. *Information, Communication & Society*, *5*(4), 513.

Garrett, J. (2003). *The elements of user experience : user-centered design for the web*. New York City: American Institute of Graphic Arts.

Geven, A., Sefelin, R., & Tscheligi, M. (2006). Depth and breadth away from the desktop: the optimal information hierarchy for mobile use. *Proceedings of the 8th conference on Human-computer interaction with mobile devices and services*, MobileHCI '06 (pp. 157–164). New York, NY, USA: ACM.

Gil, M., Giner, P., & Pelechano, V. (2011). Personalization for unobtrusive service interaction. *Personal and Ubiquitous Computing*.

Goodman, J., Dong, H., Langdon, P. M., & Clarkson, P. J. (2006). Factors Involved in Industry's Response to Inclusive Design. In J. Clarkson, P. Langdon, & P. Robinson (Eds.), *Designing Accessible Technology* (pp. 31–39). London: Springer-Verlag.

Goodman, J., Langdon, P., & Clarkson, P. (2007). Formats for User Data in Inclusive Design. *Universal Acess in Human Computer Interaction. Coping with Diversity* (pp. 117–126).

Google Inc. (2010). *Android User's Guide 2.3.4*.

Grady, J. (2008). Visual Research at the Crossroads. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *9*(3). Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/1173

Gregor, P., Sloan, D., & Newell, A. F. (2005). Disability and Technology: Building Barriers or Creating Opportunities? (Vol. Volume 64, pp. 283–346). Elsevier.

Gressgard, L. J., & Stensaker, I. (2006). The mobile service industry: strategic challenges and future business models. *International Journal of Mobile Communications*, *4*(5), 509 – 531.

Großmann, M. (2008). Comba: customizing hardware as an approach towards universal design. *Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges* (pp. 585–586). Lund, Sweden: ACM.

Grudin, J. (1989). The case against user interface consistency. *Commun. ACM*, *32*(10), 1164–1173.

Guest, G., Guest, D. G. (Greg) S., MacQueen, K., & Namey, E. E. (2011). *Applied Thematic Analysis*. SAGE Publications.

HTC. (2010). Droid Incredible User Guide.

Hair, J., Joseph, Bush, R., & Ortinau, D. (2005). *Marketing Research: Within a Changing Information Environment* (3rd ed.). McGraw-Hill/Irwin.

Han, S. H., Kim, K. J., Yun, M. H., Hong, S. W., & Jongseo Kim. (2004). Identifying mobile phone design features critical to user satisfaction. *Human Factors & Ergonomics in Manufacturing*, *14*(1), 15–29.

Hanington, B. (2003). Methods in the making: A perspective on the state of human research in design. *Design Issues*, *19*(4), 9–18.

Hassenzahl, M., & Ullrich, D. (2007). To do or not to do: Differences in user experience and retrospective judgments depending on the presence or absence of instrumental goals. *Interacting with Computers*, *19*(4), 429–437.

Haywood, A., & Boguslawski, G. (2009). "I Love My iPhone ... But There Are Certain Things That 'Niggle' Me." In J. A. Jacko (Ed.), *Human-Computer Interaction. New Trends* (Vol. 5610, pp. 421–430). Berlin, Heidelberg: Springer Berlin Heidelberg.

Hellman, R. (2007). Universal Design and Mobile Devices. *Universal Acess in Human Computer Interaction. Coping with Diversity* (pp. 147–156).

Holt, K., Geschka, H., & Peterlongo, G. (1984). *Need assessment*. Wiley.

Holtzblatt, K., Wendell, J. B., & Wood, S. (2004). *Rapid Contextual Design: A How-to Guide to Key Techniques for User-Centered Design*. Morgan Kaufmann.

Hong, J., Suh, E., & Kim, S.-J. (2009). Context-aware systems: A literature review and classification. *Expert Systems with Applications*, *36*(4), 8509–8522.

Hoye, T., & Kozak, J. (2010). Touch Screens: A Pressing Technology. *Tenth Annual Freshman Engineering Sustainability in the New Millennium Conference April* (Vol. 10).

ISO JTC 1. (2009, June 15). Information technology -- Accessibility considerations for people with disabilities -- Part 1: User needs summary; Part 2: Standards inventory; Part 3: Guidance on user needs mapping. ISO.

InsightExpress. (2010). InsightExpress Uncovers Shift in Mobile Consumer Segments. Retrieved July 31, 2011, from http://www.insightexpress.com/release.asp?aid=457

Ishii, H. (2008). Tangible bits: beyond pixels. *Proceedings of the 2nd international conference on Tangible and embedded interaction*.

Ishii, H., & Ullmer, B. (1997). Tangible bits: towards seamless interfaces between people, bits and atoms. *Proceedings of the SIGCHI conference on Human factors in computing systems* (p. 241).

Iwarsson, S., & Ståhl, A. (2003). Accessibility, usability and universal design: positioning and definition of concepts describing person-environment relationships. *Disability & Rehabilitation*, *25*(2), 57.

Jaeger, P. T. (2006). Telecommunications policy and individuals with disabilities: Issues of accessibility and social inclusion in the policy and research agenda. *Telecommunications Policy*, *30*(2), 112–124.

Johnson-Laird, P. N. (1983). *Mental models*. Harvard University Press Cambridge, MA.

Jones, M., & Marsden, G. (2006). *Mobile interaction design*. John Wiley and Sons.

Jordan, P. W. (1998). *An Introduction To Usability* (1st ed.). CRC.

Jordan, P. W. (2002). *Designing Pleasurable Products: An Introduction to the New Human Factors*. CRC.

Kanayama, T. (2003). Leaving It Up to the Industry: People With Disabilities and the Telecommunications Act of 1996. *The Information Society*, *19*(2), 185.

Kane, S. K, Jayant, C., Wobbrock, J. O., & Ladner, R. E. (2009). Freedom to Roam: A Study of Mobile Device Adoption and Accessibility for People with Visual and Motor Disabilities. Presented at the ASSETS '09, Pittsburgh.

Kane, Shaun K., Jayant, C., Wobbrock, J. O., & Ladner, R. E. (2009). Freedom to roam: a study of mobile device adoption and accessibility for people with visual and motor disabilities. *Proceedings of the 11th international ACM SIGACCESS*

conference on Computers and accessibility, Assets '09 (pp. 115–122). New York, NY, USA: ACM.

Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of Social Media. *Business Horizons*, *53*(1), 59–68.

Keates, S. (2006). *Designing for Accessibility: A Business Guide to Countering Design Exclusion* (1st ed.). CRC.

Keates, S., & Clarkson, J. (2003). *Countering design exclusion : an introduction to inclusive design*. London ; New York: Springer.

Keating, E. (2007). *The Role of the Mobile Phone in the Welfare of Aged and Disabled People*. The University of Texas at Austin and NTT DoCoMo, Inc.

Kenney, M., & Pon, B. (2011). Structuring the Smartphone Industry: Is the Mobile Internet OS Platform the Key? *Journal of Industry, Competition and Trade*, *11*(3), 239–261.

Kiljander, H. (2004). *Evolution and Usability of Mobile Phone Interaction Styles*. Helsinki Universtiy of Technology.

Kim, H., Heo, J., Shim, J., Kim, M., Park, S., & Park, S. (2007). Contextual Research on Elderly Users' Needs for Developing Universal Design Mobile Phone. *Universal Acess in Human Computer Interaction. Coping with Diversity* (pp. 950–959).

Kim, M., Jung, E., Park, S., Nam, J., & Choe, J. (2007). Application of a Universal Design Evaluation Index to Mobile Phones. *Human-Computer Interaction. Interaction Platforms and Techniques*, 364–373.

King, N. (2004). Using templates in the thematic analysis of text, 256–270.

King, N. (2007). Template Analysis. *University of Huddersfield School of Human & Health Sciences: Template Analysis*. Retrieved December 2, 2011, from http://www2.hud.ac.uk/hhs/research/template_analysis/

Kotler, P., & Armstrong, G. (2007). *Principles of Marketing, 12th Edition* (12th ed.). Prentice Hall.

Landay, J. A., Joseph, A. D., & Reynolds, F. (2009). Guest Editors' Introduction: Smarter Phones. *IEEE Pervasive Computing*, *8*(2), 12–13.

Laurel, B., & Lunenfeld, P. (2003). *Design Research: Methods and Perspectives*. The MIT Press.

Law, C. M. (2006). The technology in your cell phone wasn't invented for you. *Communications, Policy & Research Forum, Sydney, Australia*.

Law, C. M. (2010). *Responding to accessibility issues in business*. RMIT University.

Lee, Y. S., Jhangiani, I., Smith-Jackson, T. L., Nussbaum, M. A., & Tomioka, K. (2006). Design Considerations for Accessible Mobile Phones. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *50*(18), 2178–2182.

Lewis, T., & Clarkson, P. J. (2005, April 5). A user study into customising for inclusive design. Conference or Workshop Item. Retrieved August 11, 2010, from http://publications.eng.cam.ac.uk/8604/

Lidwell, W., Holden, K., & Butler, J. (2010). *Universal Principles of Design, Revised and Updated: 125 Ways to Enhance Usability, Influence Perception, Increase Appeal, Make Better Design Decisions, and Teach through Design* (Second Edition, Revised and Updated.). Rockport Publishers.

Ling, C., Hwang, W., & Salvendy, G. (2006). Diversified users' satisfaction with advanced mobile phone features. *Universal Access in the Information Society*, *5*(2), 239–249.

Ling, C., Hwang, W., & Salvendy, G. (2007). A survey of what customers want in a cell phone design. *Behaviour & Information Technology*, *26*(2), 149–163.

LoPresti, E. F., Simpson, R. C., Kirsch, N., Schreckenghost, D., & Hayashi, S. (2008). Distributed cognitive aid with scheduling and interactive task guidance. *Journal of Rehabilitation Research and Development*, *45*(4), 505–521.

Lockwood, T., & Walton, T. (2008). *Building Design Strategy: Using Design to Achieve Key Business Objectives*. Allworth Press.

Lohse, G. L., Biolsi, K., Walker, N., & Rueter, H. H. (1994). A classification of visual representations. *Commun. ACM*, *37*(12), 36–49.

Macdonald, A. (2007). The UD Phenomenon in Japan: Product Innovation Through Universal Design. *Universal Acess in Human Computer Interaction. Coping with Diversity*, 224–233.

Maragos, P. (2008). *Multimodal processing and interaction: audio, video, text*. Springer.

Martinez, M. (2010). The Mobile Phone User: Identifying Top Mobile Applications. *SSRN eLibrary*. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1691210

Mattelmaki, T. (2006). *Design Probes*. University of Art and Design Helsinki, Helsinki, Finland.

Messerschmitt, D. (2007). Rethinking Components: From Hardware and Software to Systems. *Proceedings of the IEEE*, *95*(7), 1473–1496.

Mieczakowski, A., Langdon, P., & Clarkson, P. (2009). Modelling Product-User Interaction for Inclusive Design. *Universal Access in Human-Computer Interaction. Addressing Diversity* (pp. 559–567).

Mieczakowski, A., Langdon, P. M., & Clarkson, P. J. (2010). Investigating Designers' Cognitive Representations for Inclusive Interaction Between Products and Users. *Designing Inclusive Interactions* (pp. 133–143).

Miles, M. B., & Huberman, A. M. (1999). *Qualitative data analysis*. SAGE.

Milne, S., Dickinson, A., Carmichael, A., Sloan, D., Eisma, R., & Gregor, P. (2005). Are guidelines enough?: an introduction to designing web sites accessible to older people. *IBM Syst. J.*, *44*(3), 557–571.

Montague, K., Hanson, V. L., & Cobley, A. (2011). Adaptive Interfaces: A Little Learning is a Dangerous Thing... In C. Stephanidis (Ed.), *Universal Access in Human-Computer Interaction. Design for All and eInclusion* (Vol. 6765, pp. 391–399). Berlin, Heidelberg: Springer Berlin Heidelberg.

Mueller, J., Jones, M., Broderick, L., & Haberman, V. (2005). Assessment of User Needs in Wireless Technologies. *Assistive Technology*, *17*(1), 57–71.

Nexus One: User's Guide. (2010). Google Inc.

Nguyen, T., Garrett, R., Downing, A., Walker, L., & Hobbs, D. (2007). Research into Telecommunications Options for People with Physical Disabilities. *Assistive Technology*, *19*(2), 78–93.

Nielsen, J. (1993). *Usability Engineering*. Academic Press Inc.

Oulasvirta, A., & Blom, J. (2008). Motivations in personalisation behaviour. *Interacting with Computers*, *20*(1), 1–16. doi:10.1016/j.intcom.2007.06.002

Oulasvirta, A., Tamminen, S., Roto, V., & Kuorelahti, J. (2005). Interaction in 4-second bursts: the fragmented nature of attentional resources in mobile HCI. *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 919–928). Portland, Oregon, USA: ACM.

Palen, L., & Salzman, M. (2002). Beyond the handset: designing for wireless communications usability. *ACM Trans. Comput.-Hum. Interact.*, *9*(2), 125–151.

Park, B., Song, S., Kim, J., Park, W., & Jang, H. (2007). User customization methods based on mental models: modular UI optimized for customizing in handheld

device. *Human-Computer Interaction. Interaction Platforms and Techniques*, 445–451.

Penn, G. (2000). Semiotic analysis of still images. *Qualitative research with text, image and sound: A practical handbook*, 227–245.

Persad, U., Langdon, P., & Clarkson, J. (2007). Characterising user capabilities to support inclusive design evaluation. *Universal Access in the Information Society*, *6*(2), 119–135.

Pires, C. G., Pinto, F. M., Rodrigues, E. M., & Dias, M. S. (2011). On the benefits of speech and touch interaction with communication services for mobility impaired users.

Porter, M. E. (2008). The Five Competitive Forces that Shape Strategy. *Harvard Business Review*, *86*(1), 78–93.

Reed, P. (1994). ANSI/HFES software user interface standardization: critical issues. *SIGCHI Bull.*, *26*(2), 12–15.

Reed, P., Holdaway, K., Isensee, S., Buie, E., Fox, J., Williams, J., & Lund, A. (1999). User interface guidelines and standards: progress, issues, and prospects. *Interacting with Computers*, *12*(2), 119–142.

Renaud, K., & van Biljon, J. (2008). Predicting technology acceptance and adoption by the elderly: a qualitative study. *Proceedings of the 2008 annual research conference of the South African Institute of Computer Scientists and Information Technologists on IT research in developing countries: riding the wave of technology* (pp. 210–219). Wilderness, South Africa: ACM.

Roam, D. (2008). *The Back of the Napkin: Solving Problems and Selling Ideas with Pictures* (1st ed.). Portfolio Hardcover.

Roeber, H., Bacus, J., & Tomasi, C. (2003). Typing in thin air: the canesta projection keyboard - a new method of interaction with electronic devices. *CHI '03 extended abstracts on Human factors in computing systems*, CHI EA '03 (pp. 712–713). New York, NY, USA: ACM.

Rogers, E. M. (2003). *Diffusion of Innovations, 5th Edition* (5th ed.). New York City: Free Press.

Rozen, D., Anulewicz, J., & Senn, T. (2010). *Bringing Mobile Segmentation to Life*. Carlson Marketing. Retrieved from http://carlsonmarketing.mediaroom.com/index.php?s=55&item=151

Samsung. (2008). SAMSUNG unveils new consumer segmentation model to spur growth | News from SAMSUNG. Retrieved July 31, 2011, from

http://www.samsung.com/my/news/newsRead.do?news_seq=8567&page=1

Samsung. (2012). Jitterbug | Samsung SPH-a310 - Cell Phones. Retrieved March 25, 2012, from http://www.samsung.com/us/mobile/cell-phones/SPH-A310ZRADYN

Sanders, E. (2000). Generative tools for co-designing. *Collaborative Design*, 3–12.

Sanders, E. (2001). Virtuosos of the Experience Domain. *Proceedings of the 2001 IDSA Education Conference*. Presented at the IDSA Education Conference.

Sanders, E. (2008). ON MODELING: An evolving map of design practice and design research. *interactions*, *15*(6), 13–17.

Schiffman, H. R. (2001). *Sensation and Perception: An Integrated Approach* (5th ed.). Wiley.

Simon, H. A. (1962). The architecture of complexity. *Proceedings of the American philosophical society*, *106*(6), 467–482.

Sprint. (2011). Sprint Customers. Retrieved July 31, 2011, from http://developer.sprint.com/site/global/home/why_sprint/sprint_customers/sprint_customers.jsp#addict

Stapleton, S., Adams, M., & Atterton, L. (2007). A mobile phone as a memory aid for individuals with traumatic brain injury: a preliminary investigation. *Brain Injury: [BI]*, *21*(4), 401–411.

Stewart, T. (2000). Ergonomics user interface standards: are they more trouble than they are worth? *Ergonomics*, *43*(7), 1030.

Story, M. F. (2006). Resources on Accessible/Universal Design Principles and Performance Measures. *Rehabilitation Engineering Research Center on Accessible Medical Instrumentation (RERC-AMI)*. Retrieved February 4, 2009, from http://www.rerc-ami.org/ami/projects/d/2/udg/

Suri, J. F. (2003). The experience of evolution: developments in design practice. *The Design Journal*, *6*(2), 39–48.

T-mobile. (2008). T-Mobile Segmentation: Need a Fresh Perspective? Retrieved from http://www.coroflot.com/jennpidgeon/T-Mobile

TC 159/SC 4. (1998). *Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability* (p. 22). ISO (The International Organization for Standardization).

TC 159/SC 4. (1999). *Human-centered design processes for interactive systems* (p. 22). ISO (The International Organization for Standardization).

Tetzlaff, L., & Schwartz, D. R. (1991). The use of guidelines in interface design. *Proceedings of the SIGCHI conference on Human factors in computing systems: Reaching through technology* (pp. 329–333). New Orleans, Louisiana, United States: ACM.

The Center for Universal Design. (1997). *The Principles of Universal Design, Version 2.0*. Raleigh, NC: North Carolina State University.

The Nielsen Company. (2011). State of the Media: Mobile Media Report Q3 2011. Retrieved January 1, 2012, from http://www.nielsen.com/us/en/insights/reports-downloads/2011/state-of-the-media--mobile-media-report-q3-2011.html?status=success

Tidwell, J. (2005). *Designing Interfaces: Patterns for Effective Interaction Design*. O'Reilly Media, Inc.

Trace Center. (1999). Trace Center Cell Phone Reference Design. Retrieved March 8, 2010, from http://trace.wisc.edu/docs/phones/tcrd1/tcrd1.htm

Tufte, E. R. (1990). *Envisioning Information*. Graphics Press.

Tufte, E. R. (1997). *Visual Explanations: Images and Quantities, Evidence and Narrative*. Graphics Press.

Tufte, E. R. (2001). *The Visual Display of Quantitative Information, 2nd edition* (2nd ed.). Graphics Press.

Turkle, S. (2008). Always-on/always-on-you: The tethered self. *Handbook of mobile communication studies*, 121–137.

U.S. Congress. (1998). *Section 508 of the Rehabilitation Act* (p. 149). Retrieved from http://www.fcc.gov/Bureaus/Wireless/Notices/1998/fcc98055.pdf

Ullmer, B., & Ishii, H. (2001). Emerging Frameworks for Tangible User Interfaces. In J. M. Carroll (Ed.), *Human-Computer Interaction in the New Millenium* (pp. 579–601). Addison-Wesley.

Utterback, J. M., Vedin, B.-A., Alvarez, E., Ekman, S., Sanderson, S. W., Tether, B., & Verganti, R. (2006). *Design-inspired Innovation*. World Scientific Publishing Company.

VanBiljon, J. (2006). *A model for representing the motivational and cultural factors that influence mobile phone usage variety* (Doctoral Dissertation). University of South Africa, Pretoria, South Africa.

Vander Veer, G. C., & del Carmen Puerta Melguizo, M. (2002). Mental Models. In J. A. Jacko & A. Sears (Eds.), *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications* (1st ed., pp. 52–80). CRC.

Verstockt, S., Decoo, D., Van Nieuwenhuyse, D., De Pauw, F., & Van de Walle, R. (2009). Assistive smartphone for people with special needs: the personal social assistant. *Human System Interactions, 2009. HSI'09. 2nd Conference on* (pp. 331–337).

Vikas, S. (2010, December 2). Android bloatware: The goose that craps on the golden egg? *Technoholik*. Retrieved February 27, 2012, from http://technoholik.com/opinion/mobile/smartphone/android-bloatware-the-goose-that-craps-on-the-golden-egg/937

Visser, F. S., Stappers, P. J., van der Lugt, R., & Sanders, E. (2005). Contextmapping: experiences from practice. *CoDesign*, *1*(2), 119–149.

Want, R. (2009). When cell phones become computers. *Pervasive computing, IEEE*, *8*(2), 2–5.

Webdesigner Depot. (2009, May 22). The Evolution of Cell Phone Design Between 1983-2009. *Webdesigner Depot*. Retrieved February 24, 2012, from http://www.webdesignerdepot.com/2009/05/the-evolution-of-cell-phone-design-between-1983-2009/

Weedon, Gunn, Griffin, Forsythe, J. L. R., Norell, & McCowa. (2001). *Human Movement* (4th ed.). Churchill Livingstone.

Wensveen, S. A. G., Djajadiningrat, J. P., & Overbeeke, C. J. (2004). Interaction frogger: a design framework to couple action and function through feedback and feedforward. *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques* (pp. 177–184). Cambridge, MA, USA: ACM.

Wind, Y. (1978). Issues and Advances in Segmentation Research. *Journal of Marketing Research*, *15*(3), 317–337.

Wireless RERC. (2006). User Personas. Retrieved March 8, 2010, from http://www.wirelessrerc.org/about-us/projects/previous-work/r1-assessment-of-user-needs/user-personas/

Wireless RERC. (2010). Survey of User Needs: 2010. *Rehabilitation Engineering Research Center for Wireless Technologies*. Retrieved February 1, 2009, from http://www.wirelessrerc.org/for-consumers/survey-of-user-needs.html

Wright, P. C., & McCarthy, J. (2005). The value of the novel in designing for experience. *Future interaction design*, 9–30.

Yen, D., & Chou, D. (2000). Wireless communications: applications and managerial issues. *Industrial Management + Data Systems*, *100*(9), 436.

Yin, R. K. (2009). *Case study research: design and methods*. SAGE.

Zhang, L., & Liu, Y. (2010). On methods of designing smartphone interface. *2010 IEEE International Conference on Software Engineering and Service Sciences (ICSESS)* (pp. 584–587). Presented at the 2010 IEEE International Conference on Software Engineering and Service Sciences (ICSESS), IEEE.

Zheng, P., & Ni, L. M. (2006). Spotlight: The Rise of the Smart Phone. *IEEE Distributed Systems Online*, *7*(3).

Ziefle, M. (2010). Information presentation in small screen devices: The trade-off between visual density and menu foresight. *Applied Ergonomics*, *41*(6), 719–730.

Ziefle, M., & Bay, S. (2004). Mental Models of a Cellular Phone Menu. Comparing Older and Younger Novice Users. *Mobile Human-Computer Interaction – MobileHCI 2004* (pp. 571–572).