UNDERSTANDING HUMAN-TECHNOLOGY INTERACTIONS:

THE ROLE OF PRIOR EXPERIENCE AND AGE

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UNDERSTANDING HUMAN-TECHNOLOGY INTERACTIONS:

THE ROLE OF PRIOR EXPERIENCE AND AGE

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SUMMARY

Everyday technologies are intended for use by everyone with no specific training and minimal instructions. Prior research (e.g., Norman, 2002; Polson & Lewis, 1990) has suggested that these technologies are usable if users can leverage their prior experience. However, different users will leverage different experiences to operate the same technologies (Blackler, Popovic, & Mahar, 2003a). This dissertation systematically examined the role of prior knowledge in the operation of everyday technology by diverse users, specifically users of different ages and experience levels.

In Study 1 encounters with everyday technologies were self-reported by younger adults, older adults with low technology experience, and older adults with high technology experience. Technology repertoires for younger adults and high tech older adults were comparable, though high tech older adults reported using more kitchen and home health care technologies. Low tech older adults reported fewer technologies than high tech older adults overall, but particularly fewer PC and internet technologies. Participants generally were successful with their technology encounters, and no age or experience differences were found in the number of reported problems. Prior experience was the most cited reason for success with technologies, including new technologies. Low tech older adults also reported that success was also due to a focused attention approach that reduced opportunity for distractions. All participants reported, however, that prior experience was not always sufficient for successful technology use. Younger adults also reported a significantly higher number of problems due to interference from prior knowledge.

In Study 2 video recorded observations were made during participant interactions with thee exemplar everyday technologies (i.e., an alarm clock, a video camcorder, an electronic book reader). Participants with more relevant experience generally performed

better. Younger adults performed at higher levels across technologies, and some high tech older adults also performed at high levels that included optimal performance on some tasks on some technologies. Some low tech older adults completed all tasks successfully, and many were successful in most tasks. However, there were few optimal performances by low tech older adults, and some low tech older adults were only partially successful on some tasks. Overall, data suggests that age-related differences in performance were not completely overcome by higher general technology experience.

Appropriate use of prior experience seemed to be a key factor for successful performance in Study 2, though high levels of general technology experience may be sufficient for learning to successfully use a novel technology. Prior experience included not only specific similar technologies but also prior knowledge of at least one component (appearance, location, operation) of necessary technology controls. Within the operation component, knowledge of expected feedback may have been particularly helpful for guiding participants to proceed with the next action in the task.

Participants from all groups also used knowledge in the world for successful interactions. Older adults particularly seemed to inspect information on the technology and to consider possible actions before selecting specific controls. This technique may be similar to the focused attention approach described by low tech older adults in Study 1.

Results from this research suggest that understanding users' prior technology background is necessary for designing technologies with which they can be successful. However, it also seems necessary to incorporate the right information on the technology at the right time and place to elicit the target knowledge in the head and to guide usage of that knowledge. Usability analysis that is focused on assessing the optimal way in which successful users interact with the technology and strengthening the presentation of the design components that facilitate this path can provide the right foundation for wider success with everyday technologies among adults of different ages and backgrounds.

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Chapter 1: Understanding Everyday Technology Use

In the 21st century completing routine errands and civic activities in developed countries requires use of a myriad of technologies, many of which people must use with little or no instruction. Yet, even with over two decades of research on human interaction with technologies that could help designers, technology users still experience difficulties with many of these everyday, purportedly simple devices and systems. As cost pressures reduce fund availability for customer service from a person at initial contact or to resolve problems, the imperative for creating effective, efficient, usable technologies becomes even more critical.

In 2006 an international standards committee addressed this issue with publication of ISO 20282-1, entitled "Ease of operation of everyday products" (International Standards Organization, 2006). Part 1 of this document, "Design requirements for context of use and user characteristics," specified the scope of the products included in the standard as "everyday products". First, the scope was limited to "mechanical and/or electrical products with an interface that a user can operate directly or remotely to gain access to the functions provided." (International Standards Organization, p 1). Second, the standard specified five categories of products (p. 1).

1) Consumer products intended for some or all of the general public which are bought, rented or used, and which may be owned by individuals, public organizations, or private companies;
2) Consumer products intended to be acquired and used by an individual for personal rather than professional use (e.g., alarm clocks, electric kettles, telephones, electric drills);
3) Walk-up-and-use products that provide a service to the general public (such as ticket-vending machines, photocopying machines, fitness equipment);
4) Products used in a work environment, but not as part of professional activities (e.g., a coffee machine in an office);
5) Products including software that support the main goals of use of the product (e.g., a CD player).

The standard prescribed user characteristics for designers to assess early in the product development process. Although characteristics such as age, body size, visual and auditory abilities, biomechanical attributes, and knowledge of the display language may be fairly easy to assess and describe in a target population, the element, “knowledge of comparable machines”, may be elusive for the diverse population targeted for everyday products (International Standards Organization, 2006, p. 6). Related knowledge elements such as “semantic knowledge for key terms” may be equally elusive. The composite set of knowledge of both elements may additionally vary in recency of access, frequency of access, and depth across the population, which can influence familiarity and recall for individual users (Reason, 1990). This variability of prior knowledge is likely to subsequently influence the usability of the target products, but research investigations to help designers determine appropriate ways to accommodate these differences with design have not been conducted.

To investigate how knowledge differences may influence human interaction with these everyday products, the present study included younger and older adults for two reasons. First, the variability of older adults’ knowledge can serve as a proxy for the diversity of knowledge that might be found within the general public. Consistent research results reveal that a sample of older adults typically has higher semantic knowledge than a sample of younger adults (e.g., Ackerman & Rolfhus, 1999; Beier & Ackerman, 2001). In addition, the length of their life experiences increases the likelihood of a broader knowledge base in the older adult sample. The second, related reason for examining age differences is the desire to better understand technology design that leverages cognitive capabilities maintained with age. Previous research has found that prior knowledge helps people learn in spite of ability differences (Beier & Ackerman, 2005).

Therefore, identifying successful approaches to leveraging semantic knowledge in everyday interactions may facilitate greater social participation in a technology-dependent society.

Therefore, the purpose of the present research was to investigate how prior knowledge and age influence human-technology interactions (HTI) with everyday products. The scope of everyday products was further constrained to electrical devices, that is, products that require batteries or electricity for operation. As described in Chapter 2, this research focused on new and infrequently used products for which people must exhibit their ability to learn basic functionality through experimentation. Chapter 3 reviews research investigating the use of prior knowledge in technology interactions. Chapter 4 reviews research on age-related differences in technology knowledge and HTI with everyday products. Chapter 5 summarizes the research questions and methods used to investigate this question. Chapter 6 describes the methods for Study 1, and Chapter 7 describes the results for Study 1. Chapter 8 describes the methods for Study 2, and Chapter 9 describes the results for Study 2. Chapter 10 concludes with a summary of the findings from both studies along with theoretical and practical applications for this research.

Chapter 2: Prior Knowledge Use in Interactions with Untrained Technology

Early computers were expensive; consequently, computer operators were carefully selected and trained to use them correctly. As computing costs and size dropped, manufacturers began to develop desktop and home-based computers that users might be able to learn on their own or with little training. By observing how these users interacted with computers, researchers developed an understanding of the psychological processes applied in these interactions. In particular, they observed that users experimented with these systems using prior knowledge in pursuit of task goals. In this section I will review this research to identify common components and open questions raised by the studies.

Characteristics of untrained learning

A series of case studies of untrained users interacting with new technologies established that even users motivated to learn a new type of system often encounter new types of difficulties with this approach. Several characteristics of untrained use were reported from experienced typists using the computerized word processing systems developed in the early 1980s (e.g., Carroll & Mack, 1984; Carroll & Rosson, 1987; Lewis & Mack, 1982). First, these users gradually learned how to execute key functions by experimenting with functions rather than by studying the manual. Function labels were used to set operational expectations, and feedback was used to evaluate the true functional meaning. Second, users were active and creative in incorporating new knowledge (of the word processing system) into their old knowledge (prior typewriter knowledge and word processing functions already learned). Third, experimentation and exploration was non-systematic, and ad-hoc reasoning and observation may have created problems as much as they guided resolution (Carroll & Mack). Apparent progress toward task completion allowed users to continue operation after an error until they reached a fixed constraint (e.g., a closed rather than saved document could not be retrieved for editing). When users made mistakes, they were often disoriented and further complicated the mistake through misinterpretations of coincidental events. Fourth, the typewriter metaphor created several problems due to non-transferrable functions. For example, users did not understand why they could not type in document margins or the difference between save and close functions that both produced the same visible result (i.e., the document disappeared from the screen). Lastly, completely new functions such as file management were very difficult to discover. Overall, participants seemed to leverage prior experience to successfully complete the target tasks, but the experience was used in somewhat unpredictable ways.

An experimental study by Singley and Anderson (1987) systematically examined the specific experience transferred between related systems. Individuals learned line editor and screen editor word processing programs, practiced on the different systems, and were evaluated on their performance on the target system after transfer. Results showed that all declarative knowledge about the text editing process flow transferred successfully. From a procedural perspective, the planning components of text editing were learned across editors with decreased planning time and elimination of supporting steps over the course of the study. Participants transferred to a new system relied on the familiar method if it was still available, and only updated their knowledge if the function was new or if the command was clearly easier than the previous method. Even participants learning different but equally complex perceptual motor commands for the same functions exhibited little negative transfer between the two screen editors. The few instances of negative transfer observed were characterized by the study authors as positive transfer of nonoptimal methods rather than instances of true procedural interference. Participants seemed to have used similarities between commands or cues to select the most accessible execution method. As long as planning for specific functions was similar between editors, transfer occurred when no high cost or absolute constraints prevented the user from using the previously learned command. Transfer might not occur, however, if an alternative command was more salient or had a lower cost.

Consistent with these studies of transfer for similar functions in a work environment, research has revealed similar results for users interacting with novel technologies designed for non-work usage. For instance, Shrager and Klahr (1990) developed a discovery learning paradigm to investigate how users with little computer programming experience would interact with a mechanized toy car. Seven participants were instructed to learn as much as they could about the toy car in thirty minutes. The study revealed that all used the same experimentation method as was used in the word processing studies (e.g., Carroll & Mack, 1984; Carroll & Rosson, 1987; Lewis & Mack, 1982), with participants hypothesizing, experimenting, and evaluating the functions for different labeled buttons. Participants transferred knowledge from other devices (such as a calculator) to hypothesize functions about the car, as well as to develop explanations to account for behavior deviating from their original hypotheses. Interestingly, all seven participants discovered the same small set of rules during the study, supporting the hypothesis that a similar explanatory model was developed by all participants. The authors noted that the low cost for exploring, allowing users to make mistakes and interpret the feedback based on prior experience, facilitated the trial-and-error process that was generally successful even though participants did not discover the correct reasons for all errors.

Theory of easily learned interfaces

In spite of the success that users could achieve exploring a system, system designers were frustrated to find that intensive empirical testing was the only way to incorporate science in what was otherwise more like an artistic endeavor (Polson & Lewis, 1990). The theory of easily learned interfaces was developed to synthesize findings from case studies and research on specific aspects of design to provide structure to the art with a theoretical foundation for exploration (Polson & Lewis). It was based on experimental findings from problem-solving research. In the theory, Polson and Lewis proposed two mechanisms that allowed individuals to easily use the correct previous knowledge if it was available or to evaluate potential actions if previous knowledge did not appear to be relevant.

The first mechanism was label-following through which users selected obvious surface cues to identify labels that best matched the goal based on perceptual similarity and probability of progressing toward the goal. Good matches increased the user's confidence that selecting the label would help progress toward the goal. If only one label or action was available, users would choose that action if no penalty was involved because they inferred that the action must be on the way to the goal. If familiar labels did not match the goal, users would search among novel uses of familiar words or technical terms as these suggested actions that may have an unknown consequence. If nothing seemed likely, users would pick at random. Two recommended keys to design based for label-following were effective labels (identified via focus groups within design) and feedback that clearly informed the users of their current path.

The second mechanism was hill-climbing that involved the search for an optimal solution in a problem-space. Based on the response to the previous action selected, users analyzed the effect of choices, particularly to identify causal relations between actions and responses that were most helpful in developing a system representation sufficient to plan future actions. Because this mechanism involved a learning component, users might select actions that helped them to refine their system representation by finding actual and artificial constraints. This mechanism allowed users to organize results based on perception of coherence or sense of relations even if the organizing principle for the system was still unclear. Thus, additional keys to design for hill climbing were a lenient attitude toward errors and low cost for selecting actions based on guessing. In fact, Polson and Lewis (1990) proposed that interactions with easily learned interfaces are based on design for successful guessing. The complete list of design principles for successful guessing (Polson & Lewis, p. 214) is:

1) Make the repertoire of available actions salient;
2) Use identity cues between actions and user goals as much as possible;
3) Use identity cues between system responses and user goals as much as possible;
4) Provide an obvious way to undo actions;
5) Make available actions easy to discriminate;
6) Offer few alternatives;
7) Tolerate at most one hard-to-understand action in a repertoire;
8) Require as few choices as possible.

This theory has been examined by other researchers (Franzke, 1995; Franzke & Rieman, 1993; Rieman, Young & Howes, 1996). Franzke's dissertation examined effects of display-based system characteristics on participant exploration and learning retention after minimal (10 minute) and typical (1 week) delays. Her study found that participants indeed used label-following, with well-labeled objects found more quickly independent of the number of items on the display. Label-following was even preferred over direct-manipulation (afforded) features, though label usefulness depended on semantic closeness with the user's definition of the goal. More items on the display/feature options led to poorer performance that continued even after a week delay. Some interaction features (like dragging and dropping, double-clicking) were hard for users to discover, though hard-to-discover items were typically retained even after a week delay. More well-labeled items, particularly those on sub-menus, were forgotten after delays but were easily rediscovered. Overall, users' discovering the items even once facilitated discovery and performance on repeat trials, but system complexity affected recall such that more exploration was generally needed after a delay to trigger complete recall.

Naturalistic exploratory and learning strategies

Although the research reviewed thus far suggests that motivated users in a study can learn technologies if properly designed, few studies have systematically examined people's naturalistic exploratory learning strategies with technologies. Rieman (1996), however, conducted a diary study with 14 adults in an academic environment. All participants had at least some college experience, including current undergraduates, though the sample generally had significant graduate experience in computer science or engineering-related fields. In the diary study participants tracked learning events on work-related computer activities for one week, with a structured interview conducted after the week to examine problem-resolution strategies. Results showed that participants encountered a mean of 4.3 of these problems during the week, though more problems were found for users obtaining new software. In general, learning of feature knowledge was demand-based with users rarely exploring to discover new features or read the manual unless an actual goal surfaced. The dominant problem-solving strategy was reading the manual or asking for help, but participants also used trial and error to complement external support in completing their task. Some individual differences in resolution approaches were found based on the user's general technical background (novice or experienced), with one participant specifically referencing "hacking" to get the task completed without concern for procedural correctness.

These findings are generally consistent with the systematic study of exploratory learning, as well as anecdotal reports of individuals' interactions with everyday technologies (e.g., Blackler, 2003b; Freudenthal, 1998; Norman 2002). Two specific aspects of these reports are worth noting. First, users may be willing to use the technologies to achieve their goals, but they are not motivated to invest additional time learning the system beyond necessary features and functions. In fact, experienced users of menu-based systems showed poor recall for menu headers and labels and precise effects for even commonly used functions (Mayes, Draper, McGregor, & Oatley, 1988; Payne, 1991). Thus, although they may be exposed to other features or labels on the display, users are likely to have little recall for these features to suggest other functions possible on the system. Indeed, Polson and Lewis's (1990) theory of easily learned interfaces provides exactly the desired framework for guiding user interactions with a bottom-up design that requires little cognitive effort. In regular, reliable environments, off-loading instructions from memory to the interface can be an efficient and effective strategy for users (Payne, Howes, & Reader, 2001).

Second, though, users still frequently develop an explanatory “mental model” of the systems they interacted with in spite of no intention to learn or attend to the interaction. As Payne (1991) discovered in informal interviews with automated teller machine (ATM) users, users could provide explanations for system operation based on their experience with other functions. For instance, several users speculated that the ATM cards themselves held the user’s personal identification numbers to facilitate use in machines from different banks. Clearly, these user mental models may be inaccurate or incomplete, which could contribute to users’ difficulties in learning other functions on these systems because people learn technologies more easily and effectively with correct mental models (Kieras & Bovair, 1984). In fact, some researchers believe that mental models are even necessary for resolving problems encountered with everyday technologies (Payne, 2003). Feature familiarity, however, may make the display appear more regular and related to a prior system than it actually is, facilitating negative transfer and possibly errors (Singley & Anderson, 1987).

One recommendation to reduce errors is to put guidance on the display (knowledge in the world) that links to a user’s prior knowledge (knowledge in the head) (Norman, 2002). Analysis of user interaction case studies such as those cited above, however, suggests that users may not use knowledge in the world as designers may have expected when they were creating the display. In fact, research studies have revealed that people weigh costs and benefits at the moment to determine whether to use knowledge in the world or knowledge in the head (Fu & Gray, 2004; Gray & Fu, 2004; O’Hara & Payne, 1998). Users may in general prefer to minimize cognitive effort, but they minimize it for short-term rather than long-term benefits. In interactive environments, they seem to prefer a series of general, interactive procedures that provide fast, incremental feedback rather than specialized procedure(s) whose shorter duration may be invisible to the user (Fu & Gray). If there are perceptual-motor costs to identifying any action or narrowing the choices to the correct one, however, users may try to recall the correct option or mentally plan a series of steps to reduce the perceptual-motor actions (Gray & Fu; O'Hara & Payne). Consideration of long-term benefit to learn the optimal approach in a particular environment is rarely considered by users, though it may be rational based on their particular prior experiences. Gray, Fu, and colleagues have developed cognitive models to allow designers to predict user behavior from a bottom-up/microstrategy perspective, though they cannot support predictions when the users' mental model of the system or domain is incomplete or incorrect.

The challenge for designers is to create technologies that can effectively guide users in normal operations and support problem-solving for the errors users encounter. Users seem to learn to use new technologies based on experimentation and use of prior procedural and declarative knowledge, though no systematic study capturing the frequency and type of new technology learning has been found. Although recently developed cognitive models may facilitate some design decisions, particularly for interaction features, the process for predicting the broader knowledge set for target users is still unknown. The next chapter examines the question of prior knowledge use in interactions to investigate this issue.

Chapter 3: Evaluating Prior Experience in Human-Technology Interaction

Research on design for everyday technologies and web sites suggests that designers facilitate recognition of a target label or interaction feature based on prior knowledge rather than forcing users to recall the function (Nielsen, 1994). In the general psychological literature, recognition is frequently based on feelings of familiarity (e.g., Diana, Yonelinas, & Ranganath, 2008) and requires little cognitive effort (Craik & McDowd, 1987). With the breadth of technologies individuals have experienced, it is unclear how designers can elicit the right set of knowledge that is not only generally familiar but also specifically correct for available functions on a particular technology. The purpose of this chapter is to describe research investigating the use of prior knowledge in human technology interaction (HTI). I will first elaborate on how prior knowledge is used in technology interactions and then describe user problems managing conflicts and errors with prior knowledge. I will then review research on the use of reason in resolving issues with prior knowledge.

Studies on use of prior knowledge

Although research has frequently cited the use of prior knowledge in untrained interactions, few research studies have systematically investigated the types of prior knowledge that are used in everyday technologies. However, Blackler's (2006) dissertation provides a thorough investigation of the role of prior knowledge in intuitive interactions such as those everyday HTIs that are the focus of this paper. In particular, she described intuitive use of products as "utilizing knowledge gained through other experiences. Therefore, products that people use intuitively are those with features they have encountered before." (Blackler & Hurtienne, 2007, p. 38).

Blackler (2006) conducted two experiments to observe usage and evaluate proposed measurements for intuitive interactions with a digital camera (Experiment 1) and a universal remote (Experiment 2). Both experiments used similar methods and measurements, with minor adjustments reflecting findings from Experiment 1. Therefore, the common research method will be presented, but results will be discussed separately.

Participants with differing levels of experience with technologies, particularly the digital camera and universal remote, were tested in a calm and permissive environment to promote intuitive use (Blackler, 2006). Participants were instructed to think aloud as they attempted to execute two or three functions with the device, and they were encouraged to try to figure out operation by themselves without a manual. After the tasks were completed, participants completed a technology familiarity questionnaire that recorded frequency and breadth of use of general technologies and those related to the target technologies. A structured interview completed the study. Variables, methods, and measurement tools are listed in Table 3.1, with the first two columns extracted directly from the text (Blackler, Popovic & Mahar, 2003b, p. 499) and the third column summarizing additional explanation from the text. Note from this table that *intuitive uses* were coded as those quick (less than 5 seconds) actions selected with no evident reasoning or elaboration. There is no reason to expect that all technology interactions with everyday products will necessarily fit these criteria, but the coding provides an approach for discriminating types of interactions that may be useful for design of methods in the current study.

Table 3.1.
Relevant variables, methods, and measurement tools for intuitive interaction (Blackler, Popovic & Mahar, 2003b, p. 499)

Dependent variables	**Methods and measurement tools**	**Explanation**
Time to complete all operations, smaller tasks or components of tasks	Observation using Observer Video Pro	
Correct, inappropriate, and incorrect uses of camera features	Observation using Observer Video Pro	
Conscious reasoning apparent during each use	Observation using Observer Video Pro Concurrent protocol	*intuitive* – fast decision (< 5 sec.) with no evident reasoning; *quick comment* - enough reasoning to verbalize a few words, *trial and error* - random playing with buttons in exploratory manner; *with working* - reasoning evident, *using manual* - outside help masked previous experience
% of first or only uses of features per participant that were intuitive	Observation using Observer Video Pro Concurrent protocol	
% of uses of each feature that were intuitive	Observation using Observer Video Pro Concurrent protocol	
Mistakes on each feature	Observation using Observer Video Pro Concurrent protocol	measured as mistakes per feature and number of unsuccessful total uses per feature
Participants' level of technological familiarity	Technology familiarity questionnaire	List of common or particularly relevant high technology (e.g., this specific camera, same manufacturer but different model, mobile phone, PDA, web browser); Products rated on frequency of use – from 6 (daily) to 0 (never); Total calculated as a sum of frequency weighting factors for each product.
Familiarity of each feature	Structured follow up interview	List of common or particularly relevant high technology (e.g., this specific camera, same manufacturer but different model, mobile phone, PDA, web browser); Each product rated on number of features used (use manual, as many discovered without manual, just enough to use, limited knowledge limits use, none)
Intuitiveness of each factor of each feature, based on user expectations	Structured follow up interview	
Tendency to use experience of previous products when encountered with a new one	Structured follow up interview	Not included in Experiment 2 because deemed too subjective.

Experiment 1 revealed that prior knowledge of features from technology in general or specifically from a digital camera allowed participants to use those features intuitively (Blackler, Popovic & Mahar, 2003b). In fact, participants with higher technology familiarity scores (indicating broad and frequent technology usage) could use more features intuitively in their first encounter and were more successful completing tasks. Thus, broad and frequent technology usage may provide a more accessible repertoire of different features that might be used in a particular product like the digital camera. On the other hand, expert users of digital cameras with lower technology familiarity scores performed the tasks more slowly and effortfully, perhaps because these experts' functional knowledge was linked to a limited set of specific camera implementations. Some functions, however, were only discovered by experienced users of digital cameras, suggesting not only that general technology knowledge is important for intuitive use but also that domain knowledge contributes to usage.

Familiarity and first time usage of particular features were useful measurements for intuitive interaction because they allowed assessment of prior experience (Blackler, Popovic & Mahar, 2003b). Familiar features were used intuitively more often, and unfamiliar features required additional time and effort due to trial-and-error usage. Intuitive first/only uses required significantly less time to complete. A high percentage of intuitive uses were correct vs. inappropriate or incorrect, suggesting that intuition is generally correct but not perfect. In fact, those usages that were quick but inappropriate or incorrect may have been transferred from a different technology than the designer intended.

Results from Experiment 2 were similar to those from Experiment 1(Blackler, Popovic & Mahar, 2003a). In particular, mean familiarity of features had a strong correlation with the percentage of intuitive uses of features and with the percentage of intuitive first uses. Most mistakes were reported to be due to size or labeling of buttons, lack of familiarity of specific features, and lack of awareness of mode settings. Anxiety may have interfered with successful and intuitive use. For several participants with low technology familiarity scores, once they had experienced difficulty with a task, they tried alternative strategies to continue but could not even use features they had used successfully in the past. Overall, participants with lower technology familiarity score made more mistakes and needed more time to resolve their mistakes.

Based on findings from these experiments, Blackler, Popovic, and Mahar (2006) proposed three design principles (p. 10):

1) Use familiar features (including affordances, function, location, appearance of feature) from same domain;
2) Transfer familiar things from other domains to make obvious how to use less well-known functions;
3) Use redundancy and internal consistency within the product and system;

These principles were formalized into a model called the intuitive interaction continuum (see Figure A.1 in Appendix A). This continuum was created to guide designers in developing products that could be used intuitively. The continuum aspect of the model suggests that there may be a range of features available based on the type and level of knowledge available for target users. On the left side of the continuum, body reflectors is a term from industrial design literature that means products or parts for which humans can easily perceive potential fit with their body because they "resemble or mirror the body [or body part] because they come into close contact with it" (Bush, 1990, p. 2).

Headsets, shoes, and eyeglasses are examples of these items that may be perceived and used as easily as physical affordances (Blackler, 2006). Thus, most humans are likely to have learned their fit and functionality at an early age and to be very familiar with them. On the right side of the continuum, however, only a small number of individuals may be able to access the transferred features based on limited exposure to a particular domain.

The Blackler et al. (2003b) research on prior knowledge use with everyday technologies is an important contribution to the overall goal of my dissertation for three reasons. First, the experiments demonstrate that a systematic approach to evaluating familiarity and user expectations in HTI is possible. Second, Experiment 1 suggests a predictable difference between how users with broad technology experience but limited domain experience and users with more limited general technology experience but deep domain experience interact with a device. This finding may inform the choice of feature selection by designers based on which user group will be more prevalent. Third, the continuum of knowledge and experience that could be used in design provides an interesting framework for selecting features based on user knowledge. It may be possible in subsequent experiments to manipulate the types of knowledge expected to be used to examine the factors leading to knowledge selection.

Two key questions emerge from these experiments. First, is the knowledge evaluated by users at the correct level of analysis? The analysis was coded at the level of individual feature selections, which may be biased for bottom-up processing based on procedural rather than semantic knowledge. If knowledge is transferred based on similarity between mental models, however, top-down processing may produce different characteristics that may require different coding. Second, the experiments indeed seem to demonstrate that differences in experience are correlated with differential usage, but the experiments do not answer the "why" question adequately. For instance, why is one set of knowledge (general) selected instead of a different set of knowledge (domain)? Is one type of knowledge better for achieving a particular type of goal?

From a methodological perspective, the research also has several gaps that could be refined in a subsequent design. First, the definition of "intuitive" used to code and analyze the results may be circular. Along the same lines, level of verbalization is the key factor used in coding intuitive uses. This attribute has been identified in prior research (e.g., Hammond, 1996), but use of this attribute for coding can be problematic because researchers do not really know why the user did not verbalize at a particular point (e.g., perhaps they were distracted and forgot to verbalize but could still act based on prior knowledge). Using lack of verbalization as the coding criterion is also problematic because it suggests that the knowledge is unconscious, making it difficult to discover in a standard interview. As noted earlier, it can also be difficult to ascertain exactly what in the environment led to the user's implicit choice to use that knowledge. Also, though the measurements were applied in a systematic fashion, there is nonetheless a transformation of data that would be better supported with alternative data collection techniques that are more objective and consistent with the goal of understanding knowledge, or at least the familiarity users are accessing for their interactions.

Five other studies that investigate everyday technology interactions in adults across the lifespan were identified as listed in Table 3.2.

Table 3.2.
Studies investigating everyday technology interactions in adults across the lifespan

Reference	Everyday technology	Participants
Freudenthal (1998)	Exp 1. Photo CD computer software	16 younger adults (19-25) & 16 older adults (59-69)
	Exp. 2, Menued information retrieval system	16 younger adults (19-25) & 16 older adults (59-69)
	Exp. 3, Menued information retrieval system	25 younger adults (19-25) & 24 older adults (59-69)
	Exp. 4 Computer simulation of fish tank	20 younger adults (19-25) & 20 older adults (59-69)
	Exp. 5 Simulated medical laser device	20 younger adults (19-25) & 20 older adults (59-69)
	Exp. 5 Simulated medical laser device	24 younger adults (19-25) & 24 older adults (59-69)
Freudenthal (1999)	TV VCR	8 older adults (59-69)
Freudenthal (2003)	Digital thermostat	14 adults (25-73)
Kang & Yoon (2008)	Portable media player (PMP) MP3 player	30 younger adults (20-29) 30 middle-aged adults (46-59)
Langdon, Lewis, & Clarkson (2007)	Low technology functions in car Multimode digital camera	16 adults (23-84)

Across these studies and across the represented age groups, relevant experience affected learning more than age. Similar to the Blackler (2006) findings, differential background knowledge was implicated in performance differences in the Kang and Yoon (2008) study. Specifically, user frustration on a PMP was correlated with lower background knowledge of personal computers and the Internet. Additionally, frustration with the MP3 player was correlated with background knowledge of cell phones. An overall lack of knowledge about technology also led to more trial and error strategy vs. systematic exploration on the MP3 player. Younger and older adults used similar strategies to successfully interact with the systems, even if they were relatively complex (Freudenthal, 1998; Freudenthal, 2003). Participants in both age groups learned more when instructed to learn as much as they could about the system with the discovery learning paradigm than when instructed to complete specific tasks (Freudenthal, 1998). Age-related effects identified in these studies will be discussed in Chapter 4.

Together, these studies corroborate general findings described in Chapter 2 that untrained users use prior knowledge in interacting with new technologies. Additionally, these studies reveal individual differences in use of prior knowledge based on breadth and depth of experience with other technologies. Users with more technology experience may also use different strategies when interacting with a new technology, including differences in "intuitive" feature selections and systematicity, but the breadth of functionality learned on the new technology seems more affected by instruction (i.e., discovery learning vs. completing set tasks).

Managing conflicts and errors with prior knowledge

One particular challenge with everyday technologies, especially those owned and operated by groups or organizations as most web sites are, is that the information on the system may change between user experiences. Although content providers and system developers may attempt to clearly label new information and to provide sufficient guidance for new operations, this information on the display may not be used for a variety of reasons. As described in Section 2.3, for instance, users may unconsciously ignore clear knowledge in the world in favor of prior knowledge in their head based on perceived costs and benefits for accessing each knowledge type (e.g., Fu & Gray, 2004; Gray & Fu, 2004). Another reason display information may be ignored is because it conflicts with prior knowledge. This section discusses this rationale by describing research about how users manage conflicts between prior learning and current displays.

One such study investigated how knowledge is acquired and updated on a web site (Jones, Farris, & Johnson, 2005). Two experiments tested the effect of schema development and inconsistent knowledge on web usage in an invented web site and domain that allowed control of relevant system knowledge users could bring to the task. In the first experiment undergraduate participants searched for the same set of information ten times. Web site navigation was simplified to include only back, forward, stop, and refresh commands. Results of this experiment showed that all participants steadily improved their interaction efficiency with practice and were almost perfect at the end (Jones, Farris, & Johnson, 2005). Participants seemed to initially use random selections to search for information, but they gradually developed a coherent organization schema for the animals to support perfect selection.

In the second experiment undergraduate participants learned initial information for the same invented web site (Jones, Farris, & Johnson, 2005). Participants then completed ten cycles of information searches using one of two versions of the web site. The two web site versions represented information consistent or inconsistent with the learned information, and web navigation was limited as described in the first experiment. Results showed that the majority of participants initially used correct selections, rising to greater than 90% in cycles 3-10. Performance on the inconsistent site approached those on the consistent site by the end of the experiment, but participants on the inconsistent site continued to have search difficulties even after five cycles of eventually finding the information. The researchers speculated that participants did not in fact use a complete schema to manage their navigation. Instead, information was stored in multiple ways, allowing redundant access for normal usage. In correcting errors, however, corrections could only be made using the schema subset active for achieving the current goal. If the next search for the information used the previously inactive subset, errors were made again until this subset was updated. Thus, the experiments together demonstrated how users gradually built and corrected a knowledge base used in HTI.

Another type of inconsistency users must resolve is choosing how to interact with a feature that is similar to different devices though it operates differently on each device. To extrapolate from Blackler's (2006) research, users may find that a new digital camera has borrowed interaction styles from an MP3 player, though some users may have already encountered this interaction on a video camera in a slightly different way. Designers then have to determine which technology example the user is likely to access. Research in non-technology areas suggests that knowledge previously used in the same environment and context as the current situation provides redundancy to primary cues in the target system, reducing the probability of errors such that there is only one likely option (Hogarth, 2001). For example, lower cognitive effort may be required to select between alternative options when perceptual discrimination derived from practice in specific contexts minimizes competition between alternatives and strengthens activation of the most likely option (Schneider & Fisk, 1984).

In Reason's 1990 book *Human Error*, he suggested that similarity or frequency is used to resolve conflicts between selections when multiple options are initially possible. Similarity matches between the current situation and the candidate are typically used in convergent situations when the situation provides multiple specific cues that uniquely identify one candidate (or a reduced number of candidates). In everyday technology situations, a particular device might be located in a specific context that provides cues about possible purposes and ways to start. For example, a touch screen with a microphone located near the front entrance of a big apartment complex may be used by visitors to phone apartment occupants for access. On the other hand, frequency matches are typically used in divergent situations such as category searches when the cues are poorly specified or the user has insufficient domain knowledge to interpret the cues. A technology example of this might be found in calling a customer service line for an unfamiliar company, only to be greeted by an automated attendant announcing options that make no sense to the caller. The caller may then remember that pressing 0 has been the most frequent option allowing them to get personal assistance even if that option is not announced. Research suggests that estimates of similarity and frequency are generated immediately and with low effort when the cues are presented. These estimates then guide metacognitive appraisals about which strategy to use or how to further evaluate the subset of candidates identified with the initial processes.

Use of reasoning in prior knowledge access

As described earlier in this chapter, familiarity is generally useful for exploring new systems by selecting labels and functions that have been successful in the past. If the environment is not completely regular, however, selecting the right option may not be a direct match but an integration of prior and new knowledge by reasonably filling in missing information that resolves critical differences (Reason, 1990). Feelings of familiarity provide one element to match prior information, but the retrieved information must then be analyzed for fit within the overall domain knowledge, progress to date, and current goal.

This analysis of fit can take many forms, but has been analyzed in the past as plausibility. In one study, four experiments were conducted to investigate how familiarity and plausibility guided exploration of constrained web sites (Payne, Richardson, & Howes, 2000). Participants learned information by reading a paragraph that increased familiarity for target terms. They then explored a web site with the same information using only menu search. Web sites were manipulated in different experiments to include new and implausible information.

Results showed that participants used plausibility as their first measure for possible match in selecting a particular menu option (Payne, Richardson, & Howes, 2000). If the options were not plausible within the set of information provided, they would not be chosen at all. Familiarity, however, was used strategically by participants. If the participant did not reach the information goal before using a menu path accessible from the current options, they chose an unfamiliar option because they knew that the familiar options did not work. If they had reached the goal through the given menu, however, they relied on the familiarity by choosing from the familiar options. Thus, the researchers speculated that individuals realized that they forget some information, and that they are more likely to not even recognize an option when there are more choices on a menu. Feelings of familiarity could be particularly helpful in avoiding known bad choices or recognizing when plausibility or another strategy may provide more reliable guidance for directing people toward their goal.

Accurate and efficient use of prior knowledge has been shown to depend on whether other possible selections are reasonable candidates. An eye tracking study was conducted to determine the effects of poor or reasonable distracters on basic performance measures as well as visual search strategies (Brumby & Payne, 2008). Results showed that the relevance of the distracters to the actual target affected not only selection time, but also visual search strategies. With distracters of medium relevance to the target, eye movements were slower to evaluate the options whereas “skipping” behavior was observed in menus containing targets that were poor distracters. This change in eye movements, typically an unconscious behavior, suggests that the strategic use of familiarity in prior knowledge also occurs at an unconscious level.

In summary, this chapter has illustrated that different types of knowledge are used in HTI depending on the user’s prior experience, but it is unclear how the specific knowledge used is selected by the user. Several challenges to predicting the knowledge selection were discussed. First, is knowledge selection primarily made at the feature (bottom-up) or mental model (top-down) level? Second, does general technology experience influence the ability to discover cues to knowledge selection at both levels? Third, how are other factors such as similarity, familiarity, and frequency used in knowledge selection? Last, in naturalistic untrained situations, how do users update and correct relevant knowledge for the technology of interest? Age differences in typical technology experience and breadth of general knowledge may also contribute to knowledge use for HTI. Before discussing the research design to investigate these questions, the last background chapter will review research about age-related differences in prior knowledge use in HTI.

Chapter 4: Aging and interactions with new technologies

For researchers interested in creating technologies that can help older adults remain active and independent, identifying opportunities for leveraging cognitive abilities that are maintained as individuals age is crucial. Previous research has found that prior knowledge helps users learn new concepts in spite of differences in cognitive abilities (Beier & Ackerman, 2005). Given that semantic knowledge remains fairly stable with age (Zacks, Hasher, & Li, 2000), this finding suggests that new technologies designed to leverage semantic knowledge in older adults may be successfully learned. The purpose of the current chapter is to review research investigating the use of prior knowledge by older adults in technology interactions. First, I review research on age-related differences in technology knowledge. Then, I review findings from studies introduced in Table 3.2 that investigated use of untrained technologies across age groups. Last, I briefly review age-related changes in cognitive abilities found to be important for HTI.

Age-related differences in technology knowledge

As discussed previously, successful use of technologies based on prior knowledge may be dependent on experience with a specific technology. Surveys consistently show that older adults typically have lower levels of technology experience than younger adults (e.g., Czaja, Charness, Fisk, Hertzog, Nair, Rogers, & Sharit, 2006; O'Brien, et al., 2008, Pew Internet & American Life Project, 2006). These lower levels of experience can decrease the chance that older adults will have the prerequisite knowledge for a particular technology without careful selection. However, there are two ways to understand the likely technologies known by older adults and to predict age-related differences in technology knowledge that may be used in interacting with new everyday technologies.

The first source for identifying likely technology knowledge is based on the technology generation for the current cohort of older adults. The technology generation concept was developed in research conducted by Docampo Rama (2001) regarding the set of technology-general procedural knowledge known by a cohort of individuals based on products available during their formative years. The concept was supported by prior research (Sackmann & Weymann, 1994, cited in Docampo Rama) which found that individuals who had experienced similar consumer products before age 25 exhibited similar interaction behavior at time of test. The interaction style for each generation was characterized by conceptual operations (tasks), interaction techniques (input and output devices) and interaction structures (procedures or functions).

Based on a detailed analysis of technologies available during the formative periods for adults in the Netherlands in the late 1990s, four technology generations were identified:

1) *Electro-mechanical*, featuring a 1-1 interaction between the device type and the conceptual technique with a single button per function. Technologies in this generation are characterized by numerous switches, rotary dials and push buttons. These were predominant in the 1960s.
2) *Remote control*, featuring separate devices with touch buttons to interact with a separate display. These were predominant in the 1970s.
3) *Displays*, featuring displays that allowed fewer buttons on the product because software-based displays presented new functions whereby single buttons supported multiple functions using mode buttons. These were predominant in the 1980s.
4) *Layered menus*, featuring new visual, software-based elements and menu-based navigation and selection. These were predominant in the 1990s.

Using these definitions, the typical older adult today (65+) is part of the electro-mechanical generation. Docampo Rama (2001) assessed older adults' operating technologies based on layered menu interaction styles, observing differences in types of errors, speed-accuracy trade-off, and self-efficacy. As expected by the dramatic difference between the electro-mechanical and layered menu interaction styles, menuing operations were particularly difficult. Designers could expect that knowledge of the interaction style of older users (which will change as the cohorts age) can set expectations for which interactions users will be most fluent. As noted previously in the description of Franzke's (1995) research, some interaction styles are particularly difficult to discover and remember; use of styles within the technology generation of target users may facilitate discovery and transfer.

A second group of sources for identifying likely technologies is comparative studies examining age differences in technology usage for similar technologies. In some studies, technology usage may be quite high and similar across age groups. For instance, 97% of younger adults (18-23), 96% of older adults (65-74), and 93% of older adults (75+) reported using the microwave oven at least occasionally (O'Brien & Olson, unpublished data). For other technologies, technology usage may vary dramatically between age groups. With digital cameras, 74% of younger adults (20-29), 50% of older adults (60-69), 31% of older adults (70-79), and 16% (80+) reported usage (Boehm, 2007). Technologies may be similar to a target technology either because of overall functionality and goals (top-down) or because of specific features and interaction styles (bottom-up). As described in Chapter 3, the question of which type of similarity is most relevant is still open.

Age-related differences in untrained HTI

Six studies examining differences in the use of untrained technologies across age groups were reviewed in Section 3.1, including the more extensive discussion of Blackler's (2006) "intuitive use" studies. Within these studies, findings consolidated around three major age-related effects. First, technology experience matters more than age in learning to use the technologies of interest (Blackler; Freudenthal, 1998; Kang & Yoon, 2008; Langdon, Lewis, & Clarkson, 2007). Older participants with sufficient technology knowledge (measured differently in each study) were more successful in completing target tasks than same-age participants with less experience. Only younger adults with more complete technology knowledge relevant for the target technology were, however, as successful when system complexity increased (Freudenthal).

The second age-related difference was that older participants were slower with longer interaction paths for completing the same tasks, even if technology or other background knowledge was controlled (Blackler, 2006; Kang & Yoon, 2008). Freudenthal (1998) also found that latency between clicks consistently increased for older adults with each step. Older adults have also been found to make more perseverative errors whereby they continued to unsystematically cycle through a set of menu options after making a mistake (Harada & Suto, 2008). Kang and Yoon noted this behavior in their middle-aged adults, though they called them encapsulation errors because users fail to progress toward the goal despite continued interaction. These errors not only extend the time and interactions needed to complete the task, but they may also increase user's anxiety that can further reduce the user's confidence and ability to recover from the error (Harada, personal communication). Thus, this experience of increased perseverative errors can lead to some older users' unwillingness to try new features on existing technologies or explore new technologies altogether (Langdon, Lewis, & Clarkson, 2007).

The third age-related difference emerging from examples of specific interaction difficulties and preferences was that older adults showed more difficulties than younger adults. In one study, 50% of older adults did not know how to navigate through TV/VCR menus with a remote control (Freudenthal, 1999). In another study examining use of digital thermostats, older adults had more difficulty finding hidden items and understanding icons (Freudenthal, 2003). On MP3 players where short and long button presses have different functions, older adults had more difficulty discriminating between the two (Kang & Yoon, 2008). On the portable media player, older adults used fewer complex interactions such as double clicks and drag and drop (Kang & Yoon). Older adults performed more trial and error (vs. systematic exploration) actions than younger adults, and they made more errors than younger adults in the process (Kang & Yoon). Blackler (2006) also reported that older participants used fewer "intuitive" selections than younger participants, particularly for first uses of a particular feature where the selection would likely have borrowed from a different technology. Last, two studies (Freudenthal, 1999; Langdon, Lewis, & Clarkson) reported that older participants were more reluctant to attempt the seldom-used, more unique functions. Although there may be multiple sources for these interaction difficulties, including motor control and perceptual decline, the overall pattern supports the concept of technology generations and suggests that re-use of the most frequent interaction styles may be particularly helpful for older adults.

Age-related changes in cognitive abilities

Beyond knowledge per se, there are many other cognitive abilities that affect successful HTI. This section will briefly review age-related changes in cognitive abilities that may be particularly relevant for evaluating use of prior knowledge for HTI, especially "knowledge in the world" that includes technology displays. First, the overall pattern of age-related changes in memory reinforces Nielsen's (1994) recommendation to promote recognition versus recall in display design. Specifically, the familiarity used in recognizing prior knowledge is preserved or at least less affected by age than recollection (Healy, Light & Chung, 2005; Yonelinas, 2002). Second, higher semantic memory for older adults can mitigate age differences for short menus, though this mitigation rapidly declines further into the menu structure where users are more dependent on short-term and working memory (Freudenthal, 1998). Working memory particularly seems important for users to track their place within menus (Mayhorn, Stronge, McLaughlin, & Rogers, 2004), though spatial memory has also been found to correlate with successful menu navigation (Pak, Rogers, & Fisk 2006). Because both working (Zacks, Hasher, & Li, 2000) and spatial (Bach et al., 1999) memory typically decline with age, display design based on label-reading with low need for storing prior selections could mitigate age differences.

Second, HTI design must optimize opportunities for recognition of the correct prior knowledge. Correct recognition is more challenging because it is based on episodic memory, which typically declines with age (e.g., Zacks, Hasher, & Li, 2000). In particular, items which are too similar can be difficult for older adults to discriminate because the hippocampus, used in encoding contextual details used for discrimination, is less able to encode fine distinctions between similar items (Elfman, Parks, & Yonelinas, 2008). Better selection of the appropriate prior knowledge may also require some recollection memory to retrieve specific details of the prior experience for effective discrimination (Malmberg, 2008). Thus, difficulties in episodic memory may interfere with prior technology re-use and actually introduce confusion beyond what a designer may envision based on their own experiences with selected prior technologies.

Third, older adults seem to have different strategies for selecting from prior knowledge versus retrieving knowledge on displays than younger adults. For instance, older adults continued to search for noun-pairs on a display even after practice on memorized paired items (Touron & Hertzog, 2004). Similarly, older adults continued to confirm displayed task instruction cues in a task switching experiment even when they did not provide new information (Lagrone & Spieler, 2006). On the other hand, older adults were more likely to use prior knowledge to answer questions about inconsistently presented information than younger adults, even though they were told that the presented information was always correct (Adams, 2006). These conflicting results make predictions about use of knowledge in the world or knowledge in the head more difficult.

In summary, older adults are likely to differ from younger adults in the way they interact with everyday technologies for several reasons. Firstly, their fundamental interaction knowledge is different based on differing devices available to shape this knowledge during their formative years. Secondly, as a group they are less likely to use the same complement of technologies as younger adults so that some target technologies are less familiar in general or in the same range of contexts and goals. Lastly, age-related declines in cognitive abilities relevant for HTI may modify their capabilities and strategies even if the base knowledge has the same familiarity, frequency of use, and recency. Although these effects have been demonstrated to a limited extent in several studies, no research has been conducted that specifically confirms these effects and facilitates behavioral predictions.

Chapter 5: Overview of the Research

Purpose

The purpose of this research was to examine the effects of prior experience and age on HTI. Of particular interest was a class of technologies called everyday technologies designed for interaction with no training and limited instruction or in-person assistance. The literature review described three gaps in the research that were addressed by the current studies. First, substantial research evidence has shown that adults can use technologies without training, but no systematic study has investigated the incidence of encounters with these devices in everyday activities. Similarly, research evidence suggests the common approaches used in first-time use with untrained technologies, but studies have not revealed the rate of first-time use success versus incidence of problems that the user must resolve.

Second, prior research highlights the role of prior knowledge and experimentation in successful use of untrained technologies, but the research does not reveal how effective prior knowledge is selected. Although experimental research suggests that familiarity and recency may contribute to selection when multiple sources of prior knowledge are available, the role of these factors has not been investigated in naturalistic environments.

Third, several studies have shown that technology experience is more important than age alone in predicting a user's success with an untrained technology, but unique errors and interaction characteristics have still been reported for older adults in these studies. These age-related effects may be due to different technology generations or levels of experience with selected target technologies used in design for a specific technology.

Research Design

Two qualitative studies were designed to assess the type of prior knowledge selected by the user for the interaction, how that information is selected, and age-related differences in interactions with untrained technologies. Both studies used extreme group designs in two ways. First, younger and older adults participated in both studies to help uncover age-related differences and to represent differences in breadth of everyday knowledge as discussed in the Introduction. Second, older adults with low and high technology experience were selected to disentangle interaction differences based specifically on depth and breadth of technology experience. The higher tech older adults were intended to represent a population approximately equal in experience to the typical younger adult in this study to allow testing for general experience effects on performance that are distinct from age-only effects.

The first study was a diary study designed to systematically collect participant encounters with new and infrequently used technologies over a ten-day period. Participants also recorded all technology interactions on the first day of the study to establish a baseline of their regular technology experience and frequency of use. Encounters with new and infrequent technologies were analyzed to assess how participants learned how to interact with the technology to accomplish their goal, particularly in reference to prior experience. All technology problems encountered over the study period were also analyzed to evaluate the role of prior experience in these problems and to identify error recovery strategies, particularly in reference to prior experience.

The second study was an observational study in which participants were monitored as they interacted with three everyday technologies. These technologies were selected to represent potentially relevant differences in prior knowledge as well as factors contributing to user reliance on prior knowledge such as device complexity, breadth of functionality, and previous task completion through other methods and products. Reference to prior knowledge was elicited from participants by asking them to do the following for each technology: describe system features, complete selected tasks, instruct an imagined friend on completing the same tasks, and report prior experience with key controls on the selected devices.

Research Hypotheses

Study 1. Dependent variables from Study 1 were based on self-report due to the nature of the study, but the systematic nature of the collection process was designed to facilitate reliability. The first goal of this study was to determine the technology repertoire for each participant group based on type of technology, frequency of use, and encounter rate within the 10-day period. With these data, typical age and experience differences could be identified by comparing each of these components for the repertoire. The second goal of the study was to understand the types of problems reported by participants according to the technology usage frequency and category. The third goal was to understand the role of knowledge in everyday technology use, differentiating the role of knowledge for successful vs. unsuccessful encounters, as well as the role of knowledge in resolving problems. For each goal age differences were assessed by comparing results for younger adults and high tech older adults, and experience differences were assessed by comparing results for high tech older adults and low tech older adults.

Based on previous research, I hypothesized that the number of technologies would be similar for younger adults and high technology older adults, but these older adults would experience more errors. Additionally, due to technology generation differences, I also expected that some technologies may be less successfully used by older adults in general, regardless of their overall technology experience. Lastly, I expected fewer encounters and more errors for low technology older adults due to less technology background that would facilitate effective problem-solving.

Among older adults, I expected that differential use of prior knowledge between the two technology groups with high technology older adults using prior knowledge more, not only to directly retrieve information from a prior success but also to more effectively evaluate display guidance and response feedback. Alternatively, high tech older adults might experience more problems than low tech older adults because their prior experience elicited transfer of irrelevant components that interfered with proper use of the current technology. Nonetheless, high technology older adults might ultimately succeed more because their higher overall technology experience engendered sufficient technology self-efficacy to persevere and identify effective support resources for the right solution.

Study 2. Dependent variables for Study 2 included both qualitative and quantitative data to evaluate age and experience differences in interacting with the same three technologies. As with Study 1, research hypotheses were based on two major sets of comparisons: between younger adults and older adults with high technology experience, and between older adults with high technology experience and older adults with low technology experience. Age-related differences were assessed using comparisons between younger adults and high tech older adults. Experience differences were assessed using comparisons between high technology and low technology older adults. Where relevant and possible, qualitative data were transformed into quantitative data after categorization to facilitate comparisons.

The primary goal of this study was to objectively assess the role of age and prior experience in everyday human-technology interaction. Experience differed not only among the participants, but also in the expected relevant experience that participants were able to access during their interactions. The three exemplar technologies differ in the expected relevant experience that participants had: one novel technology for which few participants were expected to have specific relevant experience and little similar experience; one current, simple technology for which younger adults and high tech older adults were expected to have had experience with similar technologies; and one "classic" technology for which all participants were expected to have relevant experience. Although this was an exploratory study focused on describing the human-technology interactions with a focus on effects of prior experience, I nonetheless had hypotheses that will be described based on either age-related or experience-related differences.

Age group comparison. Quantitative measures collected for this study are typical for usability analysis such as task success rate, optimal task completion rate, task completion time, and interaction length. Based on prior research, I expected higher values for all measures except task success rate. Error rate, task completion time, and interaction length were likely to be higher as they indicate the different interaction style reported for older adults whereby increased clicks are used by older adults to recover from errors because they do not respond to interface guidance as effectively as younger adults (Kang & Yoon, 2008). Higher error rates may also be more likely for older adults due to inability to discriminate between similar experiences (e.g., different web pages on the same web site) in successful vs. unsuccessful prior navigations. Lower numbers of successful task completions in which participants complete the task but with errors may also reflect sufficient experience to resolve errors but retrieval of several possible methods that must be tried. Thus, overall, I expected quantitative comparisons to reveal that even with experience, high tech older adults still interacted differently than younger adults.

Participants' subjective perceptions of their interactions may also provide some insights regarding the role of prior experience in everyday technologies. If participants had no prior experience with the specific or similar technologies, for instance, they may express more frustration with the technology though no specific element of cognitive workload is rated higher. Alternatively, their lack of experience may lead to satisfaction with any level of success they achieve. Given the high similarity of general technology experience expected for both younger adults and high tech older adults, I expected both to rate higher frustration for the novel technology without designating a particular aspect of cognitive workload as the reason.

Qualitatively, I expected that more robust functional knowledge of a technology type would lead to more successful use for some technologies. An individual with substantial knowledge of the task process and domain should be able to guide their step-by-step interactions even with a completely new version of a product from the well-known domain. Thus, I expected that older adults would be more likely to use this latter rationale for the "classic" technology due to experience with the tasks across multiple versions of the same product type. Younger adults, however, would have only experience with a few versions of this classic product type, leading to technology knowledge with limited generalizability. A more robust experience set with different recent PC and Internet applications, however, could lead to easier use of the novel technology for younger adults who may be more likely to interact with new technologies in their school work than older adults who are more likely to be retired. Due to the nature of this functional question, it was important to assess participants' prior experience with the most relevant technologies for each study technology to understand the likely repertoire an individual would be using.

Experience comparison. Similar analysis was conducted between high tech and low tech older adults, but prior research suggests several expected differences from the age group comparison. From a quantitative perspective, I expected that the dominant difference for low technology older adults would be an inability to complete some tasks, particularly on the novel technology. Even on the simple technology, completion time and interaction length were expected to be longer. Subjectively, I expected that low tech older adults would rate cognitive workload to be higher on several dimensions, though satisfaction would be fairly high even if they were not successful in completing the tasks because their expectations for their performance were lower.

From a qualitative perspective, I expected that the low tech older adults would be able to use a new exemplar of a classic technology as well as high tech older adults though the completion time may be longer. Because they were expected to have a smaller technology repertoire than high tech older adults, low tech older adults might be more likely to review labels and examine controls carefully to determine how to interact with a new technology. High tech older adults, however, might be as likely to use a trial and error approach as younger adults. Thus, high tech older adults may be expected to make more actions in error due to a preference for trial and error as well as a broader technology repertoire that may generate conflict between two likely reference technologies for a new function.

Chapter 6: Study 1 Method

Participants

The participants were 10 younger adults, ages 18 to 28 years, and 20 older adults, ages 65 to 75 years (See Tables 6.1 and 6.2 for an overview of the participant characteristics.) A total of seven participants, one younger adult and six older adults, were replaced during this study as described in Appendix E. Younger adult participants were recruited from the undergraduate population at the Georgia Institute of Technology. Older adults were recruited from a laboratory database of community-dwelling participants, with equal numbers of high and low technology users. Ten participants were included in each group to double the minimum number recommended for identifying all errors in usability testing (Nielsen, 2000).

High and low technology experience levels were determined by determining participant technology experience scores. Similar to the technology experience framework used by Kang and Yoon (2008), a technology experience score was used to identify participants in the top and bottom thirds of their age cohort according to technology breadth and depth of experience in representative everyday technologies. As shown in Table 6.3, *t*-tests ($p<.05$) did not identify significant differences in technology experience between younger adults and high technology older adults. T-tests did reveal that high and low technology older adults only differed in technology experience. Perceptual speed differences found between younger adults and high technology older adults are fairly typical (e.g., Czaja et al., 2006.).

All participants were native English speakers with visual acuity of 20/40 for far and near vision (corrected or uncorrected) and normal hearing acuity (hearing to at least 3000 hz, corrected or uncorrected, assessed with Earscan Audiometer (Micro Audiometrics, 2008). Participants received either course credit of six hours or monetary compensation of $108 for their participation in this study.

Table 6.1.
Participant Demographics for Study 1

	Younger Adults (n=10)		***High Tech Older Adults (n=10)***		***Low Tech Older Adults (n=10)***	
	M	**SD**	**M**	**SD**	**M**	**SD**
Age	20.40	1.35	71.20	2.78	72.70	1.77
Gender						
Male	5		4		4	
Female	5		6		6	
Highest level of Education						
Master's degree			1		2	
Bachelor's degree	1		7		1	
Some College/ Associates degree	7		2		2	
High School Grad/GED	2				5	
Ethnicity						
African American	1		1		5	
Hispanic Caucasian	1		0		5	
Non-Hispanic Caucasian	4		8		0	
Other	4		0		0	
Annual household income						
<= $30,000	3		2		7	
$30,000-$60,000	2		2		1	
> $60,000	3		3		2	
other/not mentioned	2		3		0	
Health compared with others of same age						
Excellent	3		5		1	
Very Good	4		3		3	
Good	3		2		6	

Table 6.2.
Ability Test Scores

	Younger Adults (n=10)		***High Tech Older Adults (n=10)***		***Low Tech Older Adults (n=10)***	
	M	**SD**	**M**	**SD**	**M**	**SD**
Digit Symbol Substitution[1]	71.50	13.67	56.80	17.14	45.00	12.48
Reverse Digit Span[2]	8.60	2.12	6.80	2.90	6.40	2.37
Shipley Vocabulary [3]	32.30	2.67	33.80	4.87	32.40	5.72
Technology Experience[4]	19.20	1.75	18.10	1.73	7.90	1.60

Notes: [1]Perceptual speed, number correct (Wechsler, 1997); [2] Memory span, number correct (Wechsler, 1997); [3] Vocabulary, number correct (Shipley, 1940); [4]Level of experience with everyday technologies (Maximum=24). See Appendix B for description of algorithm.

Table 6.3.
T-tests for Demographic and Ability Differences between Groups

	Younger vs. High Tech Older Adults	High Tech vs. Low Tech Older Adults
Age		-1.44
Digit Symbol Substitution	2.12*	1.76
Reverse Digit Span	1.59	0.34
Shipley Vocabulary	-0.85	0.59
Technology experience score	1.41	13.71*

Note: *p<.05.

Older adults were selected from a population of community-dwelling adults who had recently participated in a battery of cognitive tests and completed demographic and technology experience questionnaires.

Materials

Ability tests. The ability measures were the Shipley Institute of Living vocabulary scale (Shipley, 1940), the Reverse Digit Span test (Wechsler, 1997), and the Digit Symbol Substitution test (Wechsler). Participants also completed a demographics, health, and technology experience questionnaires (Czaja, Charness, Fisk, Hertzog, Nair, Rogers, & Sharit, 2006).

Technology Screening. High and low technology experience levels for community-dwelling older adults (ages 65-75) were determined through assessment of recent technology usage. Technology experience questionnaires (Appendix C) were administered over the years 2006-2008 in three geographically separate and ethnically diverse areas of the United States as part of the CREATE research program (www.create-center.org). Data were collected separately by laboratories at participating CREATE universities according to a standard protocol. Participants were screened for cognitive impairment according to the Short Portable Mental Status Questionnaire (criterion: ≤ 2 errors; (Pfeiffer, 1975) and the Weschler Memory Scale (Logical Memory subscale; age-adjusted criterion; (Weschler, 1997)).

From these surveys, a single measure of technology experience was developed (similar to Kang & Yoon, 2008). This measure was comprised of everyday technology frequency, Internet frequency, breadth of everyday technology use, and breadth of computer functional knowledge. Specific questions reflecting these components were selected from the CREATE (www.create-center.org) survey to use in calculating this measure. Responses to selected questions were coded and summed into a single score as described in Appendix B. This score was computed from 110 older adults (ages 65-75) in the CREATE survey. Boundaries for the top and bottom thirds for this population were calculated as shown in Table 6.4, with top and bottom thirds designated for high and low technology experience, respectively. Atlanta area CREATE participants whose scores placed them into high and low experience groups were selected into a database subset for standard recruiting procedures in the present research.

Table 6.4
Technology Experience Level Calculation

Technology Experience Group	***Technology Score Range***	***Number of Older Adults (65-75) in CREATE database (n=111)***	***% of Older Adults (65-75) in CREATE database***
1 (Low)	0-11	39	35%
2 (Medium)	12-15	31	28%
3 (High)	16-24	41	37%

All participants completed the technology experience questionnaire during the study, and scores were recalculated. These study scores were used to confirm placement within the appropriate technology experience group. Participants whose scores now fell within the medium technology experience group were replaced.

Orientation. To ensure that participants had a similar, reliable understanding of everyday products of interest for this study, two different presentations of everyday technologies were shown to each participant before they began the study. First, participants viewed a video called “Day in the Life” that documented all technologies one individual used in a typical day (Neo Insight, 2007). This video included all technologies listed in Table D.1 in Appendix D-1. Second, participants viewed an online Power Point slide show with digital pictures of technologies used by pilot participants and other devices participants might be likely to use based on recent technology surveys (e.g., O’Brien et al., 2008; Pew Internet & American Life Project, 2006). This slide show included all technologies listed in the Table D.2 in Appendix D-1. One point emphasized in these presentations was that there may be different versions of the same device that a participant may use, though the frequencies of the devices may be different. For instance, a participant might use their own cell phone every day such that they are very familiar with menus, labels, interaction modes, etc. on this cell phone. If they used a friend’s cell phone for the same functions, however, they might find different menus, labels, interaction modes, etc. that must be used correctly to complete the function.

Technology inventory. Prior research studies have used different technology experience questionnaires to determine the specific background of participants relevant to tested technologies in their studies (e.g., Blackler, 2006; Kang & Yoon, 2008). Obtaining this current technology experience was particularly important given the familiarity and recency effects of this prior knowledge on selection of specific target knowledge (Reason, 1990). For the current study, participants reported every technology used in the 24-hour period of the first day of their study. As shown in Appendix D-2, participants reported all devices and applications used that day, as well as the time spent using each technology on that day. On the third page of the inventory, participants were also asked to report other frequently used everyday technologies as they were encountered, though they were not used on the first day of the study. A typical frequency of usage at least once per week was used to differentiate frequent from infrequent technologies (i.e., those reported only once on the inventory or with each use on the daily journal as described below).

Daily Journal. Diary studies have been used in which participants can report events as they occur, while they are completing their daily tasks. (e.g., Mamykina, & Mynatt, 2006; Voida, Grinter, & Duscheneaut, 2006). In the daily journal (shown in Appendix D-3), participants recorded each new technology, new feature/function on standard technology set, infrequently-used technology, and infrequently-used feature/function on standard technology set. In addition to noting the time and date of the encounter, they also reported additional details about the encounter such as the availability of instructions and individuals to help them.

Participants were also asked to report every technology encounter in which they experienced a problem, including those frequently used, everyday technologies reported on the inventory. No exemplars or specific instructions for problem identification were provided to allow participants to determine problem definition on their own, but participants were explicitly directed to include all encounters in which they had questions such that final determination could be made during the follow-up interview. A journal instruction sheet (Appendix D-4) was given to participants and reviewed with them during the orientation session.

The journal was kept by participants for ten consecutive days beginning on a Friday and ending on a Sunday ten days later. This timeframe was chosen to provide five consecutive days of typical daily activities such that the study would capture technologies within a fairly routine day. Two weekends were also included to allow for different activities that may be more likely to occur on weekend days. Typicality of this period in each participant's life was reported during the structured interview.

Although many recent diary studies use technology itself (such as personal digital assistants and voice recorders) to capture events, this study allowed participants to use either a Microsoft Excel spreadsheet or a printed version of the journal for two reasons. First, one of the older adult groups was at the lower end of technology experience, which could confound accurate technology entry. Second, pilot participants (one older adult and three younger adults) reported that the printed version was sufficiently easy for them to use given the number of technologies of interest they encountered during the entire study period. Both documents were given to participants with sufficient number of blank pages to facilitate access at all times. Participants were also given the option to complete both the inventory and journal electronically, but all chose to write the documents by hand except for one low tech older adults who completed both using a manual typewriter.

Structured Interview. The structured interview was developed to guide users through recollection and elaboration of their encounters with new and infrequently used technologies documented in the journal. As shown in Appendix D-5, three categories of questions were developed to elicit appropriate elaboration about the strategies and hypothesized problem facilitators and inhibitors according to the participant's initial description of the event. Within each category, encounters were probed to assess prior knowledge used in the interaction. If prior knowledge was used, participants were also asked to assess recency and depth of experience for the reference technology or procedural/semantic knowledge. Errors and problem resolution strategies were also probed to elicit descriptions of additional information that may have been retrieved.

The questions were purposefully ordered such that each event was recalled in detail to facilitate logical recollection. A general question was posed at the end to allow participants to add information not discussed and to summarize the event, particularly the reasons for success or failure with the technology. The categories were ordered such that those incidents likely to elicit the most frustration (used before but encountering a problem) were presented after participants had described successful encounters. Interviews were audio recorded for full transcription, coding, and analysis.

Procedure

The study took approximately nine hours for older adults and six hours for younger adults. Approximately three hours of the study were conducted in the laboratory and the rest of the time was outside of the laboratory. Three additional hours were allocated for older adults based on the pilot study, and confirmed by participant reports at reminder calls and during the follow-up lab visit, for detailed documentation and periodic journal reviews throughout each day. Participants were scheduled for the study based on availability for orientation no more than 24 hours before the Friday of the study start and structured interview no more than 36 hours after the Sunday of study end. Materials given to participants can be found in Appendix D (D-2 through D-4).

Participants were first given a detailed description of the study, and then questions were answered about the description and their participant rights. Participants then provided informed consent. They were then screened for visual and hearing acuity before completing the Digit Symbol Substitution test (Wechsler, 1997), the Reverse Digit Span test (Wechsler, 1997), and the Shipley Institute of Living vocabulary scale (Shipley, 1940).

Participants were then oriented to their primary task of documenting their encounters with new and infrequently used technologies. They were asked to remember the technologies they had used since they woke up this morning to connect the study with their own experiences. A pre-recorded video and slides of digital photos were then used to show the technologies of interest as described above in Orientation. As participants viewed the video and digital photos, they were able to ask any questions about why the technology shown fits the definition of everyday technologies.

Participants were then given a copy of the technology inventory to complete on the first day of the study. Instructions for completing the technology inventory were reviewed and questions answered. Then, participants were given the daily journal to complete on all ten days of the study. Instructions for completing the daily journal were reviewed and questions answered. For both the technology inventory and the daily journal, participants were instructed to include any product that required electricity or battery to operate. They were instructed to err on the side of including any device that may fit this description rather than excluding it if they had any questions.

After the orientation, participants were given a contact sheet, background questionnaire, and technology questionnaire to complete before they returned to the laboratory after ten days for the structured interview. Participants were advised of the reminder process (described below) and asked for the best contact information for telephone, texting, or email reminders according to their preference. Lastly, the scheduled time and date for the structured interview was confirmed.

On the first day of their journal-reporting, participants began reporting all technologies in their technology inventory. If they encountered new and infrequent technologies, products or features on existing products, or problems with even frequently used products, these encounters were reported in the daily journal. For each encounter, participants reported the date and time of the encounter, a brief product description, and a task description. Then, participants reported whether they had used the technology (or function) before. Lastly, participants described any problems they encountered with this technology.

During the ten days of the study, participants were reminded of their participation with phone calls, text messages, or emails at their preferred time each day (see Table 6.5). The reminder included specific instructions for what information was to be reported on which document (i.e., the journal or inventory) on each day. Participants were also asked if they had any questions and given the researcher's contact information to pose these questions if direct contact was not made. On the second Friday of the study (Day 8), participants were also reminded of the time and date of their scheduled structured interview.

Table 6.5.
Communication Mode Selected for Participant Reminders.

	Younger Adults (n=10)*	***High Tech Older Adults (n=10)****	***Low Tech Older Adults (n=10)***
Email reminder	4	5	1
Telephone reminder			
Text message reminder	7	6	9

Note: * One younger adult and one high tech older adult requested email and text or telephone reminders for part of the study time due to brief travel away from typical email access.

When participants returned to the laboratory for their structured interview, they were reminded of the study purpose and their participant rights. The contact sheet, background questionnaire, technology questionnaire, technology inventory, and daily journal were then collected from the participant before the structured interview began. As the audio recording began, participants answered questions about the typicality of the study time frame compared to their regular routine (Patel, Kientz, Hayes, Bhat, & Abowd, 2006). They then listened as the researcher reviewed the technology inventory and daily journal to confirm that all entries could be read. The researcher then reviewed the list of encounters, briefly coding each encounter based on the following criteria:

- A: NO for "Used Before" and NO for "Any problems"
- B: NO for "Used Before" and YES for "Any problems"
- C: YES for "Used Before/Frequently" and No for "Any problems"
- D: YES for "Used Before/Frequently" and YES for "Any problems"
- E: YES for "Used Before/Infrequently" and NO for "Any problems"
- F: YES for "Used Before/Infrequently" and YES for "Any problems"

During this coding process, any encounters reported that did not refer to a technology or did not meet the criteria for one of these categories were crossed off on the journal sheet. After all encounters were coded, participants were asked if any other unreported encounters were recalled that occurred during this time period. If there were, these encounters were documented and coded as described above. Participants reporting only frequently used technologies with no problems were questioned specifically about how they shopped, cooked, cleaned their house, and communicated with friends to elicit any encounters not previously recalled.

Using the coded encounters, the researcher then probed the encounters using the structured questions. Encounters were probed in category order such that all Category A and E encounters were discussed first, then Category B and F encounters were discussed, concluding with Category D encounters. A Category C encounter was discussed if it seemed relevant to another encounter or if the nature of the encounter was unclear. Participants were allowed to take a break as needed as long as the break did not occur in the middle of a specific encounter discussion. After all coded encounters were discussed, audio recording was stopped. Participants were given an exit interview (Appendix D-6) and study debrief (Appendix D-7). Lastly, participants were compensated as appropriate for their age group and time spent on the study.

Chapter 7: Study 1 Results

This chapter describes the results of the diary study in which participant encounters with everyday technologies were collected and analyzed. This chapter is organized by the three primary research questions. First, what is the repertoire of everyday technologies among individuals across age groups and technology experience levels? Within the repertoire, reported technologies are presented by category and frequency of use for each participant group. Second, are participants successful using these technologies? Problems are described for each participant group by problem type and category. Third, what is the role of knowledge in everyday technology use and does it differ by age and experience? Technology encounters were analyzed to identify the availability of prior knowledge, use in successful encounters, use in problem encounters, and use in resolving problems.

Age and experience differences were evaluated through two separate comparisons for each set of questions. Age differences were assessed by comparing the measures for the questions of interest between younger adults and the high technology older adults. Experience differences were assessed by comparing measures for the questions of interest between high technology older adults and low technology older adults.

Representative Nature of Data Collected

To claim that an understanding of everyday technology use can be gained from these data, it was crucial that the study period accurately reflected participants' typical schedules. To reflect typical use in this timeframe, it was also crucial that the self-report methodology and attention to technology use did not substantially change participant behavior. As shown in Table 7.1, most participants reported that the study period was typical and that their behavior was minimally affected by the study.

Table 7.1

Description of Participant Perceptions of Study Period and Study Effect on Behavior

	Younger Adults (n=10)		***High Tech Older Adults (n=10)***		***Low Tech Older Adults (n=10)***	
	M	***SD***	***M***	***SD***	***M***	***SD***
How typical was this 10-day period for you? 1=completely unusual, 5=completely typical	4.00	0.94	3.8	0.79	4	0.67
Did you have guests during this time period? % yes	20%	-	10%	-	10%	-
Did you travel out of town during this time period? % yes	40%	-	30%	-	10%	-
Were you ill or injured during this time period? % yes	10%	-	10%	-	40%	-
Entering the technology interactions was easy. 1=completely agree, 5=strongly disagree	1.9	1.2	1.7	0.67	1.7	0.67
Did this journal entry process interfere with your life? % yes	0%	-	10%	-	0%	-
Do you think that this journal entry process changed your behavior? % yes	20%	-	0.3	-	0.2	-

Everyday Technology Repertoire

Overall analysis approach. The first set of analysis was developed to describe the everyday technologies participants used during the study period, particularly to establish the types and usage frequency of technologies used. Technologies reported on the participant inventory and journal were summarized and organized in several ways. First, technologies were collected into a single list for each participant group. Details about the frequency of use and problem incidence were also included in the summary lists. These summary lists were then organized in separate analysis to focus on usage by category, frequency, and encounter type within the 10-day period.

Technology type analysis. Within each participant group, items were counted to identify the number of participants in each group using the reported technology. Note that as participants were instructed to separately report multiple instances of the same technology (e.g., own computer and wife's computer, own microwave and friend's microwave), counts maintained unique instances by collapsing across number of technologies per person (e.g., 1st desktop PC, 2nd microwave). Categories were then created across participant groups to describe the types of technology included in the reports as shown in Table F.1 in Appendix F. Technologies on group lists were then categorized and summed. The resulting list, shown in Table 7.2, was analyzed to establish the technology repertoire for each participant group.

Table 7.2.
Total Technologies Used for 10-day Period

	Younger Adults (n=10)	***High Tech Older Adults (n=10)***	***Low Tech Older Adults (n=10)***
Entertainment & leisure	39	29	19
Home health care	1	7	5
Kitchen	29	58	39
Non-PC office	15	13	10
Other home	42	58	53
PC & Internet	58	35	5
Personal care & fitness	24	21	13
Shopping & purchase	23	28	15
Telephone & communication	18	24	13
Transportation	20	28	18
Total	269	301	190

Note: Data includes multiple instances of a single technology use with each category.

Table 7.2 shows that both younger adults and high tech older adults reported a substantial number of technologies used during this time period, and a chi-square test of independence revealed no significant age effect of number of technologies (p>.05). Chi square tests of independence were conducted to assess age differences by category. Results showed that younger adults reported using more PC and Internet technologies ((χ^2 (1, N=93)=5.69), *p*<.05), whereas high tech older adults reported using more kitchen technologies ((χ^2 (1, N=87)=9.67), *p*<.01). Both effect sizes were small (φ for PC and Internet technologies=.25; φ for kitchen technologies=.33). To identify significant age differences in the distribution of technologies across categories, chi square analysis was performed to assess goodness of fit. A significant effect of age was found in the comparison between younger and high tech older adults (χ^2 (9, N=570)=25.19), *p*<.005), with a small effect size (Craven's *V*=.21). Residual analysis revealed that the higher younger adult usage of PC and Internet technologies accounted for this effect.

Examining Table 7.2 for experience effects reveals that high tech older adults reported over 100 more technologies than low tech older adults, an experience difference that was significantly different according to chi-square test of independence ((χ^2 (1,N=491)=25.09), *p*<.001), with a small effect size (φ=.23). Nonetheless, low tech older adults still reported 190 technologies during the 10-day period, which is substantial.

High tech older adults reported numerically more technologies in each category than low tech older adults. Chi-square tests of independence for each category, however, revealed that the experience difference was significant only for PC and Internet technologies ((χ^2 (1,N=40)=22.5), *p*<.001) with a large effect size (φ=.75), and shopping technologies ((χ^2 (1,N=43)=3.93), *p*<.05) with a small effect size (φ=.30). Chi-square analysis of the distribution across categories revealed no significant effect of experience (*p*>.05). Figure 7.1 shows the distribution of technologies across categories for each participant group.

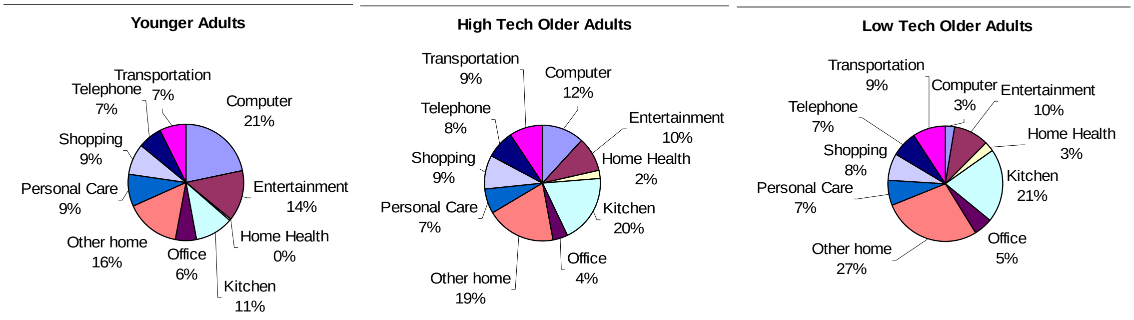


Figure 7.1. Percentage of reported technologies from 10-day period by category.

Breadth of technology repertoire. To discriminate the breadth of different technologies used within each participant group, a second calculation was conducted on the data set. Unique instances of technologies within the participant groups were counted, eliminating multiple counts of the same technology used by different people. Note, though, the distinctions of multiple instances of a device used by the same person (e.g., own laptop and community PC; own microwave and friend's microwave) were maintained such that a category could have own PC, second PC, third PC, etc. as needed. Table 7.3 shows the number of unique technologies reported within each participant group.

Table 7.3.
Unique Technologies Reported within Each Category

	Younger Adults (n=10)	*High Tech Older Adults (n=10)*	*Low Tech Older Adults (n=10)*
Entertainment & leisure	21	13	9
Home health care	1	4	3
Kitchen	11	22	16
Non-PC office	8	8	5
Other home	14	28	26
PC & Internet	16	13	2
Personal care & fitness	13	12	9
Shopping & purchase	13	15	8
Telephone & communication	5	8	4
Transportation	11	14	7
Total	117	137	89

Note: Date includes represents unique instances of a technology within each category.

Examination of potential age differences revealed that high tech older adults reported more unique technologies than younger adults, but this effect was not significant according to chi-square independence test (p>.05). The difference in unique PC and Internet technologies between younger and high tech older adults was smaller than the total counts, and the age effect in this category was no longer significant in the chi-square independence test(p>.05). Now, however, the only significant age effect according to the chi-square independence test was the higher number of unique other home technologies by high tech older adults ((χ^2 (1,N=42)=4.67), p<.05), with a small effect size (φ=.33). Chi square analysis on the distribution of unique technologies across categories revealed no significant effect of age (p>.05).

Examination of potential experience differences from Table 7.3 revealed that high tech older adults also reported more unique technologies than low tech older adults, and the effect was significant according to the chi-square independence tests ((χ^2 (1,N=226)=10.19), p<.005), with a small effect size (φ=.21). Although high tech older adults also reported more unique technologies in each category, the only significant difference according to the chi-square test of independence was in the PC and Internet category ((χ^2 (1,N=15)=8.07), p<.005), with a large effect size (φ=.73). Chi square analysis on the distribution of unique technologies across categories revealed no significant effect of experience (p>.05).

Average technology usage differences. The second analysis examining differences within the repertoire focused on describing average usage by participants within each group. From these category averages, comparisons could be made across age and experience to assess typical differences overall and within individual categories.

Table 7.4 shows average counts and range of technology counts for each category by participant group, along with significant differences found in t-tests of age and experience differences. Significant age differences were found for home health care (*t*(18) =-2.55, *p*<.05) and kitchen (*t*(18) =-2.17, *p*<.05) technologies, with high tech older adults reporting significantly more technologies in each category than younger adults. Significant experience differences were found for average number of PC and internet (*t*(18) =6.21, *p*<.001), telephone and communication (*t*(18) =2.2, *p*<.05), and total technologies (*t*(18) =3.50, *p*<.01).

Table 7.4.
Average Technology Counts by Category within the 10-day Period

	Younger Adults (n=10)				High Tech Older Adults (n=10)				Low Tech Older Adults (n=10)		
	M	*SD*	*Range*		*M*	*SD*	*Range*		*M*	*SD*	*Range*
Entertainment & leisure	3.9	3.03	(0-10)		2.9	1.66	(1-7)		1.9	1.45	(0-4)
Home health care	0.1	0.32	(0-1)	*	0.7	0.67	(0-2)		0.5	0.71	(0-2)
Kitchen	2.9	2.6	(0-8)	*	5.8	3.33	(2-12)		4.1	2.08	(1-8)
Non-PC office	1.5	1.27	(0-4)		1.3	1.16	(0-4)		1.0	0.82	(0-2)
Other home	4.2	1.55	(2-7)		5.9	3.18	(2-13)		4.7	2.83	(1-9)
PC & Internet	5.8	3.61	(2-13)		3.5	1.43	(1-6)	*	0.5	0.53	(0-1)
Personal care & fitness	2.4	1.78	(0-5)		2.1	1.2	(0-4)		1.3	1.95	(0-6)
Shopping & purchase	2.3	1.49	(0-4)		2.8	3.08	(1-11)		1.7	1.49	(0-4)
Telephone & communication	1.8	0.63	(1-3)		2.4	1.35	(1-5)	*	1.3	0.82	(0-3)
Transportation	2.0	1.49	(0-4)		2.8	1.87	(1-6)		1.7	0.82	(0-3)
Total	26.9	5.74	(18-37)		30.1	8.31	(18-44)	*	19	6.45	(11-29)

Note: *p<.05 for T-tests between neighboring columns.

Analysis of usage frequency. Prior research has suggested that the frequency with which a participant accesses prior knowledge may influence how the same or similar knowledge is used at a specified time (e.g., Reason, 1990). Therefore, the technology repertoire should also note usage frequency for the reported technologies. As shown in Table 7.5, data about frequency of use for reported technologies were collected in two documents. The threshold of at least weekly usage for frequent categorization was based on the assumption that a participant's knowledge about these technologies would be retrieved significantly more often than those used at longer intervals. Note that frequency categorization was made at the level reported by the participant (i.e., overall technology or feature) such that features could be designated as new or infrequent even though the overall technology may be frequent. For example, participants may use their cell phone on a daily basis but infrequently select a custom ring profile.

Table 7.5.
Experimental material source for reported technology frequency.

Usage Category	Usage Rate	Data Source
Frequent	At least once/week	Inventory
Infrequent	Less than once/week	Journal
New	Never used before	Journal

Table 7.6 shows a summary of the usage frequency of all reported technologies. Overall, the majority of the reported technologies were used frequently, and this effect was significant according to chi-square test of independence ((χ^2 (2,N=760)=494.66), p<.001) with a large effect size (φ=.81). In fact, the majority of reported technologies for each participant group was frequent technologies according to chi-square test of independence (younger adults: ((χ^2 (2,N=269)=127.95), p<.001) with a large effect size (φ=.69), high tech older adults: ((χ^2 (2,N=301)=220.55), p<.001) with a large effect size (φ=.86), low tech older adults: ((χ^2 (2,N=190)=494.66), p<.001) with a large effect size (φ=.81)). Chi-square analysis was performed to assess age and experience differences in the distribution of technologies by frequency. Neither analysis identified significant effects (p's>.05). Thus, the majority of technologies in an individual's repertoire was used at least weekly, a frequency that should reasonably establish these technologies as prior knowledge. Figure 7.2 shows the distribution of technologies for each participant group by frequency of use.

Table 7.6.
Frequency of Reported Technology Usage

	Younger Adults (n=10)	High Tech Older Adults (n=10)	Low Tech Older Adults (n=10)	Totals
Frequent Technologies	177	221	142	540
Infrequent Technologies	50	52	40	142
New Technologies	42	28	8	78
Totals	269	301	190	760

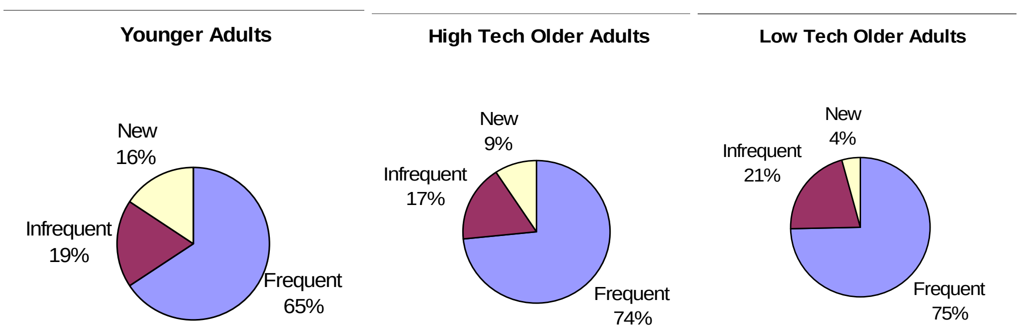


Figure 7.2. Percentage of reported technologies from 10-day period by frequency of use.

Technology repertoire summary. The everyday technology repertoire was investigated in two ways across participant groups: technology type and frequency of usage. First, similarities and differences in technology types among the participant groups were examined on an overall, breadth, and average basis. Analysis of overall counts of technology revealed no age differences in the number of technologies used, but younger adults reported a higher percentage of their technologies were PC and Internet technologies. These results were consistent with expectations that high technology older adults would use relatively the same number of technologies as younger adults. The fact that younger adults still used more of the PC and Internet technologies that were the primary basis for selecting the older adults as "high tech", however, suggests that younger adults may be more intense users of this technology category. The fact that a difference was not identified when the list was trimmed to unique technologies suggests that the source of the difference was that more of the younger adults use the same computing and internet technologies, perhaps for similar tasks. Older adults may have more heterogeneous computing and internet technology usage due to a wider variety of tasks they executed during this study period than full-time students during a college semester.

Other age differences in technology types were more consistent with expectations from prior research. Some variation was found in the categories for which high tech older adults reported more usage than younger adults, depending on the statistic used. The fact that these variations were found in kitchen and other home technologies was consistent with younger adults' higher likelihood of spending most of their time on college campuses with lower need for individual food preparation and home maintenance.

Experience differences in the technology repertoire were generally consistent with expectations. High tech older adults reported more technologies than low tech older adults, particularly in the PC and Internet domain. The fact that this technology category did not represent a significantly different percentage of technology types was somewhat surprising, but the effect of a higher count in this category may have been muted by the similar distribution in categories like home health, kitchen, office, and personal care. These other categories represent typical tasks that all independent older adults must complete regardless of technology experience. Thus, even low tech older adults report using a range of technologies.

Nonetheless, significant experience differences identified in two analyses may be useful for elucidating overall patterns and preferences. First, overall counts for shopping technologies were higher for high tech older adults than low tech older adults, though this difference did not surface in breadth or average analyses. As suggested by anecdotal reports during the structured interviews, low tech older adults may prefer to use non-technological means for shopping and getting money such as writing checks and visiting a human teller at a bank. Second, high tech older adults used a higher average number of telephone and communication technologies than low tech older adults. This may be due to use of more features in the same devices such as in cell phones. Alternatively, people who use more PC and internet technologies may be more likely to select a variety of communication technologies for interacting with other people.

The second approach to investigating the technology repertoire was examining the frequency of technology usage. Overall and in each participant group, the most reported technologies reported were used at least once per week. No significant age or experience effects were found in the distribution of frequent, infrequent, and new technologies. Thus, most of an individual's technology repertoire is accessed fairly frequently and may serve as prior knowledge that could facilitate (or interfere with) new and infrequent technologies. These differences will be considered further in the examination of participant journals about problems and use of prior knowledge for technology success.

Encounter Analysis

After examining the overall technology repertoire for participant groups, analysis turned to assessing the items of primary interest for the structured interviews: problem encounters with any technology and the use of knowledge for interacting with new and infrequent technologies. An encounter was defined as a participant's interaction with a specific technology at a specific date and time. Encounters were tallied from participant journals and the structured interview recordings based on these journals. The audio recordings were transcribed and coded for analysis as described below.

Approach to interview coding and analysis. First, structured interview transcripts for each participant were divided into separate files for each technology encounter. The initial and final questions from the structured question set were used to identify the beginning and end of each encounter. Each encounter file was then loaded into the MaxQDA data analysis program (Verbi Software, 2007) and coded with the frequency/success category assigned during the interview (as described in Chapter 6).

Encounter tally. Table 7.7 lists the number of encounters reported by participants during the 10-day period that were analyzed to examine technology problems and use of prior knowledge. This list includes all encounters discussed that provided specific answers to structured questions, excluding brief encounters reported by participants but for which time allowed minimal discussion (19 excluded for this reason). Note that in contrast to Table 7.6, the majority of the encounters were infrequent and new technologies for which the research question of prior knowledge use could be explored.

Table 7.7.
Everyday Technology Encounters Reported during the 10-day Period

	Younger Adults (n=10)	***High Tech Older Adults (n=10)***	***Low Tech Older Adults (n=10)***	***Totals***
Frequent Technologies				
Reported success	6	8	5	19
Reported problem	13	25	3	41
Infrequent Technologies				
Reported success	38	34	27	99
Reported problem	9	8	6	23
New Technologies				
Reported success	28	17	4	49
Reported problem	14	13	2	29
Totals	108	105	47	260
Percentage of Total	41.5%	40.4%	18.1%	

Note: Data from Journals.

Each encounter transcript was read and coded twice, once by the primary researcher and once by one of two research assistants. After initial coding development, coding was completed for five encounters. Comparisons of coding agreement found Kappa for the 1st and 2nd coders was .72; Kappa for the 1st and 3rd coders was .67. Disagreements were resolved by modifying the coding scheme and recoding. After ten additional encounters were coded, reliability for all 15 encounters was compared. Inter-rater reliability was now better than .70, a reliability substantially better than chance (McGill et al., 2004), with Kappa of .77 for 1st and 2nd coders and .71 for 1st and 3rd coders. Therefore, the remaining encounters were split by coders 2 and 3 and dual coded by the primary researcher. After all were coded, ten transcripts were randomly selected for inter-rater reliability verification. Inter-rater reliability was calculated with Kappa of .75 for coders 1 and 2 and .64 for coders 1 and 3. Coders 1 and 2 resolved differences, primarily in favor of coder 1 so coder 1's coding was used in all analysis.

Problem tally. One focus for the examination of everyday technology encounters was identifying the number and source of problems reported by participants. Table 7.8 shows the number of problems reported by each participant group, the distribution of these problems across age groups, and the percentage of problems based on the number of technologies used by these participants. Consistent with expectations, high tech older adults reported slightly more problems than younger adults and problems were a slightly higher percentage of the technologies reported. Contrary to expectations, however, high tech older adults reported more problems than low tech older adults. Consistent with the lower number of technologies and low percentage of new technologies reported by low tech older adults, people in this group may choose to limit technology use to technologies with which they are confident they can be successful. This confidence may be based on specific prior knowledge or on a different approach to using new technologies.

Table 7.8.
Problems reported over the 10-day period.

	Younger Adults (n=10)	**High Tech Older Adults (n=10)**	**Low Tech Older Adults (n=10)**	**Totals**
Number of problems reported	36	46	11	93
Percentage of problems reported by all participants	38.7%	49.5%	11.8%	
Problems as a percentage of the total number of technologies reported by group participants over 10-day period (see Table 7.2)	13.4%	15.3%	5.8%	

Problem location analysis. A further question about the reported problems was identifying where problems occurred in each participant group. Table 7.9 shows the distribution of problems by frequency of technology usage and technology type. The number of problems for each cell was too small to perform statistical analysis, but this information is also presented in Figures 7.3 (Frequency) and 7.4 (Technology Type) to show the general patterns.

Table 7.9.
Distribution of Problems by Frequency and Technology Type

	Younger Adults			High Tech Older Adults			Low Tech Older Adults		
Category	Frequent	Infrequent	New	Frequent	Infrequent	New	Frequent	Infrequent	New
Entertainment & leisure	1	0	4	3	2	0	0	1	1
Home health care	0	0	0	0	0	0	0	1	0
Kitchen	0	0	0	4	0	0	0	0	0
Office	0	3	2	1	1	0	0	0	0
Other home	1	0	0	0	3	2	0	1	1
PC & Internet	9	3	5	12	2	6	0	0	0
Personal care & fitness	0	0	0	0	0	1	0	0	0
Shopping & purchase	0	1	1	0	0	0	0	2	0
Telephone & communication	2	2	0	4	0	4	2	0	0
Transportation	0	0	2	1	0	0	1	1	0
Totals	13	9	14	25	8	13	3	6	2

To statistically assess whether reported problems occurred among technologies with different usage frequencies, problem totals were computed by age group as shown in Table 7.10. Chi-square analysis was performed to examine age differences in problems based on frequency of use, but this effect was not significant ($p > .05$). Experience differences could not be examined due to the smaller number of responses for low tech older adults.

Table 7.10.
Problems Reported by Frequency

	Younger Adults (n=10)	*High Tech Older Adults (n=10)*	*Low Tech Older Adults (n=10)*	*Totals*
Frequent technologies	13	25	3	41
Infrequent technologies	9	8	6	23
New technologies	14	13	2	29
Totals	36	46	11	93

Although the effects of age and experience were not found to be significant, visual scanning of the charts in Figure 7.3 reveals several interesting patterns that should be explored further. Problems for younger adults seem to come equally from each usage category, whereas more than half of the problems of high tech older adults come from frequent technologies and less than 20% of their problems come from infrequent technologies. For low tech older adults, however, more than half of their problems occur with infrequent technologies and only about 25% occur with frequent technologies.

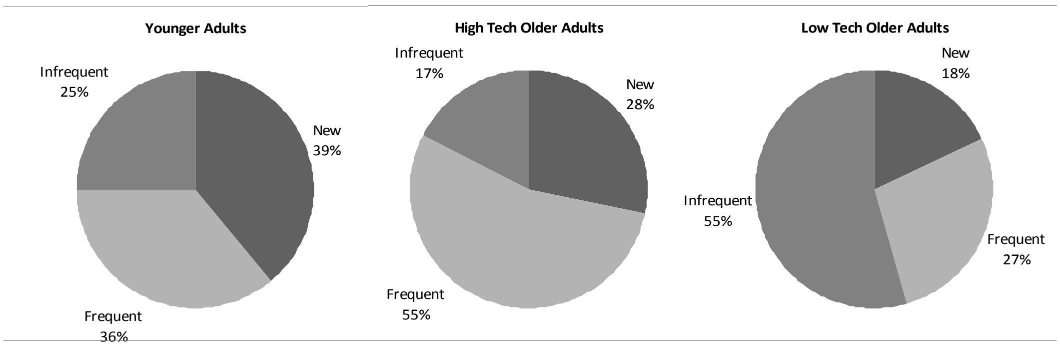


Figure 7.3. Distribution of problems by frequency of use

The only clear pattern emerging from the Figure 7.4 charts showing problem distribution across categories is that the PC and internet category accounts for nearly half of the problems reported by younger adults and high tech older adults. This finding is interesting because although the PC and internet category represents the highest percentage of technologies reported by younger adults, this category ranks third for high tech older adults. It is possible that problem occurrence made the PC and internet technologies more salient for younger adults, eliciting more reporting of these technologies than in other categories. The difference in category rank makes this explanation unlikely for high tech older adults, though.

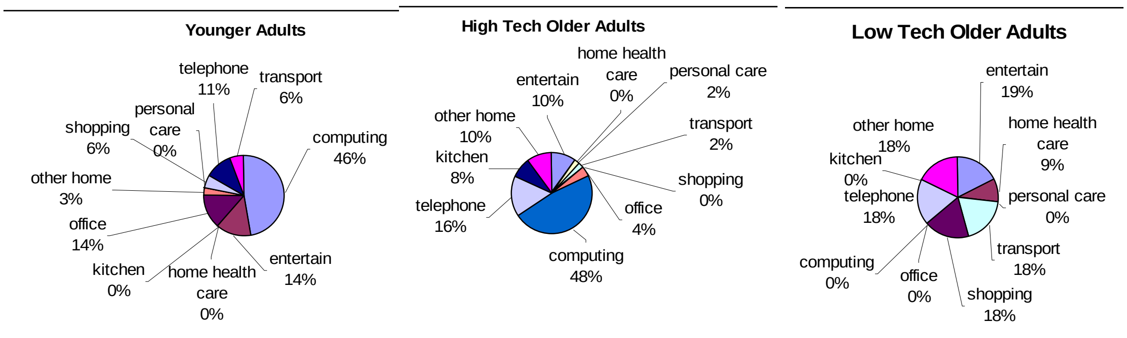


Figure 7.4. Distribution of problems by category.

Summary of reported problems. Although age differences in reported problems were not significant, the pattern of high tech older adults reporting more problems and a higher percentage of problems than younger adults was expected. An investigation of the types of problems reported is necessary to determine the reason for this difference. Given that older adults in this group were selected based on their higher level of technology experience, it seems unlikely that more prior knowledge is the only reason for the additional problems. Instead, more specific knowledge of the technologies may be necessary for problem-free usage. This may particularly be the case with PC and internet technologies that were the source of most problems for younger adults as well. Alternatively, other age-related declines such as lower visual acuity may reduce the likelihood that the high tech older adults can perceive the knowledge on the technologies to use them correctly.

An expected experience difference in which low tech older adults would report more problems than high tech older adults was also not significant, and the pattern was actually in the opposite direction as high tech older adults reported more problems and a higher percentage of problems than low tech older adults. This finding is consistent with the lower overall technology usage reported by low-tech older adults, possibly suggesting that low tech older adults limit technology usage to successful technologies unless they have no other options for completing a task. A future study examining the reasons for successful use of technologies may elucidate whether prior experience is more frequently the reason for successful use by low tech older adults. On the other hand, individuals with more technology experience may recognize that working through problems is part of technology usage such that high tech older adults may use more technologies in which prior knowledge was not available.

Role of Knowledge.

To better understand the reasons for successful use and nature of problems, the role of knowledge in everyday technologies was examined for reported encounters. The assessment of knowledge was focused on: a) whether prior knowledge was available to facilitate technology usage; b) the role of knowledge for successful encounters; and c) the potential role of knowledge in causing the problem and in resolving the problem.

Prior knowledge available. Although previous research suggests the importance of prior knowledge for successful technology use, research has not confirmed consistent availability of prior knowledge in everyday technology interactions. This would particularly be a challenge for technologies new to the participant. Therefore, structured interview questions were developed to probe the availability of prior knowledge for each interaction. Responses were coded to indicate the availability, number, type, recency, frequency, and basis of similarity for each technology mentioned. Responses were summarized for each encounter to answer yes or no to awareness of similar technologies. Table 7.11 shows the summarized responses, revealing that prior knowledge was reportedly available for a large majority of the encounters either because the specific technology had been used before or because the participant was aware of at least one similar technology. Chi-square analysis was performed to assess age and experience differences on the availability of prior knowledge, but the effects were not significant (p's$>.05$).

Table 7.11.
Reports of Prior Knowledge available at Encounter

		Younger Adults (n=10)	High Tech Older Adults (n=10)	Low Tech Older Adults (n=10)	Totals
Yes					
	Technology used before	66	75	41	182
	New but one or more similar technologies mentioned	36	24	6	66
No					
	New with no similar technologies mentioned	6	4	0	10
Indeterminate					
	New and none mentioned	0	2	0	2
Totals		108	105	47	260

Prior knowledge for successful encounters. To understand the role of knowledge and the type of knowledge accessed for successful encounters, participants were asked for each encounter, "Why do you think you were successful?" Responses were coded using the coding scheme shown in Table F.2 in Appendix F. Coding was based on the role of knowledge in the reported success with a focus on discriminating the source of the knowledge, either internal (knowledge in the head; KiH) or external (knowledge in the world; KiW), concepts first described by Norman (2002). Only one response was coded for each response, though the code "combination" was developed to encompass descriptions that referenced KiH and KiW. If multiple reasons were listed, the segment was examined for the primary and most specific reason for the success. Thus, "it was easy" and "I'd done it before" was coded as KiH. In the rare case where participants listed more than one reason that seemed equally important to them, the first mentioned was coded.

After coding was completed, counts of knowledge use were calculated for each participant group as shown in Table 7.12. Before investigating age and experience effects, the overall counts were examined to assess whether the responses were distributed in a meaningful way. Chi-square analysis revealed that several of these reasons dominated the responses (($\chi2$ (7, N=166) =213.86), p<.001), with a large effect size (Craven's *V*=1.14). Notably, residual analysis revealed that the biggest contributors to the effect were KiH, KiW (person), KiW (instructions), and approach. Specifically, prior knowledge (KiH) represented the most significant reason for a successful encounter. On the other hand, the KiW (person), KiW (instructions) and approach were suggested less frequently.

Table 7.12.
Reported Reason for Successful Encounter

Code	Description " I think I was successful because…"	Overall	Younger Adults	High Tech Older Adults	Low Tech Older Adults
Knowledge in Head (KiH)	... of my prior experience, familiarity, similarity to other devices.	81	35	35	11
Knowledge in World (KiW)	... of information outside of myself - in the world [coded specifically as one of 3 options, below]				
KiW Person	... I watched other users first, did what others did, asked others, or another person completed the task.	11	6	5	0
KiW Instructions	... I read and/or followed instructions.	9	3	4	2
KiW Device	… of information on the technology itself (such as a touch-screen).	17	10	4	3
Combination	... I used my prior knowledge as well as knowledge in the world, typically using strategies such as trial and error, familiarization, or systematic testing.	24	10	8	6
Approach	.. I controlled/optimized environment such as waiting until no one else was around.	7	0	0	7
Low Effort	... I got the result I expected, because the technology was easy or simple, or because I was having fun.	14	6	3	5
Indeterminate	… I'm not sure	3	2	0	1
Totals		166	72	59	35

To identify age-related differences in use of knowledge for successful encounters, chi-square analysis was then performed on responses from younger adults and high tech older adults. No significant difference was found (p>.05), with KiH reported for the same number of encounters for each participant group.

To identify experience-related differences in the use of knowledge for successful encounters, responses from all KiW categories were combined to allow chi-square analysis. The experience effect was significant (($\chi2$ (6, N=94) =20.04), p<.01), with a medium effect size (Craven's *V*=.46). Residual analysis revealed that the only difference contributing to this effect was the approach response, used only by low tech older adults. Interestingly, these results reveal that these participants used prior knowledge for successful encounters at the same rate as more technologically experienced people, but they had also adopted a unique approach not reported by other participants. To describe this approach, several participants noted that they were successful because they had optimized the environment to minimize distractions and focus on the technology.

To answer the specific question about whether prior knowledge was used in successful encounters, these codes were combined to reflect whether prior knowledge was used as shown in Table 7.13. Before examining age and experience effects, the overall counts were analyzed via Chi-square tests of independence. As expected, the use of prior knowledge was significant ((χ^2 (2,N=166)=68.40), p<.001) with a large effect size (φ=.64). In addition, the use of prior knowledge was significant for younger adults ((χ^2 (2,N=72)=30.08), p<.001) and high tech older adults ((χ^2 (2,N=59)=44.07), p<.001), both with large effect size (younger adults: φ=.65, high tech older adults: φ=.86) determined primarily by the higher response of prior knowledge being used. For low tech older adults, the Chi-square test of independence was also significant ((χ^2 (2,N=35)=6.4), p<.05) with a medium effect size (φ=.43)), though residual analysis did not reveal any of the response to contribute more to this effect.

Table 7.13
Use of Prior Knowledge in Successful Encounters

Use of Knowledge	Codes included	Overall	Younger Adults (n=10)	High Tech Older Adults (n=10)	Low Tech Older Adults (n=10)
Yes	KiH, Combination	105	45	43	17
No	KiW	37	19	13	5
Indeterminate	Approach, Low Effort, Indeterminate	24	8	3	13
Totals		166	72	59	35

Chi-square analysis was performed to identify age-related differences in the use of prior knowledge. The effect of age was not significant (p>.05).

Chi-square analysis was performed to identify experience-related differences in the use of prior knowledge. This effect of experience was significant (($\chi 2$ (2, N=94) =15.99), p<.001), with a medium effect size (Craven's V=.41). Analysis of residuals, however, revealed that the source of the difference was the "indeterminate" responses for which low tech older adults reported more than for high tech older adults. Note that this category includes the unique "approach" response already identified in the overall analysis. Thus, the only difference in success rationale was this unique strategy that was reported by three low tech older adults but not by any other participants.

Knowledge in problem encounters. To understand the role of prior knowledge in causing problems, participants were asked to describe each problem. All problem encounters were assigned a single code based on the reason participants identified for the error. As shown in Table F.3 in Appendix F, the codes were primarily based on differentiating system problems from knowledge-based problems, with knowledge-based codes derived from the knowledge in the head (KiH) and knowledge in the world (KiW) concepts identified by Norman (2002).

Table 7.14.
Reported Count of Problem Types.

Fault Type Code	Description "The problem was…"	Overall	Younger Adults (n=10)	High Tech Older Adults (n=10)	Low Tech Older Adults (n=10)
Knowledge in Head (KiH)	… there were problems with my knowledge and/or experience (coded specifically as one of 2 options, below)	0	0	0	0
KiH Insufficient	… … I didn't have sufficient relevant information during the interaction	20	3	12	5
KiH Interfering	… it didn't work the way I'm used to from my previous experience	10	7	3	0
Knowledge in World(KiW)	… information on the technology, instructions or demonstration was insufficient for correct usage.	13	6	6	1
Combination	… insufficient or incorrect knowledge from my prior experience as well as insufficient knowledge in the world.	12	9	3	0
System/ Product Failure	… the hardware, software, or other aspect of the system was broken.	27	8	14	5
Indeterminate	… I'm not sure	6	1	5	0
Other		5	2	3	0
Totals		93	36	46	11

Table 7.14 shows the causes for problems as reported by participants. Before investigating age and experience differences, chi-square analysis was first performed on the overall counts to identify any reasons that were significantly different from the others. A significant difference was found (($\chi 2$ (6, N=93) =27.66), p<.01), with a medium effect size (Craven's *V*=.54). Residual analysis found that the larger number of system/product failures accounted for this significant difference. These failures also accounted for the most failures in each participant group.

Chi-square analysis was then performed to assess age differences in the types of problems reported, but the result was not significant (*p*>.05). The result was not significant even if both KiH categories were combined ($p>.05$). In other words, prior knowledge did not cause more problems for high tech older adults than for younger adults.

Chi-square analysis could not be performed to identify experience differences because of the low number of problems reported by low tech older adults. However, it is notable that the two primary fault types reported by low tech older adults were also the highest categories of fault types overall. One of these fault types specifically denotes insufficient prior knowledge, but even technologically experienced people reported problems due to lack of knowledge. Technologically experienced people, however, also reported that prior knowledge also interfered with successful technology use in some cases. In these cases prior knowledge alone or in combination with knowledge in the world elicited the problem. This finding suggests that prior knowledge actually causes problems, which may be one reason that more problems were reported by technologically experienced individuals.

To answer the specific question of whether prior knowledge caused the fault, categories were combined as shown in Table 7.15. Before examining age and experience differences, chi-square analysis of the independence of responses was performed on the overall counts to identify differences in the role of prior knowledge on problem incidence. The effect was significant ((χ^2 (2,N=93)=19.42), $p<.001$) with a medium effect size (φ=.46)). Residual analysis revealed that the source of the difference was the low count of "indeterminate" responses compared to use or non-use of prior knowledge.

Table 7.15.
Use of Prior Knowledge in Causing a Fault

Use of Knowledge	Codes included	Overall	Younger Adults (n=10)	High Tech Older Adults (n=10)	Low Tech Older Adults (n=10)
Yes	KiH, Combination	42	19	18	5
No	KiW, Product/System	40	14	20	6
Indeterminate	Indeterminate, Other	11	3	8	0
Totals		93	36	46	11

Age differences were assessed by analyzing the independence of responses for younger adults and high tech older adults and by analyzing differences in the distribution of responses between the two groups. A significant difference in the role of knowledge was found in younger adults ((χ^2 (2,N=36)=11.17), p<.005) with a medium effect size (φ=.56)). Residual analysis revealed that this effect was due to the higher number of prior knowledge use and lower number of indeterminate responses. For high tech older adults, however, the effect was not significant (p>.05). Although no age effects were found between the distribution of responses (p>.05), the difference in the significance of the effects between the age groups was interesting. Especially in light of the overall effect only of indeterminate responses among all participants, younger adults appear to be more likely to cite use of prior experience as a reason for a technology problem. They are also more likely to be able to identify the reason for the problem than high tech older adults.

Because of the low number of problems reported by low tech older adults, statistical analysis of the distribution of responses between experience groups could not be performed. Instead, experience differences were assessed by comparing the independence of responses among high tech older adults (noted above) and the use versus non-use of prior knowledge responses in low tech older adults. The latter analysis could be performed because there were no indeterminate responses among low tech older adults, and it was also not significant (p>.05).

Thus, both older adult groups reported no differences between use and non-use of prior knowledge in problem incidence.

Problem resolution analysis. To understand the role of prior knowledge in resolving problems, participants were asked to describe their response to each problem. All problem encounters were assigned a single code based on the participant's description of their actions. As shown in Table F.4 in Appendix F, the codes were primarily based on identifying the source of information to resolve the problem, discriminating especially between knowledge in the head (KiH) and knowledge in the world (KiW). A single code was assigned for each problem, with "Combination" used when participants mentioned using both KiH and KiW.

Table 7.16.
Reported Strategy for Resolving Problem

Problem Resolution Code	***Description "I tried to fix the problem by…"***	***Overall***	***Younger Adults (n=10)***	***High Tech Older Adults (n=10)***	***Low Tech Older Adults (n=10)***
Knowledge in the Head (KiH)	.. Using my previous experience [in a specific way as coded below]				
Selected alternate (KiH)	… finding another way to achieve my goal without using this technology	12	7	5	0
Prior solution (KiH)	… doing what I did that's fixed the problem before.	13	6	4	3
Knowledge in the world	… getting information on the technology itself, instructions or demonstration by another person.	15	4	9	2
Combination	…using combination of external (e.g., instructions) and internal (self) information.	43	15	23	5
Replace technology	… obtaining a replacement technology	3	0	2	1
Indeterminate	.. I'm not sure [or not mentioned]	7	4	3	0
Totals		93	36	46	11

Table 7.16 shows the problem resolution approaches participants described for each encounter. Chi-square analysis was first performed on the overall counts to identify any reasons

that were significantly different from the others. A significant difference was found (($\chi 2$ (5, N=93) =64.74), p<.001), with a large effect size (Craven's *V*=.83). Residual analysis found that three responses accounted for this difference. The Combination response was significantly higher and the Replace Technology and Indeterminate responses were significantly lower than other responses. Prior knowledge was implicated in the Combination solution whereby participants used both KiH and KiW, but the Combination approach may have been used more than either source individually because the initial set of knowledge had proven to be insufficient.

Chi-square analysis was then performed to identify age-related differences, but the effect was not significant (*p*>.05). Chi-square analysis could not be performed to identify experience differences based on experience due to the small number of problems reported by low tech older adults. The pattern of responses for all participant groups, however, was consistent with the overall effect that the Combination solution was the dominant approach to resolve problems.

To answer the specific question of whether prior knowledge was used to resolve the problem, categories were combined as shown in Table 7.17. Before examining age and experience differences, chi-square analysis of the independence of responses was performed on the overall counts to identify differences in the role of prior knowledge on problem incidence. The effect was significant ((χ^2 (2,N=93)=68.19), p<.001) with a large effect size (φ=.86)). Residual analysis revealed that all reasons contributed to the difference with significantly higher use of prior knowledge and significantly lower non-use of prior knowledge and "indeterminate".

Table 7.17.
Use of Prior Knowledge in Resolving a Problem

Use of Knowledge	***Codes included***	***Overall***	***Younger Adults (n=10)***	***High Tech Older Adults (n=10)***	***Low Tech Older Adults (n=10)***
Yes	KiH, Combination	68	28	32	8
No	KiW, Replace Product	18	4	11	3
Indeterminate	Indeterminate	7	4	3	0
Totals		93	36	46	11

Age differences in use of prior knowledge in problem resolution were assessed by analyzing the independence of responses for younger adults and high tech older adults and by analyzing differences in the distribution of responses between the two groups. A significant difference in the use of knowledge was found in younger adults ((χ^2 (2,N=36)=32.00), p<.001), with a large effect size (φ=.56)). Residual analysis revealed that this effect was due to the higher use of prior knowledge and lower number of non-use and indeterminate responses. This effect was also significant for high tech older adults ((χ^2 (2,N=46)=29.26), p<.001), with a large effect size (φ=.80)). Residual analysis revealed that this effect was due to the higher use of prior knowledge and lower number of indeterminate responses. Because the effects were similar, it was not surprising that no significant effects were found between the distribution of responses (p>.05).

Because of the low number of problems reported by low tech older adults, statistical analysis of the distribution of responses between experience groups could not be performed. Instead, experience differences were assessed by comparing the independence of responses among high tech older adults (noted above) and the use versus non-use of prior knowledge in problem resolution among low tech older adults. The latter analysis could be performed because there were no indeterminate responses among low tech older adults, and it was also not significant (p>.05). Thus, high tech older adults were not more likely to use prior knowledge for problem resolution than low tech older adults, a result that was unexpected.

Summary of findings.

Overall, analysis from the diary study confirmed that prior knowledge is important across age and experience groups, though other factors may also be important. Prior knowledge was the most cited reason for success, alone and in combination with knowledge available in the world (e.g., instructions or technology design). Participants also cited knowledge in the world alone as a reason for successful encounters. No significant age or experience differences were found in the distribution of responses except for the unique reasons of “approach” for low tech older adults. Several of these participants noted that they were successful because they had optimized the environment to minimize distractions and focus on the technology.

On the other hand, prior knowledge was reported to be the reason for a problem in nearly half of the problems. Sometimes this was due to specific prior knowledge, including that which was insufficient for the task or produced interference in the current encounter. Prior knowledge alone or in combination with knowledge from the world was also reported to be the reason for problem incidence among higher technology groups. In fact, younger adults were more likely to specifically cite prior knowledge as the reason for a technology problem than other participant groups. On the other hand, both older adult groups reported no differences in use of prior knowledge in problem incidence.

The dominant problem resolution strategy across groups was a combined use of knowledge in the head and knowledge in the world, perhaps because all participants recognized that neither was sufficient alone or the problem would not have occurred. Nonetheless, there was still a higher use of prior knowledge in problem resolution among younger adults and high tech older adults than low tech older adults. For the younger and high tech older adults, technology experience may facilitate more explicit diagnosis of the problem source. A better diagnosis may then allow either appropriate selection of the right prior knowledge or understanding of the relevant knowledge in the world necessary to resolve the problem.

Discussion.

Three questions were posed for investigation in this study. First, I wanted to determine the technology repertoire for different populations of older adults to serve as a baseline for new technology design, as suggested in ISO 20282-1 (International Standards Organization, 2006). As expected from a larger survey completed by the Pew Internet and American Life Project (2003), an identifiable group of older adults uses comparable varieties and numbers of technologies as younger adults do. My data suggest that younger adults may use the same group of PC and Internet technologies more intensely than the high tech older adults, but this may be as expected because the younger adults were all full-time college students who may be more similar in their daily routines than the mostly retired older adults.

An expected difference in types of technologies used was found in home health care whereby high tech older adults used more, probably due to typically higher health care issues among older adults. The higher number of kitchen technologies by high tech older adults was also generally expected because of the student population, though the variety of kitchen technologies was interesting. The high tech older adults not only reported that they occasionally used items such as electric carving knives, mixers, and waffle makers, but they also reported that they did not use only the latest version but used treasured wedding gifts from several decades ago. Clearly, younger adults would not have this accumulation of home technologies in their repertoire, though they did report substantial usage across categories.

As expected, the data also showed that high tech older adults reported a higher number of technologies than low tech older adults and that the mean number of technologies per individual was higher for high tech older adults. Significant differences were found for PC and Internet technologies overall and on average, as expected given the complexity of these technologies. A significantly higher mean number of telephone and communication technologies by high tech older adults suggests that these individuals may use more features on each technology or may use a wider variety of communication technologies, perhaps related to their PC and Internet use. A significantly higher number of shopping technologies by high tech older adults also supports the anecdotal reports of preferences by some low tech older adults for in-person transactions. Thus, more technology usage by high tech older adults may reflect not only more relevant prior experience but also an openness and preference for using technologies for new tasks.

These data also suggest, however, that low tech older adults do use a variety of technologies in their everyday activities. For instance, some low tech older adults reported more technologies than some high tech older adults. Low tech older adults also reported some unique technologies (not reported by either high tech older adults or younger adults) such as an automated tennis server and wireless microphones. The presence of these unique technologies suggests that these people are willing to adopt technologies according to their hobbies. Additional research should investigate if prior experience is less influential on successful use when users are highly motivated and use is strictly voluntary.

The other primary goals for the study were to examine how successful participant encounters were, particularly with new and infrequent technologies, and to understand the role of prior experience in successes and problems. Data showed that new and infrequent encounter totals were related to the total number of technologies reported, with younger adults and high tech older adults reporting comparable number of encounters and low tech older adults reporting fewer. In all groups participants reported more successes than problems. Data from this study support findings from previous research that prior experience is the most common reason for technology success (e.g., Blackler, Popvic, & Mahar, 2003b; Kang & Yoon, 2008). Previous research has not, however, reported the unique approach of low tech older adults to focus on technology use without distractions as a key reason for strategy success. This may be because the strategy is subsumed under another documented strategy for high tech older adults. Observations of low tech older adults interacting with technologies could provide a more complete description of this strategy that could either link it with other research or illustrate how this approach works such that it could be used more widely and effectively. Comparing low tech versus high tech older adult usage may also facilitate an understanding of whether this strategy is used by high tech older adults but is described differently or is only elicited by low tech older adults due to lack of knowledge.

Participants also discussed the role of prior experience in causing and resolving technology problems, with some age and experience differences observed. Overall, high tech older adults reported a larger, though non-significant, proportion of more problem encounters than the other groups. Although I expected low tech older adults to report more problems, these people may choose to limit their usage to known technologies or rare occasions where they have no option but to use unknown technologies. Alternatively, high tech older adults may have learned from their higher general technology experience that problems should be expected and lack of specific experience should not deter use.

The distribution of problems by frequency of use was also directionally different for high tech older adults such that over 50% of their problems occurred in frequent (at least once/week) technologies. These problems may have been due to interference from other similar technologies or from similar tasks completed with the same technology, which was expected based on prior research and the higher exposure to different generations of technologies by older adults. High tech older adults did not, however, report that interference was the primary cause of the problem. Instead, they reported more problems due to insufficient knowledge or system/product failures. Both older adult groups reported more problems due to insufficient knowledge than younger adults, which may be been due to lower memory self-efficacy and thus expectation that they likely did not know what they needed to know. In contrast, younger adults reported more problems due to interference. This higher report of interference may be based on higher memory self-efficacy and technology self-efficacy, in addition to recalling specifically what the interfering knowledge was.

Overall, these data suggest that prior experience may not always be sufficient for successful technology use. In fact, the most common approach for resolving problems was to use a combination of prior knowledge and knowledge in the world, a tacit acknowledgement that prior knowledge was insufficient. This approach may have been particularly helpful when participants recognized interference and needed to rely on external information to help them inhibit past expectations based on prior experience. Older adults may report less interference than younger adults because they may use other information such as context to more effectively inhibit competing knowledge. Systematic observations of younger adults and older adults interacting with the same technologies may identify if negative transfer indeed is present in these interactions and potential reasons for the lack of report in a diary study.

Chapter 8: Study 2 Methods

Overview

Study 2 was designed for systematic observation of everyday technology interactions in younger adults and older adults. Each participant individually interacted with three everyday technologies with differing characteristics hypothesized to influence how prior knowledge is selected and used. Participant interactions were video recorded as they described system features, completed selected tasks, and instructed an imagined friend on use of the technology to complete these tasks. Objective and subjective measurements were gathered to describe participants' performance and use of prior knowledge. Participants were then interviewed to elicit description of their prior experience with reference technologies and specific interaction features. These interviews were video recorded for further analysis of the use of prior knowledge in technology interactions.

Methods.

Participants. The participants were 12 younger adults, ages 18 to 28 years, and 24 older adults, ages 65 to 75 years. The general participant characteristics were exactly the same as Study 1, with equal numbers of high technology and low technology older adults recruited as described in Chapter 6 and Appendix B. Participants from Study 1, however, were excluded from the recruitment pool to eliminate any potential effects of their journaling experience focused on everyday technology use. A total of nine participants, one younger adult and eight older adults, were replaced during this study as described in Appendix E. Participants received either 4 hours of extra course credit or monetary compensation of $48 for participation in the study. See Tables 8.1 and 8.2 for an overview of the participant characteristics.

Table 8.1.
Participant Characteristics for Study 2.

	Younger Adults (n=12)		High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	SD	M	SD	M	SD
Age	19.58	1.16	70.33	2.15	72.08	4.06
Gender						
Male	7		6		5	
Female	5		6		7	
Highest level of Education						
Master's degree or higher	0		3		0	
Bachelor's degree	0		4		1	
Some College/ Associates degree	6		5		8	
High School Grad/GED	6		0		3	
Ethnicity						
African American	1		1		4	
Hispanic Caucasian	1		2		0	
Non-Hispanic Caucasian	8		9		8	
Other	2		0		0	
Annual household income						
<= $30,000	2		2		5	
$30,000-$60,000	0		1		2	
> $60,000	4		5		3	
other/not mentioned	6		4		2	
Health compared with others of same age						
Excellent	3		6		2	
Very Good	4		5		4	
Good	2		1		4	
Fair	3		0		2	

Table 8.2.
Ability Test Scores for Study 2.

	Younger Adults (n=12)		High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	SD	M	SD	M	SD
Digit Symbol Substitution[1]	70.08	10.97	53.42	8.13	44.08	7.97
Reverse Digit Span[2]	9.33	2.06	6.83	2.25	7.08	2.87
Shipley Vocabulary[3]	32.92	3.55	36.42	2.64	33.42	4.91
Technology Experience[4]	18.08	1.38	18.83	2.04	8.17	2.52

Notes: [1]Perceptual speed, number correct (Wechsler, 1997); [2] Memory span, number correct (Wechsler, 1997); [3] Vocabulary, number correct (Shipley, 1940); [4]Level of experience with everyday technologies (Maximum=24). See Appendix B for description of algorithm to calculate technology experience.

As shown in Table 8.3, *t*-tests ($p<.05$) revealed that high technology older adults did not significantly differ in technology experience from younger adults. T-tests revealed typical age-related differences in perceptual speed (Digit Symbol Substitution), working memory (Reverse Digit Span), and vocabulary (Shipley Vocabulary) (e.g., Czaja et al., 2006.). Technology experience differences between the older adult groups were expected due to the use of this score in determining group membership. Because several studies have also found correlations between technology experience and perceptual speed (e.g., Umemuro, 2004), the perceptual speed difference between older adult groups was not unexpected.

Table 8.3.
T-tests for Demographic and Ability Differences between Groups

	Younger vs. High Tech Older Adults	**High vs. Low Tech Older Adults**
Age:		1.32
Digit Symbol Substitution	4.23*	-2.84*
Reverse Digit Span	2.84*	0.24
Shipley Vocabulary	-2.74*	-1.86
Technology experience	-1.06	-11.41*

Note: *p<.05.

Materials.

Ability tests. The ability measures were the same as Study 1, namely the Digit Symbol Substitution test (Wechsler), Reverse Digit Span test (Wechsler, 1997), and the Shipley Institute of Living vocabulary scale (Shipley, 1940). As with Study 1, participants also completed a demographics, health, and technology experience questionnaire (Czaja et al., 2006). The technology experience questionnaire was used to determine each participant's Technology Experience. Participants whose scores placed them in the medium technology experience level were replaced.

Cognitive orientation procedure. As described in Section 3.1, one challenge in using the "concurrent think-aloud" protocol to obtain participant rationale for selecting features in an observational study is that the think-aloud technique may interfere with the standard processing a participant may use for the interaction. A reactivity effect on cognitive processing has been identified in older adults such that abstract reasoning, as measured in the Raven's Advanced Progressive Matrices, was performed more accurately and more slowly when participants thought aloud (Fox, 2008). This effect might be expected based on the cognitive continuum index, shown in Table 8.4, that was developed by Hammond (1996). According to this index high awareness of cognitive activity, low speed for cognitive activity, and use of complex principles are likely to elicit the analytic mode of thinking that would optimize abstract reasoning, particularly if participants are instructed to "think" aloud.

Table 8.4.
Cognitive continuum index for intuitive and analytic ends of the continuum
(from Hammond, 1996), p. 182.

	Intuition	***Analysis***
Cognitive control	Low	High
Awareness of cognitive activity	Low	High
Amount of shift across indicators	High	Low
Speed of cognitive activity	High	Low
Memory	Raw data or events stored	Complex principles stored
Metaphors used	Pictorial	Verbal, quantitative

With everyday HTI, however, participants may be more likely to operate quickly with low awareness of cognitive activity and use of raw data or events rather than principles. These characteristics represent the intuitive thinking mode on the opposite side of the cognitive continuum index shown in Table 8.4 (Hammond, 1996). Eliciting sufficient description from participants during observation while they are using intuitive cognition is a research challenge. Based on the full list of intuitive characteristics from the cognitive continuum in Table 8.4, everyday HTI use may be simulated if participants' attitude during the interaction is more casual.

Two techniques were used to induce this casual approach. First, participants were shown the Power Point slide show described for Study 1 with slight variations to specifically include exemplars of the representative technologies participants would be using in this study (see

Appendix G-1). The researcher also relayed anecdotes about several technologies in which users had problems with the technology to focus the participant on design issues with the technology rather than the user. The goal was to make participants feel more comfortable operating in their normal mode (Allen & Buie, 2002). The second technique for inducing a more casual approach to using the technologies was also elicited by adopting a naturalistic social context such as used in storytelling research (Adams, Smith, Pasupathi, & Vitolo, 2002). In the present study, participants were asked to instruct an imagined friend with a similar technology background and everyday experience to them on completing the same tasks they completed earlier. Exit interview questions about participant perceptions of interference of the think-aloud technique, shown in Table 8.5, suggest that most participants in each group interacted fairly similarly with the representative HTI as their normal encounters.

Table 8.5.
Participant responses to exit interview question about think-aloud interference

	Younger Adults (n=12)		***High Tech Older Adults (n=12)***		***Low Tech Older Adults (n=12)***	
	M	**SD**	**M**	**SD**	**M**	**SD**
Do you think that narrating your interactions changed how you would have normally interacted with the technologies or devices? (1="Not at all"; 7="Completely different")	2.67	1.07	2.08	1.88	2.00	1.21

Representative everyday technologies. Three technologies were selected for investigation based on product complexity, product age, use of prior knowledge in the design, opportunity for individuals to have completed the functions in other technologies in other products, and longevity of prior knowledge accessed in device use. The three technologies selected for investigation included a simpler device and a more complex device introduced in the past five years, and an electronic household device introduced in the past five years but with predecessor devices existing prior to adulthood for the older adults. The simple vs. complex distinction was based on the number of technology features, using the first simplicity law of reduction proposed by Maeda (n.d.).

The simple technology was the Flip Video camcorder (Pure Digital Technologies, 2007), designed to be “soap-box simple” (Jana, 2008, April 28). As shown in Figure 8.1, The Flip Video has only seven buttons, including four arrow keys, “universal play”, “universal delete”, and a “red plastic ‘record’ button that draws the eye; no need for instruction” (Jana, p. 76). A limited number of possible functions are provided on the device, and task execution requires no more than two actions to operate. The Flip name and the lightweight casing are indicative of an overall aesthetic that suggests a technology created for casual users. These characteristics might make the device easy to use if participants had experience with these functions and the tasks. On the other hand, the design incorporates features from at least two reference technologies, an audio recorder and digital camera. Thus, participants might also be confused during their interaction if the feature was used based on the wrong reference technology.

Figure 8.1. Flip Video camera used in Study 2 with front (left) and back (right) views.

The more complex device is the Kindle electronic book reader (Amazon, 2007). The device was developed to incorporate features from standard books following an electronic paper metaphor with digital components from Internet publications such as search and cut and paste. Although the book metaphor is clearly dominant for operating the main Kindle functions like reading, the device also includes a small keyboard, scrollbar, and mode buttons as shown in Figure 8.2. The book metaphor might be particularly advantageous for older adults with extensive experience reading, but the multiplicity of buttons could make the device more difficult for older adults to use correctly if they could not infer the correct function (e.g., Blackler, Popovic & Mahar, 2003a; Langdon, Lewis, & Clarkson, 2007). The overall aesthetics, which have been called "clunky" by several commentators, also suggest that the device may be more difficult for adults of all ages who perceive that the device requires concentration to learn (Regan, 2007, November 28). Version 1 of the Kindle was used to reduce the variability in release times across the three devices.

Figure 8.2. Kindle book reader used in Study 2.

The third device was the Sony Dream Machine alarm clock, Model ICF-C492 (Sony Corporation, 2005a), shown in Figure 8.3. Alarm clocks have been widely available in the U.S.

since at least the 1950s; thus, all participants were expected to have some experience with at least one alarm clock prior to the study. Alarm clocks have evolved since their introduction with new features, but the fundamental procedures for operation have remained the same. Nonetheless, it seemed likely that many older participants would have used several different models of an alarm clock across different technology generations. Different models of a product are likely to have some variation in procedures, which may facilitate acquisition of a more accurate mental model for older adults than younger adults (Chen, 2006). Thus, older adults were expected to show better performance for the alarm clock on some measures than younger adults. The specific alarm clock selected for this study was advertised with a large, easy-to-read display that might be attractive for older adults with age-related declines in vision (e.g., Fisk, Rogers, Charness, Czaja, & Sharit, 2009). This alarm clock was also released to the market at approximately the same timeframe as the other two representative technologies.

Figure 8.3. Sony alarm clock used in Study 2.

Video recording apparatus. Similar to the apparatus used in Blackler (2006), participant interactions with the research technologies and structured interviews were recorded with two video cameras. One camera was focused on the participant's hands, and one camera recorded the entire scene around the participant's face and the back of devices unseen by the first camera. Both cameras were QuickCam web cameras (Logitech, 2007) to provide an unobtrusive presence in the experimental area as shown in Figure 8.4. As shown in Table 8.6, exit interview questions about participant perceptions of interference due to being video recorded suggest that most participants in each group believed that they interacted fairly similarly with the representative HTI as in their normal encounters. All recording was captured on the PC hard drive and managed through Morae Manager 3.0 software (TechSmith, 2009).

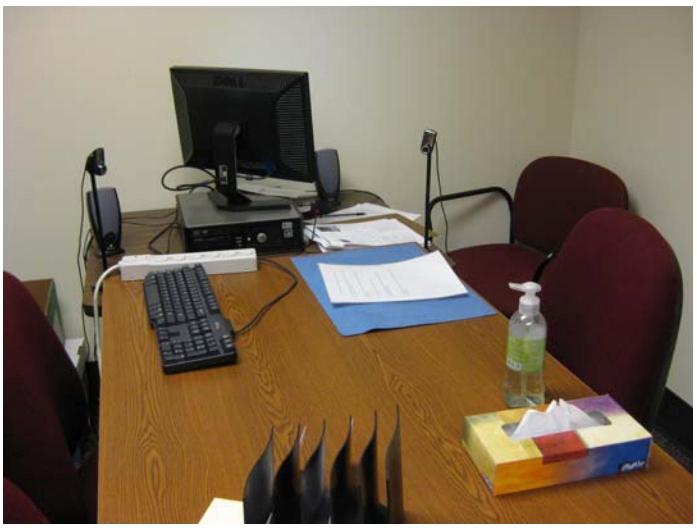


Figure 8.4. Camera and PC set up for Study 2. Note that participants were seated at the chair in front of the blue place mat such that one camera (on the right) recorded their hands and the other one (on the left) recorded the interaction from a face-on view.

Table 8.6.
Participant responses to exit interview question about video recording interference.

	Younger Adults (n=12)		***High Tech Older Adults (n=12)***		***Low Tech Older Adults (n=12)***	
	M	**SD**	**M**	**SD**	**M**	**SD**
Do you think that being video recorded changed how you would have normally interacted with the technologies or devices? (1="Not at all"; 7="Completely different")	1.75	1.14	1.58	1.44	2.00	1.35

Technology Screening. To select older adults with high and low technology experience, a technology experience questionnaire containing 110 community-dwelling older adults (ages 65-75) was used as described for Study 1 and in Appendix B. A subset of questions from Table B.1 in Appendix B was selected for use in telephone screening to increase the likelihood of recruiting participants in the high and low technology experience groups. Appendix G-2 contains the technology experience portion of the recruiting script.

Task Instructions. For each device, three tasks were developed to reflect typical novice interactions and to encourage participants to explore key features of the device. All three tasks for a particular device were typed in 14 point font on the same 8½ by 11 sheet of paper, cut into approximately equal-sized portions, and then laminated. This separation allowed the experimenter to control the start of each task for every participant. This process also reduced the memory load required by participants to monitor which task they were currently executing. Table 8.7 shows the participant tasks.

Table 8.7.
Task instructions for each everyday technology.

Technology	Task	Instruction
Alarm Clock	1	Please set the time on the clock to the current time.
	2	Change the radio station to 94.9 FM. - Listen to the music and adjust the volume to your preference. - Turn off the radio
	3	Set the alarm to wake to radio at 6:40 AM. - Make sure the clock is still displaying the correct time
Flip	1	Take about 20 seconds of a video picture of the table in front of you. - Zoom in on the toy tractor to try to focus on the John Deere label. - Stop the recording
	2	Review the video just taken - Increase the sound volume while listening to it.
	3	Find the short video taken before you arrived. - Review the video - Delete the video - Turn off the camera

Technology	Task	Instruction
Kindle	1	Open the book *The Call of the Wild* which is loaded on this Kindle. - Go to the book cover.
	2	Go to the 5th chapter in the book - Add a bookmark here. - Adjust the text size to text size 5.
	3	Open another book loaded on the Kindle called *The Three Musketeers*. - Go to chapter 6 - Add a note to the first paragraph, typing in your first name - Turn off the Kindle

Note: Each task was presented on individual cards, typed in Arial, font size 14, as described in the text.

Study Instructions. Participants were given a single, laminated sheet of paper with instructions for their recorded interactions. After reading the instructions before working with each technology, participants placed the instruction sheet to the side of the place mat where it could be referenced as needed. See Appendix G-3 for this instruction sheet.

Device Usage Questionnaire. To document prior knowledge that may have been accessed for each device, participants evaluated the familiarity of each feature on the research technology using the scale developed by Blackler (2006) though adapted for each technology. As shown in Appendix G-6, participants rated the familiarity of each feature on a Likert scale. They then listed up to three other technologies for which they could recall knowing each feature. Participants then reported the recency and frequency of use for each technology listed.

Structured Interview. The structured interview was developed to guide users through recollection and elaboration of their encounters with the assigned technology. As shown in Appendix G-8, questions were asked for each of the features and functions listed in the device usage questionnaire. The questions were designed to elicit participant expectations for each function, the source of the expectation, and how the expectation was met or contradicted by actual operation. If prior knowledge was reported for a device feature, participants were also asked to assess recency and depth of experience for the reference technology or semantic knowledge.

Technology Background Survey. In addition to the CREATE technology experience questionnaire, additional technology experience questions were asked to probe the most relevant experiences for the alarm clock, Flip, and Kindle. Selection of these potentially relevant technologies was developed based on pilot participants' data. Additional details about each similar technology such as recency, frequency, and similarity to the target technology were also probed in this survey (Appendix G-9).

Research Design

Order of Technology Interactions. To reduce potential priming effects, the order in which participants interacted with each technology was completely counterbalanced. Thus, six groups of participants were created for each order, as shown in Table 8.8. Twelve participants were included in each group to ensure that the total per group was comparable to Study 1 that had ten per group, though the total was rounded up to provide equal numbers in each group.

Table 8.8.
Order of Technology Interaction

Group A	Group B	Group C	Group D	Group E	Group F
Flip Video	Flip Video	Kindle	Kindle	Alarm Clock	Alarm Clock
Kindle	Alarm Clock	Alarm Clock	Flip Video	Flip Video	Kindle
Alarm Clock	Kindle	Flip Video	Alarm Clock	Kindle	Flip Video

Procedure. Participants were assigned to a group based on the order in which they were scheduled (see Table 8.8), with equal numbers of younger adults, older adults with high technology experience, and older adults with low technology experience assigned to each group. The technology experience questionnaire (Appendix C) and background questionnaire (Appendix H) were mailed to older adults to complete before coming to the lab. The study began as participants reviewed a description of the study and asked questions before providing informed consent. In the informed consent, participants were asked to select whether the videos of their technology interactions could be used in public presentations of this research beyond researcher analysis. They were then screened for visual and hearing acuity before completing the Digit Symbol Substitution test (Wechsler, 1997), the Reverse Digit Span test (Wechsler), and the Shipley Institute of Living vocabulary scale (Shipley, 1940).

Participants then viewed an online Power Point slide show with digital pictures of technologies, similar to that used in Study 1 but modified to include examples of technologies similar to the selected representative device. These examples of similar technologies were presented in the middle slides as noted in Appendix G-1 to minimize typical serial order effects of first/last item (e.g., Lewandowsky & Murdock, 1989). The researcher controlled the slide show and named the category of devices as they appeared on the slide show. Several anecdotes about typical technology problems (e.g., it can be difficult to find even the schedule channel on a TV belonging to someone else) were relayed to focus participants on problems with everyday technology design rather than the technology user.

The observational protocol was developed from the Blackler (2006) procedure. After ability tests were completed, participants moved to sit in front of the blue placemat shown in Figure 8.5. They were reminded that this study is primarily focused on the technology rather than on their performance to remove concerns about errors. The video recording equipment was briefly described and questions answered to reduce any anxiety about the recording process. The video recorders were then started.

Participants were first asked to describe each technology in order according to their assigned group, pointing to each feature or function without interacting with it. The researcher then moved to sit behind the participant's right shoulder as shown in Figure 8.5, where she controlled the video recording PC and provided materials for the participants. Participants were given the study instructions sheet (Appendix G-3) to read silently. The researcher then summarized the instructions and then gave the first task (Table 8.7) to the participant, reminding them to describe what they were thinking and doing as they completed the task. Although the researcher was present to guide participants if they could not get past an obstacle to the task goal, they were encouraged to try to figure out the next step themselves. If researcher guidance was provided, the researcher tried to limit instructions to suggesting the next control to use without explanation (Shrager & Klahr, 1990).

Figure 8.5. Positioning of participant and researcher technology interactions in Study 2. The female in the photo is the experimenter, and the male is an example participant.

After each task was completed, the experimenter handed the next task instruction to the participant. At the experimenter's discretion, a task was skipped if the participant clearly had difficulty with earlier tasks and appeared to be tiring. This was minimally required but was reported as "not attempted" in the participant log. After participants completed the three tasks for the first technology, they completed the NASA-RTLX inventory for the experience (Appendix G-4). They then completed the attitudinal survey for the technology (Appendix G-5).

Participants were then asked to imagine that a friend with similar background and life experience was borrowing the device to complete similar tasks; however, schedules would not allow a face-to-face demonstration. Therefore, the participant had agreed to provide a video recording of themselves using the device. Thus, participants showed their friend how to complete the same tasks as they had done in their initial interaction, narrating key points as they deemed appropriate. The same task cards (Table 8.7) for the device were given to the participant in order during the demonstration. Researcher guidance was given according to the same criterion as the original task execution.

After showing their friend how to complete the same tasks, participants completed a device usage questionnaire relevant for that technology (Appendix G-6). The researcher then conducted a structured interview (Appendix G-7) to allow participants to elaborate on their expectations and actual operation of the device. After the structured interview was finished, video recording was stopped and participants took a break of at least five minutes. At the experimenter's discretion, the "show a friend" and/or structured interview were skipped if the participant clearly had difficulty with earlier tasks, appeared to be tiring, and had already completed the full set of activities for a previous device. These omissions were minimally required but were noted in the participant log as "not attempted".

After the break, the same procedure was used for participants to interact with the other two devices according to the order determined by their participant grouping (Table 8.8). After all three technologies were used, participants completed the technology background survey (Appendix G-8). Younger adults then completed the technology experience questionnaire (Appendix C) and background questionnaire (Appendix H). All participants were given an exit interview (Appendix G-9) and study debrief (Appendix G-10) before receiving compensation appropriate for their age group at the end of the session.

Chapter 9: Study 2 Results

The chapter describes video recordings of participant interactions with everyday HTI to enable direct assessments of age and experience differences. Specifically, participants interacted with three technologies that differed with respect to expected prior use and familiarity among participants. Video recordings made during these interactions provided behavioral data to directly assess objective age and experience differences in technology interactions. Participant perceptions of cognitive workload, satisfaction, and success were also collected for each technology to allow examination of subjective performance differences. Detailed questionnaires facilitated self-report of prior experience with typical reference technologies and perceptions of key technology functions vis-à-vis participant expectations. In addition, the video recordings enabled direct evaluation of participant errors and interaction strategies due to differential use of prior experience (knowledge in the head) and technology features (knowledge in the world).

This section begins with a description of the data coding and analysis process. Then, results are presented by analyzing performance on each technology separately. Technologies are discussed in order of expected directly relevant prior experience, with the lowest presented first to facilitate assessment of the role of general technology experience before examining the role of differing specific experiences. This chapter concludes with a review of the key findings and comparison of differences between technologies and participant groups.

For each technology, three questions are discussed. First, did participants have relevant prior knowledge for the technology and did this knowledge differ between groups? Second, did performance differ by group according to objective and subjective measures? Third, did participants have prior knowledge of specific technology features to enable task success? A fourth question about participant errors and interaction strategies will be discussed only for the alarm clock on which all participants have prior knowledge.

Representative Nature of Data Collected

To claim that the recordings accurately represented participants' usual approach to interacting with everyday technologies, it was important to examine participant self-reports of typical HTI use and their perceptions regarding the effect of cameras and think-aloud on recorded interactions. To identify typical HTI approaches, participants were asked to select their first and second choices for using a new cell phone. This technology was selected for assessing typical first-use preferences because participants from all groups reported at least some experience with the technology. As shown in Table 9.1, typical preferences differed by age group. Younger adults reported that they would typically use the trial and error method that is similar to the experimental approach, whereas older adults were more likely to use external resources such as another individual or reference sheet. Thus, younger adults were more likely to be interacting with new technologies according to their preference in this study.

Table 9.1
Participant choices for first-time use of a new cell phone

	Younger Adults (n=12)	***High Tech Older Adults (n=12)***	***Low Tech Older Adults (n=12)***
First Choice (% choosing option)			
Demonstration by another person	25.0	8.3	41.7
Formal group class		25.0	
One-on-one instruction	8.3	25.0	41.7
Online			
Paper reference sheet or manual		16.7	16.7
Trial and error	66.7	8.3	
Missing		16.7	
Second Choice (% choosing option)			
Demonstration by another person	8.3	25.0	33.3
Formal group class			
One-on-one instruction	8.3	8.3	33.3
Online		8.3	
Paper reference sheet or manual	58.3	25.0	8.3
Trial and error	25.0	16.7	16.7
Missing		16.7	8.3

Note: Data from exit interviews

Table 9.2 shows participant perceptions of the effect of being recorded and narrating their actions on their behavior. These data suggest that participants were minimally affected by the recording process and their narrations during the interactions.

Table 9.2
Description of Participant Perceptions of Technology and Procedure on Behavior

	Younger Adults (n=12)		High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Do you think that being recorded changed how you would have normally interacted with the technologies? 1=not at all, 7=completely different	1.75	1.14	1.58	1.44	2.00	1.35
Do you think that narrating your interactions changed how you would have normally interacted with the technologies? 1=not at all, 5=completely different	2.67	1.07	2.08	1.88	2.00	1.21

Note: Data from exit interviews

Task segmentation. As described in Chapter 8, participants were given a break after interacting with each technology. Thus, separate recordings were created for each user on each technology. Each recording was then segmented into individual tasks within Morae. The segmentation process used the participant's reading of the first item on the task card as task start and completion of the last item listed on the task card as the task end.

Complete behavioral coding. To provide an objective assessment of performance and knowledge used by participants within technology interactions, video recordings were coded using behavioral analysis (e.g., Gnisci, Bakeman, & Quera, 2008). Behavior codes were developed to describe participant behavior within key categories of interest as shown in Table 9.3. Categories of interest were selected to describe correct versus incorrect performance, activities that may have diverted participant attention from the technology, and sources of information used such as labels or experimenter comments. In particular, the use of information participants retrieved from the technology during use was coded to describe the knowledge in the world (KiW) that supplemented or elicited a participant's prior knowledge (KiH). This KiW was coded under the category, *looks.* For each technology, specific codes were identified to encompass participant tasks as shown in Table I.1 in Appendix I for the Flip camera.

Table 9.3.
Categories Used for Coding Participant Behavior

Category	Behavior Described
Valid device actions	participant uses a valid action assigned for the set of tasks on this device, though that action may or may not be correct in the particular sequence or for this particular task. Includes finding control and setting correctly, as well as incorrect settings (as long as control could be validly used in this task)
Invalid device actions	participant uses an incorrect actions with respect to this task card. Also includes control actions invalid for any purpose on this device.
Non-device actions	participant performs actions other than technology interaction such as sneezing, checking their watch, drinking water, re-reading the task card, etc.
Looks	participant examines or finds information on the noted device (or overall search), usually designated by participant reading labels on control or moving finger along control as it is inspected. Includes checking the setting after interacting with the control. Does not include participant activating control as they describe it or point to it.
Questions	participant asks experimenter questions or general request for help
Prompts	experimenter help that keeps participant on task (i.e., moving forward, narrating actions) without providing additional information
Interventions	unsolicited experimenter actions, directives or other interventions that provide additional information to help participant proceed through task

The goal of the coding process was to develop an accurate description of the participant's interactions with the technology. To create this description, two coders individually watched the video for each task and recorded each behavior on a coding sheet such as shown on the first page of Appendix I.2. Each behavior was numbered in order of execution in the appropriate row. Behaviors were defined as actions that continued until another behavior started. Thus, behaviors in which a participant pushed the same button multiple times before reading feedback from the display or interacting with another control were only recorded once. Exceptions (such as multiple presses of the delete key required to confirm a delete on the Flip) were noted on the technology coding sheet such as in Appendix I.1. Coders could rewind and watch the segment until they were confident with their coding. Counts for each behavior and error type were tallied and reported on the second page of Appendix I.2. After coding all participants, coders met and reconciled differences by comparing the separate sheets and by reviewing targeted portions of the video until they agreed upon the correct coding. The resulting coding sequence and tally were transcribed onto a single sheet that was used for data entry.

Quick behavioral coding. A shorter coding process was also used to summarize performance on each task without coding individual behaviors. Two coders each reviewed the technology video for each participant to identify optimal and successful completion of each task. Optimal completion was coded if the participant completed all required activities with no errors or experimenter information, though the order of execution could vary as long as no additional behaviors were required. Successful completion was coded if the participant completed all required activities, though with errors, prompting, and/or interventions to do so. Partial completion was coded if the participant completed only some of the required activities. Appendix I.3 shows the quick coding sheet used for the Flip camera. After all participants were quick coded, coders met and reconciled differences on a single sheet that was used for data entry.

Kindle electronic book reader.

Participant interactions will be first described for the Kindle electronic book reader because it was presumed to be the technology for which the fewest number of participants would have directly relevant experience. In this section, experience with most similar technologies will first be presented. Then, performance by participant group will be presented and compared across age and general technology experience. Lastly, participant self-reports of prior knowledge of Kindle controls will be described for successful performances.

Table 9.4
Self Reports of Participants' Prior Experience with Technologies Similar to Kindle

	Younger Adults (n=12)		High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Have you ever used a Kindle before? (% yes)	8.3%	-	0.0%	-	0.0%	-
Have you ever used another electronic book reader before this study? (% yes)	8.3%	-	8.3%	-	0.0%	-
If yes, approximately how many electronic book readers have you used? (% used)						
1	8.3%	-	0.0%	-	0.0%	-
2-5	0.0%	-	8.3%	-	0.0%	-
More than 5	0.0%	-	0.0%	-	0.0%	-
How recently have you used an electronic book reader? 1=earlier today, 7=more than a year ago	2.0	0.0	1.0	0.0	0.0	0.0
How frequently do you typically use an electronic book reader? 1=every day, 7=used only once or twice	2.0	0.0	1.0	0.0	0.0	0.0
Have you ever read books or articles on the web? (% yes)	100%	-	83.3%	-	25.0%	-
If yes, approximately how many books or articles have you read? (% used)						
1	8.3%	-	0.0%	-	0.0%	-
2-5	0.0%	-	16.7%	-	16.7%	-
More than 5	91.7%	-	66.7%	-	8.3%	-
How recently have you read a book or article on the web? 1=earlier today, 7=more than a year ago	2.8	2.0	2.5	0.7	4.3	2.3
How frequently do you typically read a book or article on the web? 1=every day, 7=used only once or twice	2.8	2.1	2.3	1.0	4.7	2.1

Prior experience. Participants' prior experience with the Kindle, other electronic book readers, and books or articles on the web was measured through self-report and is presented in Table 9.4. As expected, few participants had any experience with any electronic book reader, including the Kindle. Numerically, more younger adults (100%) had read books and articles on the web than high tech older adults (83.3%), who read more than low tech older adults (25%), but a chi-square test of independence found that this difference was not significant (p>.05). The difference in the number of participants in each group who had read more than 5 books or articles on the web, however, was significant ((χ^2 (2, N=20)=7.9), p<.05), with a medium effect size (φ=.56)). Over 90% of younger adults had read more than 5 books or articles on the web, but residual analysis revealed that the most significant contributor to the statistical difference was the low number of low tech older adults who had read books or articles on the web. Mann-Whitney *U* tests were performed on the recency and frequency of usage for books and articles on the web to assess age and experience differences. No differences in recency were identified (both *p*'s >.05). Although the age difference in frequency was also not significant (p>.05), the effect of experience on frequency of use was significant. Specifically, the low tech older adults who had read books or articles on the web reported lower frequency of use than high tech older adults. Overall, then, electronic book reader experience was very low, but participant experience with reading books and articles on the web was fairly high and recent for younger adults and high tech older adults.

Performance. Although specific previous experience was low for all participants, younger adults and high tech older adults both had high technology experience. The research question was whether this similar technology experience led to similar levels of performance for these groups, but a different level of performance for low tech older adults. Overall performance was assessed objectively through task success and task time and subjectively through self-reports of cognitive workload and satisfaction. These results will be presented with a view toward evaluating the effect of prior experience.

Task success. Task success, for instance, may have been due to trial and error rather than prior experience. Therefore, participant completions were further assessed to determine whether only correct actions were made with no experimenter guidance. This more rigorous test of "optimal" performance was based on the assumption that prior experience not only allowed participants to know what to do next, but also facilitated control operation using only information on the technology and correctly interpreting system feedback. A different, lower level of performance was termed "successful" if the participant completed all required actions, though with errors or experimenter intervention. The next lower performance level was "partial" in which either participants only completed some of the required actions for the task or they completed all actions but they made significant errors that were not corrected (e.g., selecting the wrong book and continuing to proceed with other items listed in the task). Because all participants completed at least portions of all started tasks, the lowest recorded performance level was "not attempted". Using this framework, scores were assigned to tasks such that lower scores represented better performance with optimal=1, successful=2; partial=3, and not attempted=4. A mean score for each task was then computed for each participant group.

Table 9.5.
Participant Performance on Kindle Tasks

Task	Number with score	*Younger Adults (n=12)*		*High Tech Older Adults (n=12)*		*Low Tech Older Adults (n=12)*	
		M	***SD***	***M***	***SD***	***M***	***SD***
Go to cover		1.83	0.58	2.08	0.29	2.42	0.51
	Optimal	3	-	0	-	0	-
	Successful	8	-	11	-	7	-
	Partial	1	-	1	-	5	-
	Not attempted	0	-	0	-	0	-
Bookmark/ Text size		2.00	0.00	1.92	0.29	2.17	0.58
	Optimal	0	-	1	-	1	-
	Successful	12	-	11	-	8	-
	Partial	0	-	0	-	3	-
	Not attempted	0	-	0	-	0	-
Add note		2.00	0.00	2.08	0.51	2.58	0.67
	Optimal	0	-	1	-	0	-
	Successful	12	-	9	-	6	-
	Partial	0	-	2	-	5	-
	Not attempted	0	-	0	-	1	-

Note: Mean score determined by assigning scores for level of task completion: optimal=1, successful=2; partial=3, and not attempted=4.

Table 9.5 shows mean and individual task results for the Kindle. Visual inspection of this table shows that younger adults and high tech older adults were more successful on all tasks than low tech older adults, although at least 50% of participants completed all tasks across groups. Only three younger adults, however, completed the first task optimally, and all younger adults were successful after the first task in which one person was only partially successful. The overall pattern of performance was similar between younger adults and high tech older adults with slightly more variable performance for the third task, but Mann-Whitney *U* tests performed on the mean scores identified no significant age differences (all *p*'s>.05). The overall pattern of performance was different between high tech and low tech older adults, though, with over 80% of high tech older adults successful on each task but at least 25% of low tech older adults were only partially successful on each task. One low tech older adults was having so many problems with the Kindle that the experimenter did not ask her to try the third task to reduce frustration for a subsequent technology and allow her to finish the study in a reasonable timeframe. Mann-Whitney *U* tests performed on the mean scores for each task identified no significant experience differences (all *p*'s>.05), however. The lack of significance may be due to the small sample size.

Task time. Task time comparisons in this study allowed standard assessment of age and experience differences, whereby shorter task times could indicate more relevant prior experience as participants needed less time to study options, controls, and/or feedback. Task times are presented in the graphs comparing age and frequency differences in Figure 9.1. T-tests to assess age differences in task times revealed that younger adults were significantly faster than high tech older adults on all three tasks (go to cover ($t(22) = -6.00$, $p < .001$); bookmark ($t(22) = -2.30$, $p < .05$); add note ($t(22) = -4.44$, $p < .001$)). T-tests of experience differences revealed significant differences for the bookmark ($t(22) = -2.63$, $p < .05$) and add note ($t(21) = -2.64$, $p < .05$) tasks, with high tech older adults significantly faster than low tech older adults.

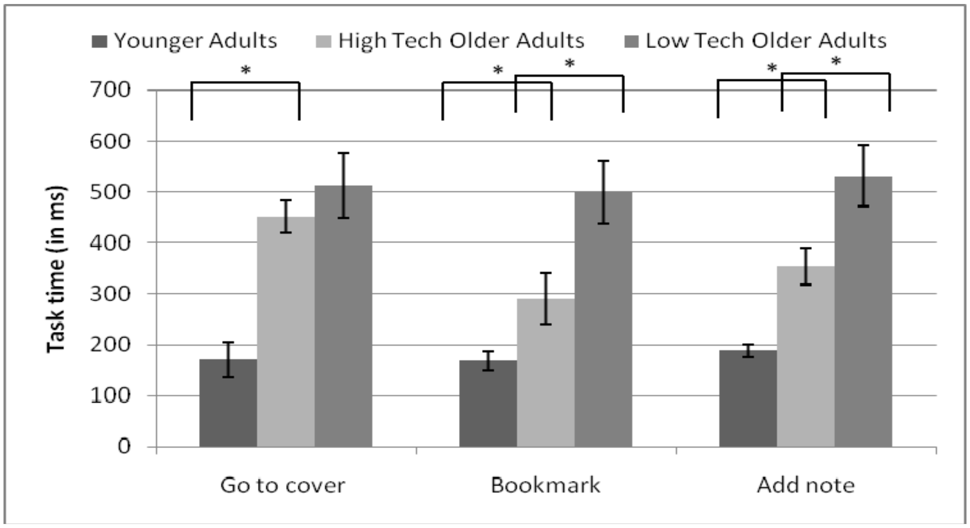


Figure 9.1. Task time comparisons for Kindle Tasks. Graph shows comparisons between younger adults, high tech older adults, and low tech older adults.* indicates a significant difference ($p < .05$). Bars represent standard error of the mean.

Subjective evaluation. Participants' subjective perceptions of the Kindle interaction may also provide insights regarding the role of prior experience in everyday technologies. If participants had no prior experience with the specific or similar technologies, for instance, they may express more frustration with particular aspects of cognitive workload. Alternatively, their lack of experience may lead to satisfaction with any level of success they achieve.

Table 9.6.
Self-reported Cognitive Workload and Satisfaction with Kindle Interaction

	Younger Adults (n=12)			High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	SD		M	SD	M	SD
Cognitive Workload (1=Low, 10=High)							
Overall cognitive workload	4.57	1.31	*	6.70	1.39	7.05	1.95
How much mental and perceptual activity was required?	5.58	1.56	*	8.25	1.22	8.58	2.11
How much physical activity was required?	3.25	2.38		4.67	3.28	6.42	3.50
How much time pressure did you feel?	4.17	1.53	*	6.58	2.43	6.33	2.87
How hard did you have to work?	5.17	1.11	*	8.17	1.03	7.42	2.39
How insecure, discouraged, did you feel?	4.67	2.61		5.83	3.07	6.50	3.12

	Younger Adults (n=12)		High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	SD	M	SD	M	SD
Perceptions of Success and Satisfaction (1=Low, 10=High)						
How successful do you think you were?	7.83	1.53	7.42	2.78	4.83	3.16
How satisfied are you with your performance?	6.50	2.47	6.42	3.29	4.17	2.92

Note: *p<.05

As shown in Table 9.6, participants generally reported a moderate level of cognitive workload, success, and satisfaction. Mann-Whitney *U* tests were performed to assess age and experience differences in each measurement. These tests revealed that, compared to high tech older adults, younger adults reported lower workload overall (U=19, p<.005, r=.63), and individually for mental and perceptual activity (U=11.5, p<.001, r=.72), time pressure (U=26.5, p<.01, r=.54), and work effort (U=2, p<.001, r=.84). Contrary to expectations, participants in both groups did not just report general frustration without designating a particular area of higher workload. Instead, higher ratings for mental and perceptual activity suggested that this component most contributed to perceptions of moderate workload. No age effects were identified for success or satisfaction. No experience effects were revealed for any self-reported cognitive workload, success, or satisfaction.

Fit with Prior Knowledge. In addition to recalling similar technologies as sources for interacting with new technologies, users may also simply recognize particular controls from entirely unrelated domains to begin their interactions. This approach may be particularly useful for interacting with unfamiliar devices with unknown functions and feature sets such as the Kindle that was not used by most participants before this study. Therefore, examining what prior knowledge may have been used also requires asking participants to evaluate key controls on the Kindle.

The question of prior knowledge was addressed by examining participant responses to questions about the appearance, location, and operation for each control on the Familiarity Questionnaire (Appendix G-6), completed after all tasks were finished on the technology. Because participants had responded based on how much the control met their expectations on each dimension, this response indicated how well the control fit their prior experience (knowledge in the head). For example, a response of "Exactly" to a question such as "Did the power control look as you expected it to?" suggests that prior knowledge about a power control was sufficient to easily recognize this control. A mean response that was less than 6 (score for "Exactly") suggests that additional information from the Kindle itself (knowledge in the world) was necessary to identify the control. Only responses from participants who were successful on the first task in which the control should be used were included in the calculation so that total knowledge of the control (prior knowledge + knowledge gained from control experience) was sufficient for correct use. Three key questions about this control knowledge were: 1) was the control itself similar to another technology known by participants? 2) did control knowledge differ by dimension? 3) did control knowledge differ by age or experience?

Table 9.7.

Self Reported fit of Prior Knowledge with Control Experience on Kindle

Task first used	Control	Dimension on Familiarity Questionnaire	Younger Adults	High Tech Older Adults	Low Tech Older Adults
Find cover			**(n=11)**	**(n=11)**	**(n=7)**
	power	Appearance % answering "Exactly"	45.50%	54.50%	28.60%
		Location % answering "Exactly"	18.20%	0.00%	14.30%
		Operation % answering "Exactly"	90.90%	90.90%	28.60%
		Similar to another technology % answering "Yes"	90.90%	90.90%	71.40%
	scroll	Appearance % answering "Exactly"	36.40%	36.40%	42.90%
		Location % answering "Exactly"	36.40%	36.40%	42.90%
		Operation % answering "Exactly"	72.70%	36.40%	28.60%
		Similar to another technology % answering "Yes"	100.00%	90.90%	42.90%

Task first used	Control	Dimension on Familiarity Questionnaire	Younger Adults	High Tech Older Adults	Low Tech Older Adults
	Home	Appearance % answering "Exactly"	36.40%	9.00%	28.60%
		Location % answering "Exactly"	0.00%	0.00%	14.30%
		Operation % answering "Exactly"	36.40%	27.3%	28.60%
		Similar to another technology % answering "Yes"	27.30%	9.10%	71.40%
Bookmark/ Text Size			**(n=12)**	**(n=12)**	**(n=9)**
	Text size	Appearance % answering "Exactly"	16.70%	16.70%	22.20%
		Location % answering "Exactly"	8.30%	8.30%	11.10%
		Operation % answering "Exactly"	33.30%	58.30%	33.30%
		Similar to another technology % answering "Yes"	66.70%	75.00%	88.90%
Open other book/ Add Note			**(n=12)**	**(n=10)**	**(n=6)**
	Next page	Appearance % answering "Exactly"	0.00%	20.00%	0.00%
		Location % answering "Exactly"	25.00%	20.00%	0.00%
		Operation % answering "Exactly"	75.00%	90.00%	16.70%
		Similar to another technology % answering "Yes"	83.30%	40.00%	50.00%
	Add note	Appearance % answering "Exactly"	0.00%	10.0%	0.00%
		Location % answering "Exactly"	0.00%	0.00%	0.00%
		Operation % answering "Exactly"	8.30%	20.00%	16.70%
		Similar to another technology % answering "Yes"	58.30%	50.00%	83.30%

Table 9.7 shows the self-reported prior knowledge fit for six controls used on the Kindle, though usage differed by task. For example, power should only be used twice, once in the first task to turn the Kindle on and once in the third task to turn the Kindle off. On the other hand, the scroll control was used multiple times both for cursor movement and key entry on all tasks. The top three rows for each control report the percentage of participants who judged that the control looked/was located/operated exactly as they expected. The last row records the percentages reporting that the control was similar to another technology.

*Control similarity to other technologies***.** The first question was whether the controls were similar to another technology, and surprisingly the answer was not all of the time. Even the power control that was at least eventually used successfully by all participants did not suggest a similar technology for nearly 10% of younger adults and 10% of high tech older adults. Chi-square analysis to assess the independence of the "yes" responses across participant groups revealed no significant differences for the measured controls (all p's>.05), though the small number of "yes" responses for the home control prevented statistical analysis for this control.

Note that participants' "no" responses may indicate that the source technology was simply not accessible. Given that each "yes" elicited a question during the interview about which technology it was similar to, some participants may have answered no because they could not remember a specific technology or because they did not want to discuss it. The fact that the responses varied between controls even within the Kindle, however, suggests that something specific about that control was likely to have elicited the "no" response. Alternatively, answers to one or more dimensions of the control that were significantly different from their expectation may have made them less likely to believe that the control on a known technology was similar enough. These cases, then, may represent examples of interference due to knowledge from several different sources. Given that all participants included in this calculation were successful on the noted task (a behavioral test of knowledge rather than an analytic test of knowledge as the questionnaire may have invoked), it was therefore useful to look at the individual dimensions of the control to evaluate useful prior knowledge.

Control knowledge by dimension. The second set of questions about control knowledge was whether control knowledge differed by dimension. As suggested in reviewing the previous question, the degree of fit with participant expectations differed by dimension. Due to the small sample size per group, statistical analysis was not possible. Visual inspection of Table 9.7, however, reveals that the dimensions were judged differently by participants in most cases. For example, over 90% of younger adults judged that the power control operated exactly as expected, but fewer than 50% judged that it appeared exactly as expected and fewer than 20% judged that the location was exactly as expected. It is more surprising then, to identify controls like the scroll that have similar ratings across dimensions for several groups. Controls with these consistent judgments may be less likely to produce interference because they suggest the same expectation across all dimensions. Among the dimensions, it was also interesting to note that with one exception (scroll operation judgment by low tech older adults), participants were more likely to judge control operation to be equal to or greater than the appearance or location dimensions for each control. This dimension may be more important because participants appeared to ascribe two questions to this: how do I interact with it and what will happen after my interaction. One or both of these questions may be the most important knowledge in predicting task success.

*Age and experience differences in control knowledge***.** The last set of questions returns to the issue of age or experience differences in prior knowledge. Due to the small sample size, analysis was only possible for power operation and next page operation. Chi-square tests of independence revealed only a significant difference for next page operation (χ^2 (2,N=19)=6.74), p<.05) with a large effect size (φ=.60). Residual analysis revealed that the lower percentage of low tech older adults (16.7%) reporting that the operation of the next page exactly fit their expectations significantly accounted for the difference. A visual inspection of Table 9.7 reveals some expected patterns (e.g., younger adults and high tech older adults show similar high judgments for operation of the power control that is higher than low tech older adults), but anomalies as well (e.g., appearance of home and text size control judged higher fit by low tech older adults than high tech older adults). These anomalous patterns, however, suggest that specific prior knowledge may supplement general technical knowledge gaps to facilitate success for low tech older adults.

Summary of Kindle Interaction. Evaluation of Kindle performance was expected to provide data on how participants with different age and experience levels interact with an everyday technology for which few participants were likely to have specific experience. As expected, specific Kindle and more generic electronic book reader experience was low, but younger adults and high tech older adults had recent, significant experience reading books and articles on the web. Results showed that at least 50% of participants in each group completed every task, but there were few optimal performances. All younger adults were successful in the latter two tasks, suggesting that they had learned how to operate the key functions of the Kindle after only one task. No significant age or experience differences were identified for task success, but significant age and experience differences were identified in task time. Younger adults were faster than high tech older adults on all three tasks, and high tech older adults were faster than low tech older adults on the second and third tasks. Significant differences in subjective performance were reported by high tech older adults in higher workload, mental and perceptual processing, time pressure, and work effort. These data suggest that high tech older adults may have been initially challenged to use this unfamiliar technology on the first task, but their prior technology experience may have facilitated acquisition of Kindle-specific knowledge as suggested by Beier and Ackerman (2005). The higher levels of performance by younger adults may have been based on broader, more intense experience with PC and Internet technologies that provided the base structure for Kindle interaction. Compared with high tech older adults with similar general technology experience, younger adults may have been able to learn this structure more easily using their higher perceptual motor speed and working memory. Thus, equating general technology experience between participant groups may not fully mitigate age-related declines.

Another possible source of prior knowledge was prior experience with individual controls. Many successful participants did report that the controls were similar to other technologies they knew, but patterns of differences in control knowledge across different dimensions (appearance, location, and operation) suggest that some prior knowledge may have interfered with optimal use on the Kindle. For example, over 35% of younger adults reported that the appearance and operation of the home control was exactly as they expected but none of them reported that the location was an exact fit. Observations of participant interactions revealed that many younger adults expected all important functions to be accessed on a menu rather than on the keyboard, so they typically searched several menu options before identifying the home button on the keyboard.

Review of participant judgments of exact fit also revealed that the operation of a control was equal or higher than other dimensions of the control, suggesting that this knowledge may be most important for utilizing a control to achieve task success. No patterns of age differences in control knowledge were identified, indicating that younger adults and high tech older adults both had similar prior knowledge. Patterns of experience differences were generally consistent with expectations that low tech older adults would have lower prior knowledge of technology controls. However, reverse patterns found for several controls in which low tech older adults had higher prior knowledge suggest that specific knowledge can supplement an overall technology experience gap to allow low tech older adults to succeed in spite of lower general technology experience.

Flip Video Camcorder.

The next technology examined was the Flip video camcorder, expected to have low specific experience for any participant group but high familiarity from similar technologies among younger adults and high tech older adults. In this section, experience with the most similar technologies will first be presented. Then, performance by participant group will be presented and compared across age and general technology experience. Lastly, participant self-reports of prior knowledge of Flip controls will be assessed for successful performances.

Table 9.8.
Self Reports of Participants' Prior Experience with Technologies Similar to Flip

	Younger Adults (n=12)		High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	SD	M	SD	M	SD
Have you ever used a Flip camcorder before? (% yes)	0.0%	-	0.0%	-	0.0%	-
Have you ever used another video camcorder before this study? (% yes)	100.0%	-	66.7%	-	16.7%	-
If yes, approximately how many video camcorders have you used? (% used)						
1	25.0%	-	41.7%	-	16.7%	-
2-5	50.0%	-	25.0%	-	0.0%	-
More than 5	25.0%	-	0.0%	-	0.0%	-
How recently have you used a video camcorder? 1=earlier today, 7=more than a year ago	5.2	0.94	6.0	0.52	7.0	0.0
How frequently do you typically use a video camcorder? 1=every day, 7=used only once or twice	5.3	1.1	6.1	0.6	6.5	0.7
Have you ever used a video player before this study? (% yes)	100.0%	-	100.0%	-	75.0%	-
If yes, approximately how many video players have you used? (% used)						
1	0.0%	-	16.7%	-	41.7%	-
2-5	41.7%	-	66.7%	-	16.7%	-
More than 5	58.3%	-	16.7%	-	16.7%	-
How recently have you used a video player before this study? 1=earlier today, 7=more than a year ago	3.5	1.3	3.3	1.3	5.1	2.2
How frequently do you typically use a video player? 1=every day, 7=used only once or twice	4.1	1.4	3.3	1.2	4.8	1.49

	Younger Adults (n=12)		High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Have you ever used a digital camera before? (%yes)	100.0%	-	100.0%	-	25.0%	-
If yes, approximately how many digital cameras have you used? (% used)						
1	0.0%	-	33.3%	-	25.0%	-
2-5	66.7%	-	50.0%	-	0.0%	-
More than 5	33.3%	-	8.3%	-	0.0%	-
How recently have you used a digital camera before this study? 1=earlier today, 7=more than a year ago	4.2	1.0	4.3	1.6	4.0	1.0
How frequently do you typically use a digital camera? 1=every day, 7=used only once or twice	4.1	1.1	4.4	1.0	5.0	1.7
Have you ever used an audio recorder before? (%yes)	75%	-	75.0%	-	41.7%	-
If yes, approximately how many audio recorders have you used? (% used)						
1	25.0%	-	16.7%	-	16.7%	-
2-5	50.0%	-	41.7%	-	25.0%	-
More than 5	0.0%	-	16.7%	-	0.0%	-
How recently have you used a audio recorder? 1=earlier today, 7=more than a year ago	5.9	0.9	4.4	2.0	6.5	0.6
How frequently do you typically use an audio recorder? 1=every day, 7=used only once or twice	6.1	1.4	5.4	1.8	6.7	0.6

Prior experience. Participants' prior experience with the Flip camcorder, as well as with other video camcorders, video players, digital cameras, and audio recorders were measured and are presented in Table 9.8. As expected, no participants in any group had experience with the Flip. Chi-square analysis of independence for the four similar technologies revealed significant differences for video camcorders ((χ^2 (2, *N*=22)=6.91), *p*<.05) with a medium effect size (φ=.56), and for digital cameras ((χ^2 (2, *N*=27)=6.0), *p*<.05) with a medium effect size (φ=.47). Although residual analysis revealed no single value was the primary source of the difference for video camcorders, visual inspection reveals that both younger adults (100%) and high tech older adults (66.7%) reported more previous video camcorder use than low tech older adults (16.7%).

Though not significant, the fact that all younger adults had used camcorders before but only two-thirds of the high tech older adults indicates that more inter-individual variability in prior experience may be present for the high tech older adults.

For digital cameras, however, all younger adults and high tech older adults reported prior use, and residual analysis revealed that the 25% prior use by low tech older adults was significantly different. A similar, but non-significant pattern was revealed in which an equal, high percentage of younger adults and high tech older adults reported using video players and audio recorders whereas low tech older adults used fewer of each (75.0% for video players and 41.7% for audio recorders). Thus, younger adults and high tech older adults had similarly high previous experience with a set of related technologies to the Flip, but fewer low tech older adults reported experience with this set of related technologies.

To assess the robustness of the difference in experience, Mann-Whitney *U* tests were performed on the recency and frequency of prior use for each of these related technologies. The only significant age difference was identified for camcorders where both recency (U=10.5, p<.001, r=.74) and frequency (U=18.0, p<.001, r=.66) were lower (i.e., more recent and more frequent) for younger adults. Experience differences were significant for both measures for the full set of technologies, as shown in Table 9.9. Thus, knowledge gained from experience with camcorders may be less accessible for high tech older adults than younger adults, and knowledge gained from experience with all similar technologies may be less accessible for low tech older adults than high tech older adults.

Table 9.9.
Statistical Tests of Recency and Frequency of Usage of Similar Technologies between High Tech and Low Tech Older Adults

	Recency	**frequency**
Camcorder	*U*=22.5, *p*<.001, *r*=.66	U=29.0, *p*<.005, *r*=.59
Video player	*U*=24.5, *p*<.01, *r*=.57	*U*=20.5, *p*<.01, *r*=.61
Digital camera	*U*=19.0, *p*<.01, *r*=.65	*U*=17.0, *p*<.001, *r*=.68
Audio recorder	*U*=30.0, *p*<.01, *r*=.52	*U*=31.0, *p*<.05, *r*=.52

Performance. For the Flip, several differences in prior experience have been identified (above) but the effect of these differences on performance is unknown. Overall performance was assessed objectively through task success and task time and subjectively through self-reports of cognitive workload and satisfaction. The analysis report follows the same process as detailed for the Kindle in the prior section.

Task success. Table 9.10 shows task performance results for the Flip. Visual inspection reveals that at least two-thirds of younger adults performed the first two tasks optimally, whereas few optimal performances were exhibited by the high tech older adults and none by the low tech older adults. Fewer of the younger adults performed optimally on the last task in which participants not only had to select the delete key, but they also had to correctly select this delete key to confirm deletion. Consistent with this pattern, Mann-Whitney *U* tests performed to identify age differences in the mean task scores only revealed significant differences for the delete video task (*U*=42, *p*<.05, *r*=.42) in which more younger adults were more successful than high tech older adults. The lack of statistical significance for the other tasks may have been due to the small sample size and variability in the high tech older adults.

Mann-Whitney *U* tests performed to identify experience differences in the mean task scores revealed significant differences for the record video (*U*=28.5, *p*<.01, *r*=.58) and for the delete video task (*U*=42, *p*<.05, *r*=.42). In both tasks, more high tech older adults were successful than low tech older adults.

Table 9.10.
Participant Performance on Flip Tasks

Task	Number with score	Younger Adults (n=12)			High Tech Older Adults (n=12)			Low Tech Older Adults (n=12)	
		M	*SD*		*M*	*SD*		*M*	*SD*
Record video		1.33	0.49		2.25	0.62	*	2.58	0.51
	Optimal	8	-		1	-		0	-
	Successful	4	-		7	-		5	-
	Partial	0	-		4	-		7	-
	Not attempted	0	-		0	-		0	-
Play video		1.25	0.45		1.92	0.51		2.17	0.39
	Optimal	9	-		2	-		0	-
	Successful	3	-		9	-		10	-
	Partial	0	-		1	-		2	-
	Not attempted	0	-		0	-		0	-
Delete video		1.92	0.51	*	2.33	0.49	*	2.58	0.51
	Optimal	2	-		0	-		0	-
	Successful	9	-		8	-		5	-
	Partial	1	-		4	-		7	-
	Not attempted	0	-		0	-		0	-

Note: *p<.05. Mean score determined by assigning scores for level of task completion: optimal=1, successful=2; partial=3, and not attempted=4.

Task time. Although task success differences between younger adults and high tech older adults were not statistically significant, performance differences may be identified through task time measurements if prior experience allowed participants to select the correct control without trial and error. Task times are presented in the graphs comparing age and frequency differences in Figure 9.2. T-tests performed to identify age differences in task time revealed significant differences on both the record video ($t(22)$ =-3.27, p<.005) and play video ($t(22)$ =-3.53, p<.005) tasks wherein younger adults were significantly faster than high tech older adults. T-tests performed to identify experience differences in task time revealed significant differences only on the record video task (($t(22)$ =-3.25, p<.01) whereby high tech older adults were significantly faster than low tech older adults. Visual inspection of the graphs suggests that significant differences identified in this analysis may be particularly due to the low variability in task time for younger adults on the first two tasks and consistent variability for all tasks among high tech older adults. This variability may be a key reason that significant differences were not identified in comparison to low tech older adults in the play video and delete video tasks.

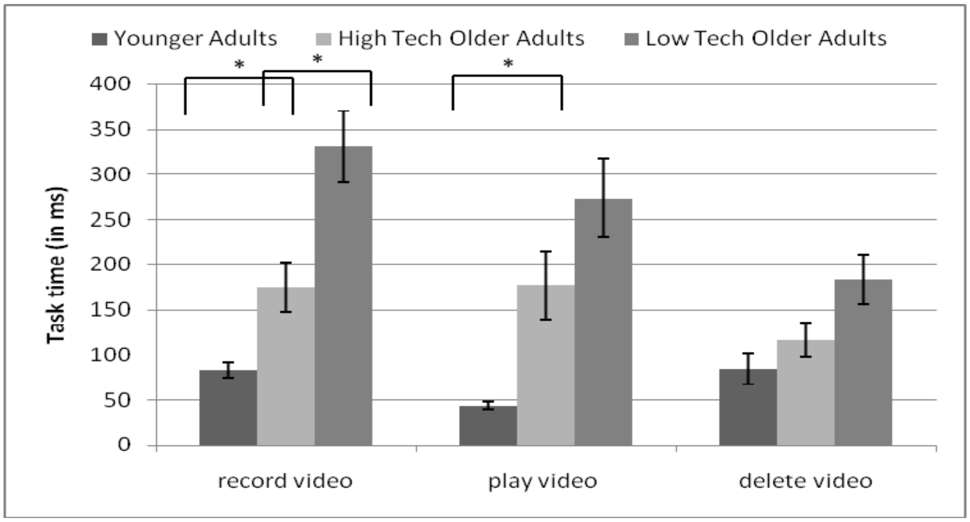


Figure 9.2. Task time comparisons for flip tasks. Graph, shows comparisons between younger adults, high tech older adults, and low tech older adults. * indicates a significant difference (p<.05). Bars represent standard error of the mean.

Subjective evaluation. Table 9.11 shows participants' perceptions of workload and satisfaction. Notably, the overall workload was low for younger adults but moderate for high tech older adults and low tech older adults. Mann-Whitney U tests performed to identify age differences in workload revealed that the overall workload (U=19, p<.005, r=.63), mental and perceptual activity (U=14.5, p<.005, r=.62), time pressure (U=36, p<.05, r=.43), and effort (U=15.5, p<.005, r=.68) were significantly higher for high tech older adults than younger adults. Consistent with the higher workload among high tech older adults was the significantly higher perceived success (U=34.5, p<.05, r=.46) for younger adults according to Mann-Whitney U tests. Contrary to prior expectations, participants in neither group reported frustration. On the other hand, Mann-Whitney U tests revealed that a higher rating for mental and perceptual activity for low tech older adults was the only significant experience difference (U=36.5, p<.05, *r*=.62). Notably, this component had the lowest standard deviation for low tech older adults (i.e., the majority reported a consistent level of high mental and perceptual activity). This high level of activity would be expected given the low level of prior experience with video camcorders that may have made the low tech older adults more dependent on trying to understand the labels and feedback on the Flip without basic task knowledge to guide their actions.

Table 9.11.
Self-reported Cognitive Workload and Satisfaction with Flip Interaction

	Younger Adults (n=12)			High Tech Older Adults (n=12)			Low Tech Older Adults (n=12)	
	M	SD		M	SD		M	SD
Cognitive Workload (1=Low, 10=High)								
Flip overall workload	2.50	0.77	*	4.77	1.82		6.38	2.04
How much mental and perceptual activity was required?	3.00	1.21	*	6.33	2.23	*	8.25	1.71
How much physical activity was required?	2.08	0.79		3.42	2.47		5.33	2.77
How much time pressure did you feel?	2.58	1.31	*	4.33	2.06		5.67	3.34
How hard did you have to work?	2.50	1.24	*	5.92	2.47		7.33	2.35
How insecure, discouraged, did you feel?	2.33	0.98		3.83	2.59		5.33	3.26
Perceptions of Success and Satisfaction (1=Low, 10=High)								
How successful do you think you were?	8.92	1.08	*	6.17	3.21		5.42	3.00
How satisfied are you with your performance?	8.42	1.73		6.42	3.48		4.75	2.45

Note: p<.05

Fit with Prior Knowledge. Younger adult and high tech older adults may have been more likely to have performed better with the Flip due to relevant prior knowledge from similar technologies to guide their initial interactions. Alternatively, prior experience may have elicited interfering knowledge that made control identification and feedback interpretation more difficult. Assessing participants' judgments of fit of key controls with their prior expectations could be an effective way to understand interference from potentially relevant technologies. As with the Kindle, the same three questions were addressed: 1) was the control itself similar to another technology known by participants? 2) did control knowledge differ by dimension? 3) did control knowledge differ by age or experience? Table 9.12 shows the self-reported prior knowledge fit for six controls used on the Flip that will be the basis for control analysis. Note that only participants successful on the first task for which the control should be used were included in the calculations.

Table 9.12.
Self-Reported Fit of Prior Knowledge with Control Experience on Flip (All Tasks)

Task first used	Control	Dimension on Familiarity Questionnaire	Younger Adults	High Tech Older Adults	Low Tech Older Adults
Record video			**(n=12)**	**(n=9)**	**(n=5)**
	power	Appearance % answering "Exactly"	75.00%	22%	20.00%
		Location % answering "Exactly"	16.70%	0.00%	0.00%
		Operation % answering "Exactly"	66.70%	89.0%	20.00%
		Similar to another technology % answering "Yes"	100.00%	88.90%	60.00%
	record	Appearance % answering "Exactly"	33.30%	56.0%	0.00%
		Location % answering "Exactly"	25.00%	44.0%	0.00%
		Operation % answering "Exactly"	50.00%	33.0%	0.00%
		Similar to another technology % answering "Yes"	100.00%	77.80%	40.00%
Play video			**(n=12)**	**(n=10)**	**(n=10)**
	play	Appearance % answering "Exactly"	16.70%	60.00%	20.00%
		Location % answering "Exactly"	16.70%	60.00%	40.00%
		Operation % answering "Exactly"	50.00%	80.00%	40.00%
		Similar to another technology % answering "Yes"	83.30%	100.00%	60.00%
	volume	Appearance % answering "Exactly"	16.70%	10.00%	0.00%
		Location % answering "Exactly"	8.30%	0.00%	0.00%
		Operation % answering "Exactly"	41.70%	30.00%	0.00%
		Similar to another technology % answering "Yes"	75.00%	70.00%	20.00%
Delete video			**(n=11)**	**(n=9)**	**(n=5)**
	prev/next	Appearance % answering "Exactly"	36.40%	33.30%	40.00%
		Location % answering "Exactly"	36.40%	33.30%	40.00%
		Operation % answering "Exactly"	54.50%	66.70%	40.00%
		Similar to another technology % answering "Yes"	100.00%	100.00%	60.00%
	delete	Appearance % answering "Exactly"	27.30%	44%	20.00%
		Location % answering "Exactly"	9.10%	33%	40.00%
		Operation % answering "Exactly"	36.40%	56%	40.00%
		Similar to another technology % answering "Yes"	90.90%	100.00%	60.00%

Control similarity to other technologies. As with the Kindle, visual inspection of judgments of fit for the Flip controls in Table 9.12 reveals that similar technologies are not always reported by participants for all controls. For the Flip, however, judgments by younger adults and high tech older adults were similar and high (>70%) for all controls. On the other hand, no more than 60% of low tech older adults reported similar technologies for any control. Chi-square analysis performed to identify differences in the distribution of participant judgments about similarity of controls to another technology revealed a significant differences only for the record control (χ^2 (2,N=21)=7.14), p<.05) with a large effect size (φ=.58). Residual analysis did not identify any responses as being significantly responsible for the difference.

Control knowledge by dimension. The second set of questions about control knowledge was whether control knowledge differed by dimension. Due to the small sample size per group, statistical analysis was not possible. Visual inspection of Table 9.12, however, reveals that the dimensions were judged differently by participants in most cases. For example, over 65% of younger adults judged that the power control operated exactly as expected and 75% judged that it appeared exactly as expected, but fewer than 20% judged that the location was exactly as expected. Given that all younger adults reported that this power control was similar to another technology, the large gap between the location and other two dimensions suggest that younger adults have a specific expectation for where the power control should be located. Even fewer (0%) of high tech older adults judged that the location was what they expected, but barely 20% also judged that the appearance of the power control was exactly as they expected. Both of these differences suggest that where participants have relevant prior experience, expectations may be fairly specific.

Two other observations are similar to the Kindle. First, one control (prev/next) had fairly consistent judgments by all participant groups across dimensions. Second, with one exception (power operation judgment by younger adults), participants were more likely to judge control operation to be equal to or greater than the appearance or location dimensions for each control. These observations suggest that attention to examining participant perceptions of the dimensions of knowledge can provide additional insights for technology design. For the prev/next control participant expectations may have been similar and consistent across dimensions, facilitating the selected implementation and correct usage. For other controls participants may use appearance and location dimensions to narrow possible functions for controls, but only exact matches for operation may facilitate error-free performance.

Age and experience differences in control knowledge. The last set of questions returns to the issue of age or experience differences in prior knowledge. Due to the small sample size, analysis was only possible for power operation and next page operation. Visual inspection of Table 9.12, however, reveals three interesting differences. First, low percentages of both groups of older adults judged both appearance and location for the power control to be exactly as they expected. In fact, many older adults specifically commented that they were unfamiliar with the power symbol, reporting for instance that "it looks like a timer". Older adults also noted that the power button was difficult to see, which may have made it even more difficult to match with an unfamiliar symbol. Second, no low tech older adult judged that the record was exactly as expected across any dimension. No low tech older adults judged volume to be exactly as expected across dimensions either, but lower scores for volume in other groups suggest that the design may have been a significant contributor to the gap in expectations across age and experience levels. The gap for the record control, though, is unique to the low tech older adults who reported significantly lower camcorder and other digital camera technologies. Without prior experience or labeling other than a salient red color, low tech older adults may have had no expectation for control use or expected feedback. The third pattern is that there were several controls like play and delete that were judged more as an exact fit for high tech older adults' expectations than for younger adults. Because high tech older adults reported less frequent and lower usage for camcorders than younger adults, they may be accessing a different reference technology such as a video player that may be more accessible for them.

Summary of Flip. Evaluating the Flip camcorder was expected to highlight performance differences for technologies in which different participant groups had different prior knowledge. Data largely support the expected performance levels. Review of specific prior experience for participants revealed that no participants had used the Flip before, but younger adults and high tech older adults had similarly used related technologies like video players and audio recorders. Younger adults had more digital camera use and more frequent and recent digital camcorder use than high tech older adults. Low tech older adults reported significantly lower use of all related technologies than high tech older adults.

The review of control knowledge revealed similar results in which younger adults and high tech older adults had similar, high experience with key controls but low tech older adults had low experience. For specific controls, however, age-related differences such as expectation that the power control would have the universal symbol were low for both high tech and low tech older adults. Experience differences were also found for the record control that showed no low tech older adults expected this control to look, operate, or be located as it was. The gap between task success and judgment of an exact fit for any volume dimension by any participant group suggests that the selected design may have created a problem for everyone. On the other hand, large gaps between dimensions for younger adults on the power control suggest that the younger adults had a specific, but different expectation for where the control would be than it was. Higher judgments of exact fit for play and delete controls by high tech older adults versus younger adults also suggests the use of different reference technologies.

Significant age differences in task success were only identified for the delete video task in which younger adults were more successful. Notably, though, at least two-thirds of younger adults performed the first two tasks optimally, whereas only a few high tech older adults and no low tech older adults performed any task optimally. Younger adults were also significantly faster for the first two tasks, with low variability of performance between these participants as expected given significantly high prior experience with digital cameras and camcorders. Younger adults were more variable on the third task, as may be expected given that delete/confirm is implemented in different ways across cameras and other technologies. As may be expected based on the variability in relevant prior experience, high tech older adults were more variable on all three tasks. Significant experience differences in task time were only found for the record video task, perhaps because low tech older adults had no expectation that the record control would look exactly as it did. Overall, participants in all three groups took longer to complete the delete video task that required first determining that the delete request required confirmation and then determining how to confirm the request. The higher, more variable time for all three groups suggests that trial and error was required to determine how to complete the confirmation on this particular camera.

Subjectively, younger adults reported that their workload was low and perceptions of satisfaction and success were high. These results were significantly different from high tech older adults who reported higher overall workload, mental and perceptual activity, time pressure, and effort on the task. Perhaps given their experience with similar technologies, the challenge high tech older adults found with seemingly simple aspects of the tasks like identifying the power button may have established a higher cognitive workload even before they got to the more complex aspects of the task like deleting a video. On the other hand, low tech older adults who were significantly slower and less successful for the record video task reported only significantly more mental and perceptual activity to deal with finding unfamiliar controls on a new technology, but they may have expected that new activities like this take time and patience to succeed. Thus, they may have been equally satisfied with what was objectively a lower level of performance.

Alarm Clock.

Because alarm clocks had presumably been used by all participants before this study (see Table 9.13), complete behavior analysis was performed for all alarm clock interactions to assess performance differences in light of similar specific knowledge but differential general prior knowledge. In this section, participants' specific prior experience with alarm clocks will first be presented. Then, performance by participant group will be reviewed and compared on objective and subjective measures. Additional performance analysis on errors and attention to knowledge in the world described in the complete behavior analysis can provide insights on differential use of prior knowledge beyond the measures collected for the Flip and Kindle. Lastly, participant perceptions of their control knowledge will be examined for successful performances.

Prior experience. Although general technology experience differentiated the two groups of older adults, the amount of specific prior alarm clock knowledge in participants was unknown. Table 9.13 presents participants' self-reports of prior alarm clock use, including current alarm clocks. All participants reported alarm clock use, and the majority reported having used more than one before the study. Mann-Whitney *U* tests to assess age and experience differences in the recency and frequency of prior alarm clock use revealed no significant differences (p's$>.05$). Although one or two participants in each group reported having used this particular alarm clock before, the majority had not. Mann-Whitney *U* tests to assess age and experience differences between similarity of participants' clock to the Sony clock in the study revealed no significant differences (all *p's*>.05). Thus, all participants generally reported significant, similar experience with alarm clocks.

Table 9.13.
Participant Self-Reported Prior Experience with Alarm Clocks

	Younger Adults (n=12)		*High Tech Older Adults (n=12)*		*Low Tech Older Adults (n=12)*	
	M	*SD*	*M*	*SD*	*M*	*SD*
Have you ever used an alarm clock before? % yes	100.0%	-	91.7%[1]	-	100.0%	-
If yes, approximately how many alarm clocks have you used in your lifetime? (% used)						
1	25.0%		0%		8.3%	
2-5	33.3%		16.7%		25.0%	
More than 5	41.7%		75.0%		66.7%	
If you use an alarm clock now, how similar is your alarm clock to the Sony clock in this study? 1=Not at all 6=Exactly the same	2.9	1.8	2.3	1.9	3.4	2.5
Have you ever used this alarm clock before? % yes	8.3%	-	16.7%	-	8.3%	-
How recently have you used an alarm clock before this study? 1=earlier today 7=more than a year ago	1.9	1.7	2.3	1.7	3.6	2.2
How frequently do you use an alarm clock? 1=every day 7=only used once or twice	3.3	1.5	3.5	1.5	3.6	0.7

[1] Participant with missing data later referenced own alarm clock as source of knowledge for specific clock control, so it seems reasonable to assume that participant had actually used an alarm clock before.

Performance. With similar, fairly broad experience with alarm clocks, participants could be expected to successfully complete typical tasks on this device, though age or experience differences may lead to differential performance. Thus, performance was assessed objectively through three measurements: task success, task times, and number of interactions, and subjectively through self-reports of cognitive workload and satisfaction. The approach for analyzing task success and task time will be the same as described above for the Kindle and Flip, but additional analysis of the reasons for differences could be performed with the alarm clock through the complete behavioral analysis. In particular, analysis of the number of interactions could help to evaluate different strategies among participant groups.

Task Success. Table 9.14 shows participant success on tasks for the alarm clocks, with different patterns of results for each task. First, these results show that all participants in every group were successful on the "listen to radio" task, and several people in each group performed this task optimally. Second, several high tech and low older adults only partially completed the "set time" task. Third, some participants in every group were only partially successful on the set alarm task. Statistically, Mann-Whitney *U* tests identified no age differences between task success scores, but experience differences were identified for the listen to radio task (U=33, p<.01, r=.52) and set alarm tasks (U=25, p<.005, r=.65) such that high tech older adults had lower (better) mean task scores than low tech older adults.

Table 9.14.
Participant Performance on Alarm Clock Tasks

Task	Number with score	Younger Adults (n=12)		High Tech Older Adults (n=12)			Low Tech Older Adults (n=12)	
		M	*SD*	*M*	*SD*		*M*	*SD*
Set time		1.50	0.52	1.75	0.75		2.25	0.62
	Optimal	6	-	5	-		1	-
	Successful	6	-	5	-		7	-
	Partial	0	-	2	-		4	-
	Not attempted	0	-	0	-		0	-
Listen to radio		1.83	0.39	1.75	0.45	*	1.83	0.39
	Optimal	2	-	3	-		2	-
	Successful	10	-	9	-		10	-
	Partial	0	-	0	-		0	-
	Not attempted	0	-	0	-		0	-
Set alarm		1.92	0.90	2.42	0.67	*	2.58	0.51
	Optimal	5	-	1	-		0	-
	Successful	3	-	5	-		5	-
	Partial	4	-	6	-		7	-
	Not attempted	0	-	0	-		0	-

Note: *p<.05. Mean score determined by assigning scores for level of task completion: optimal=1, successful=2; partial=3, and not attempted=4.

Task Time. Task times are presented in the graphs comparing age and frequency differences in Figure 9.3. T-tests to assess age differences between times for each task revealed that only the set alarm task showed a significant age difference ($t(22) = -3.27$, $p < .05$), with younger adults significantly faster than the high tech older adults. T-tests of experience differences between times for each task revealed that only the set time task was significant ($t(22) = 2.60$, $p < .05$), with high tech older adults significantly faster than low tech older adults.

These time differences may reflect knowledge differences in several ways, however. Participants may have taken more time to examine feedback and controls before deciding what to do next because these were unfamiliar and needed to be examined closely. Alternatively, participants may have thought that the controls were familiar and selected them easily, but the selection may have been incorrect and several other paths had to be tried before succeeding. Examining the number of activities executed in each task may help to determine if one of these possibilities was more likely.

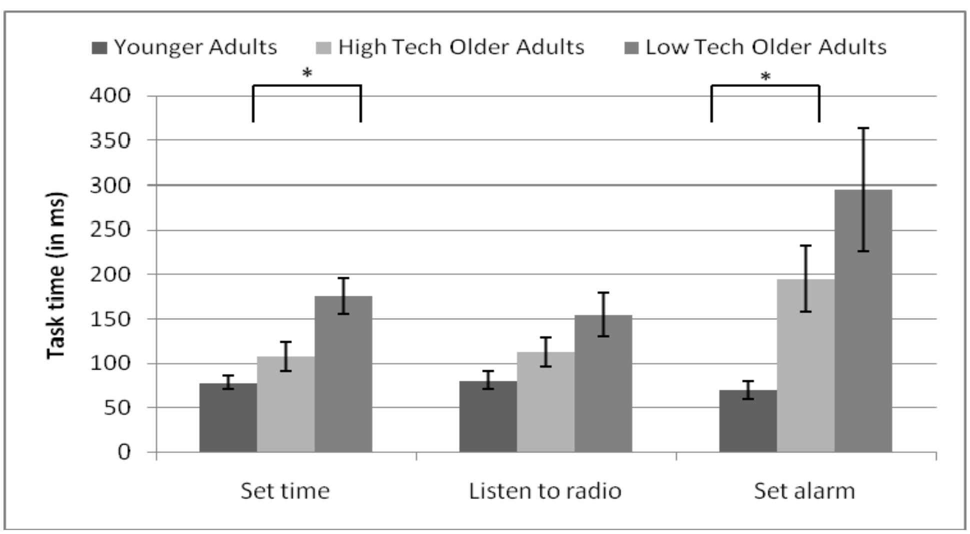


Figure 9.3. Task time comparisons for alarm clock tasks. Graph shows comparisons between younger adults, high tech older adults, and low tech older adults. * indicates a significant difference ($p < .05$). Bars represent standard error of the mean.

Interaction length. To assess whether participants completed tasks based on carefully selecting only correct controls or based on trial and error, the number of actions performed for each task were evaluated and compared for each participant group. Because the optimal path was assumed to be the minimal number of actions required to complete a task, assessments of differences in interaction length were focused on additional valid and invalid actions beyond the optimal path. Extra actions are presented in the graphs comparing age and experience differences in Figure 9.4. T-tests were conducted to assess age differences between times for each task individually. Both the set time ($t(22) = -1.64$, $p < .05$) and the set alarm ($t(22) = -3.75$, $p < .01$) action differences were significant, with a fewer number of extra actions completed by younger adults in both tasks. Thus, younger adults seemed to use trial and error less for these tasks than high tech older adults.

T-tests were also conducted to assess experience differences between times for each task individually, but contrary to expectations none of the differences were significant (all *p*'s >.05). The lack of effect may be due to the low sample size and high variability of interaction length for both older adult groups. Nonetheless, the higher interaction length for older adults suggests that trial and error was needed more than for younger adults. This may have been because information on the alarm clock (KiW) elicited incorrect knowledge in older adults that suggested incorrect actions, which then required correction. Alternatively, information on the alarm clock may have been ambiguous, requiring older adults to test different controls until they found the one that advanced them toward the goal. Both alternatives suggest that the information on the alarm clock was not as effective as it could be for older adults, but ineffective labeling and control selection may have also presented problems for younger adults. The penalty for younger adults may have been less severe, however, if their prior knowledge facilitated better feedback interpretation or if age-related cognitive and perceptual declines were the primary reason for ineffective trial and error by older adults. If the latter explanation was the case, older adults may exhibit different strategies to successfully interact with new technologies or unfamiliar examples of known technologies. It could be expected that these strategies would generate equivalent workload for the same satisfaction levels as younger adults, particularly for high tech older adults who use more new technologies than low tech older adults (see Study 1).

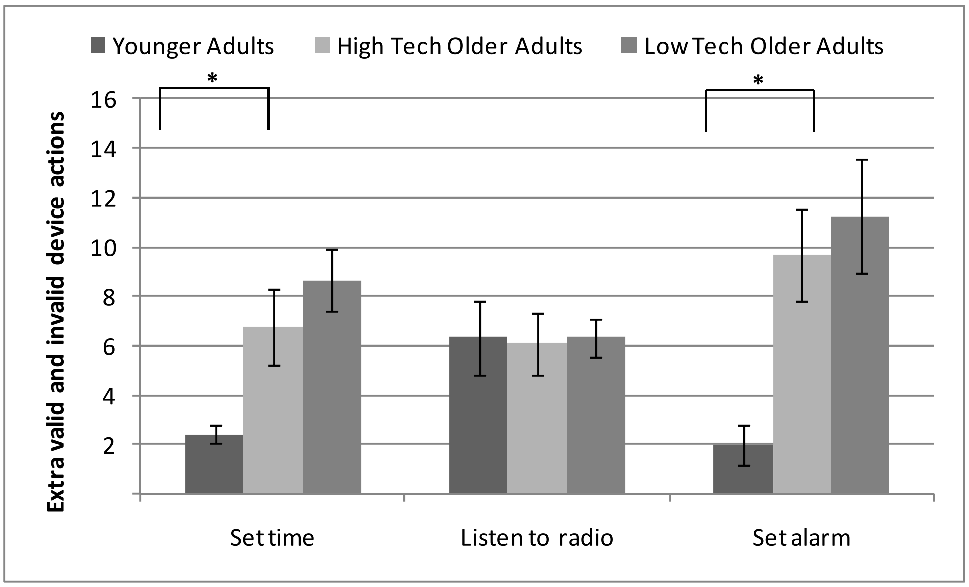


Figure 9.4. Extra action comparisons for alarm clock tasks. Graph shows comparisons of extra actions (valid and invalid) beyond the optimal path between younger adults, high tech older adults, and low tech older adults. * indicates a significant difference (p<.05). Bars represent standard error of the mean.

Subjective evaluation. Table 9.15 shows participants' perceptions of workload and satisfaction with their alarm clock interaction. In contrast to the other two technologies, Mann-Whitney *U* tests revealed no significant age or experience differences in either category of self-reports. The overall pattern of workload perception was low, though slightly higher for older adults than younger adults. The mean scores for low tech older adults were slightly higher than for high tech older adults, though the high variability makes this difficult to interpret. Nonetheless, perceived satisfaction and success were moderate to high for all participants. These results suggests that participants relatively judged their performance to be consistent with their expectations, perhaps because interacting with a new alarm clock is not an entirely novel behavior. These subjective results also indicate that this particular alarm clock was fairly representative of alarm clocks participants have used before. Thus, examining participant errors and strategies for the alarm clock may accurately represent typical interaction approaches with new exemplars of a familiar technology.

Table 9.15.
Self-reported Cognitive Workload and Satisfaction with Alarm Clock Interaction

	Younger Adults (n=12)		High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	**SD**	**M**	**SD**	**M**	**SD**
Cognitive Workload (1=Low, 10=High)						
Overall cognitive workload	2.85	0.69	3.62	2.08	4.67	2.30
How much mental and perceptual activity was required?	3.58	1.08	4.67	2.84	6.17	2.69
How much physical activity was required?	2.67	1.83	2.58	2.47	4.58	3.00
How much time pressure did you feel?	2.83	1.47	3.42	2.39	4.08	2.68
How hard did you have to work?	2.92	1.16	3.67	2.42	4.42	3.15
How insecure, discouraged, did you feel?	2.25	1.06	3.75	2.67	4.08	2.81
Perceptions of Success and Satisfaction (1=Low, 10=High)						
How successful do you think you were?	8.67	1.50	8.17	2.12	7.50	1.68
How satisfied are you with your performance?	8.08	1.98	7.67	3.08	6.83	2.44

Error Analysis. Because several performance differences have been identified in spite of the similar, substantial experience of all participants with alarm clocks, it may be expected that participants in different groups made different kinds of errors. Three types of analysis will be performed on errors to examine these differences. First, the mean number of errors will be presented and compared across groups, especially to allow comparisons with overall performance. Second, the range and total number of errors within individuals in a participant group will be presented and compared to begin to describe differences within groups. Lastly, the types of errors participants made in each task will be analyzed to explore the role of prior knowledge in the interactions.

Mean error analysis. Means and standard deviations of errors for each task were computed and compared as shown in Figure 9.5. Age differences were examined via t-tests for each task individually. Only the set alarm task was significant (*t(22)=-2.88, p*<.01), with younger adults committing fewer errors than high tech older adults. Experience differences were then examined for each task using the *t*-tests, but none of the results was significant (all *p*'s>.05). These results are consistent with the general performance results suggesting closer examination of the set alarm task to understand why this task was performed less successfully.

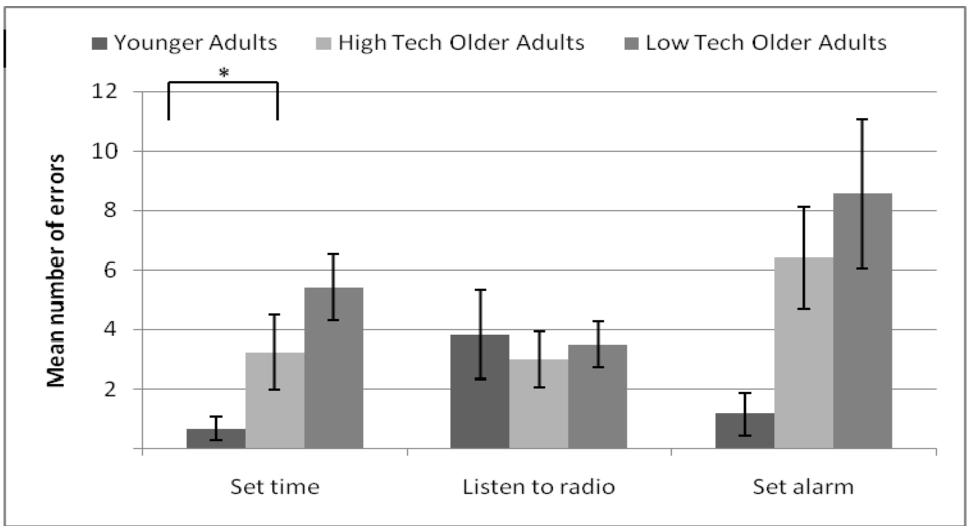


Figure 9.5. Comparisons of mean number of errors for alarm clock tasks. Graph shows comparisons between younger adults, high tech older adults, and low tech older adults. * indicates a significant difference (*p*<.05). Bars represent standard error of the mean.

Error ranges and totals. Before examining the types of errors made, it was also important to identify how different participant performance was within each group for different tasks. Table 9.16 shows the range of errors within participants and the total number of errors for each group. Mean errors (illustrated in Figure 9.5) were also reported on this table to facilitate analysis. Overall, Chi-square analysis of independence of total error counts overall were significant ((χ^2 (2,N=431)=69.92), *p*<.001), with a medium effect size (*φ*=.40). Residual analysis suggests that the lower number of errors for younger adults and higher number of errors for low tech older adults significantly accounted for the difference. Chi-square analysis of independence of total error counts for each task were significant for the set time ((χ^2 (2,N=112)=43.63), *p*<.001), with a medium effect size (φ=.40), and for set alarm ((χ^2 (2,N=195)=62.89), *p*<.001), with a medium effect size (φ=.57). Residual analyses revealed the same pattern of contribution to errors with lower number of younger adult errors and higher number of low tech older adult errors accounting significantly for the difference.

Table 9.16.
Observed Error Totals and Group Ranges within Alarm Clock Tasks

Tasks	Younger Adults (n=12)			High Tech Older Adults (n=12)		Low Tech Older Adults (n=12)	
	M	SD		M	SD	M	SD
Set Time							
Errors per participant	0.67	0.99		3.25	4.35	5.42	3.83
Range of errors among individuals in group	(0-3)			(0-13)		(0-13)	
Total number of errors in group	8			39		65	
Radio Volume							
Errors per participant	4.00	5.15		3.00	3.22	3.50	2.71
Range of errors among individuals in group	(0-15)			(0-11)		(0-7)	
Total number of errors in group	46			36		42	
Set Alarm							
Errors per participant	1.25	2.52	*	6.42	5.9	8.58	8.02
Range of errors among individuals in group	(0-9)			(0-18)		(2-31)	
Total number of errors in group	15			77		103	
Total errors per technology	69			152		210	

Note: *p<.05.

As described previously in the overall performance results, error results for the radio volume task was similar for every group overall, though the ranges were different. Note that many participants in all groups made errors on this task because they did not initially realize that the sound volume was extremely low. The radio volume had been deliberately minimized to reduce possible effects of hearing acuity differences between participants. Thus, many participants in each group pressed the correct "Radio On" button but heard no sound. Some participants in each group realized that the volume must be adjusted and proceeded to immediately find the volume. Other participants in each group tried other options including pressing the on button multiple times as well as trying other controls before realizing that the volume had to be increased before they could hear anything. Nonetheless, participants seemed to be similarly able to work through this trouble-shooting and complete this task as noted previously in Table 9.14.

*Knowledge in errors***.** The key question for this analysis was whether prior knowledge differentiated the types of errors participants made. As described above, observed errors were briefly noted and summarized on the back of the coding sheet during the activity coding process. Particular focus was placed on recording the error without inferring why the error was made. Errors were then collected and tallied on single spreadsheet for each participant group. Table 9.17 shows example errors reported for each task and participant group.

Table 9.17.
Observed Error Types within Alarm Clock Tasks

	Younger Adults (n=12)	High Tech Older Adults (n=12)	Low Tech Older Adults (n=12)
Set Time			
Example errors	incorrect use of timeset interaction control; time set attempt before selecting alarm set mode; incorrect time set	incorrect use of interaction control and alarm set control; time set attempt before selecting alarm set mode; set time incorrectly (AM/PM)	incorrect use of interaction control and alarm set control; time set attempt before selecting alarm set mode; set time incorrectly (AM/PM), set alarm rather than time; incorrect control use (radio power, brightness)
Radio Volume			
Example errors	used incorrect controls (e.g., brightness, timeset); pressed power on/power off multiple times	used incorrect controls (e.g., alarm mode, alarm/time set, brightness, tuner mode), multiple power on pushes	used incorrect controls (e.g., brightness, timeset, tuner mode, alarm mode, alarm/time set); pressed power on/power off multiple times, used tuner when volume intended, incorrectly read tuner display
Set Alarm			
Example errors	used incorrect controls (e.g., alarm reset, radio on/off); timeset attempt before selecting alarm set mode; set incorrect alarm mode; did not set alarm	incorrect mode setting for alarm and time set; used incorrect controls (e.g., alarm reset) and controls incorrectly, set incorrect time (AM/PM); reset clock instead of alarm time; did not set alarm; read time incorrectly	incorrect mode setting for alarm and time set; used incorrect controls (e.g., alarm reset, snooze) and controls incorrectly (multiple time set interaction), set incorrect time (AM/PM); reset clock instead of alarm time; did not set alarm; set incorrect alarm mode

Although one could infer use of prior experience to explain some of these errors, other explanations may also be likely. For instance, at least one participant in each group used the time set controls (see Figure 9.6) incorrectly. In this incorrect interaction, the center button on the time set control was pressed and held while the other buttons to the right and left were also pushed. Some alarm clocks use this interaction style (including Sony's 1981 version of the Dream Machine, the ICF-C10w), so these participants could have been using prior experience. However, as shown in right side of Figure 9.6, participants may also have noticed the black "TIME SET" label in front of the center button for these controls. They may have assumed that this label only applied to the center button, pressed it, and then noticed the '+' and '-' labeled buttons that must be pressed to increase or decrease the time. Both explanations are possible, and participants may not even be aware why they decided to select a particular interaction style.

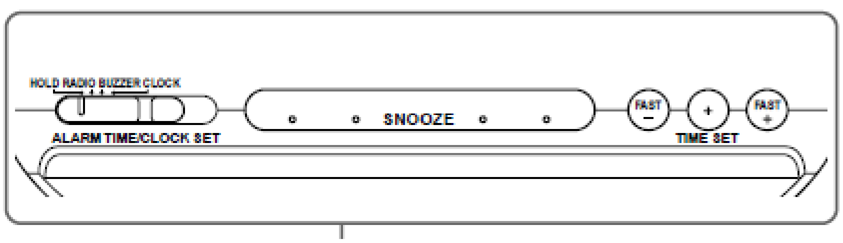


Figure 9.6. Top view of alarm clock controls. Drawing shows top of alarm clock controls with time set controls on the right and alarm time/clock set controls on the left (Sony, 2005b).

An alternative way of examining these errors is to determine if there are age or experience differences in errors that cannot be explained by prior knowledge. Indeed, some errors such as "set incorrect alarm" whereby participants set the buzzer alarm rather than the radio alarm are unlikely to be due to prior experience. This error would be made by moving the lever one slot past the radio notch, as shown on the left side of Figure 9.6. In Study 1, this information would have been classified as "knowledge in the world" that even younger adults use for details such as which way to put an ATM card in the machine. Thus, more likely reasons for this error may be inattention to the specific setting or inability to clearly determine the current notch setting; neither of these errors would be prior experience errors. Even for these settings, however, participants may be using prior knowledge such as “the left position is always home” rather than using labels on the technology. The best way to determine that knowledge in the world was being used was to analyze participant actions indicating that they were referencing this knowledge.

Knowledge in the world usage. Knowledge in the world usage was examined by analyzing participant behavior that indicates that this information was attended. As described earlier, behavioral coding included not only recording participant actions (e.g., pushing a button), but also recording participant looks. A look was identified by the participant examining or describing information on the technology (or overall search), usually designated by the participants’ reading labels on the control or moving their finger along the control as it was inspected. A look was not recorded if participants activated a control as they described it or pointed to it because it was assumed that participants merely matched what they saw with prior knowledge (i.e., recognition versus recall).

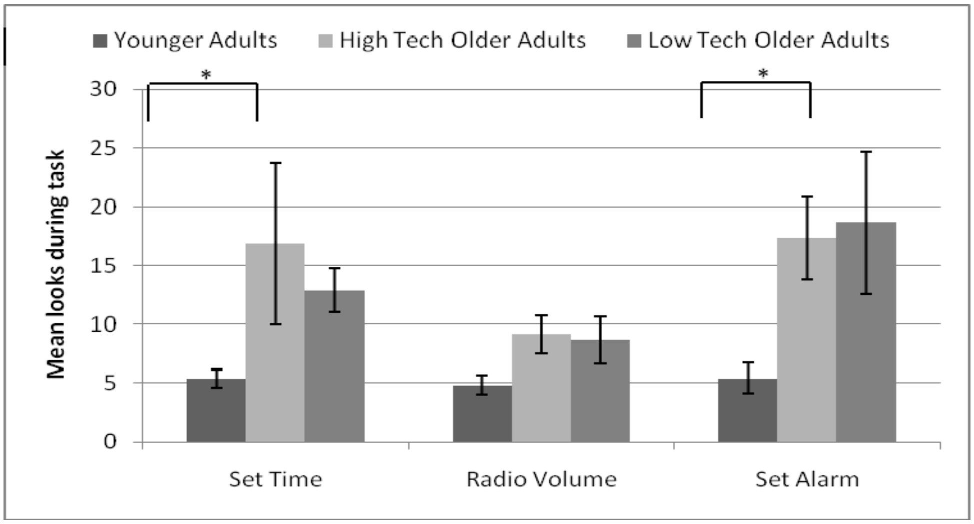


Figure 9.7. Comparisons of mean number of looks for alarm clock tasks. Graph shows comparisons between younger adults, high tech older adults, and low tech older adults. * indicates a significant difference (p<.05). Bars represent standard error of the mean.

Figure 9.7 shows comparisons to help evaluate age and experience differences in the mean number of looks across tasks. T-tests revealed age differences on the radio volume ($t(22) = -2.37$, $p<.05$) and set alarm ($t(22) = -3.19$, $p<.01$) tasks. In both tasks, high tech older adults had significantly more looks than younger adults. Looks for the set time task, however, were not significantly different ($p>.05$), but this may have been due to high variability for this task. The different behavior for the set alarm task is consistent with the age differences identified in overall performance and error analysis. The age difference in looks on the radio volume task, however, is the first difference identified for this task. This may have been due to slower searches by high tech older adults to identify function controls because of low contrast labeling (raised, but same color) of volume and tuner controls on the clock sides. Alternatively, slower searches that include label reading before control selection may be part of the trouble-shooting repertoire for high tech older adults but not younger adults. Comparison of the trouble-shooting pattern in other technologies may help to discriminate these alternatives.

Experience related differences were examined with t-tests of looks between high tech and low tech older adults. As shown in Figure 9.7, the differences were not significant (all p's>.05). Thus, general technology experience did not seem to affect the use of knowledge in the world in the alarm clock interactions.

Fit with Prior Knowledge. The alarm clock is representative of technologies for which all participants had general knowledge that could help them when interacting with a new exemplar. Participants may, however, have different specific knowledge such as experience with controls that may differentially facilitate or interfere with performance. In this analysis, participants' judgments of the fit of key controls with their expectations will be assessed to examine differences in more specific knowledge. As with the Kindle and the Flip, the same three questions will be addressed: 1) was the control itself similar to another technology known by participants? 2) did control knowledge differ by dimension? 3) did control knowledge differ by age or experience? Table 9.18 shows the self-reported prior knowledge fit for six controls used on the alarm clock that will be the basis for control analysis. Note that only participants successful on the first task for which the control should be used were included in the calculations.

Table 9.18.
Self-Reported Fit of Prior Knowledge with Control Experience on Alarm Clock

Task first used	Control	Dimension on Familiarity Questionnaire		Younger Adults	High Tech Older Adults	Low Tech Older Adults
Set time				**(n=12)**	**(n=10)**	**(n=8)**
	alarm time/ clock set	Appearance	% answering "Exactly"	33.3%	30.0%	12.5%
		Location	% answering "Exactly"	33.3%	40.0%	12.5%
		Operation	% answering "Exactly"	50.0%	50.0%	25.0%
		Similar to another technology	% answering "Yes"	75.0%	100.0%	87.5%
	time set	Appearance	% answering "Exactly"	33.3%	40.0%	0.0%
		Location	% answering "Exactly"	33.3%	40.0%	50.0%
		Operation	% answering "Exactly"	25.0%	60.0%	25.0%
		Similar to another technology	% answering "Yes"	91.7%	100.0%	75.0%

Task first used	Control	Dimension on Familiarity Questionnaire		Younger Adults	High Tech Older Adults	Low Tech Older Adults
Listen to radio				**(n=12)**	**(n=12)**	**(n=12)**
	radio on	Appearance	% answering "Exactly"	8.3%	41.7%	50.0%
		Location	% answering "Exactly"	25.0%	41.7%	25.0%
		Operation	% answering "Exactly"	83.3%	83.3%	66.7%
		Similar to another technology	% answering "Yes"	91.7%	91.7%	83.3%
	Volume	Appearance	% answering "Exactly"	75.0%	83.3%	58.3%
		Location	% answering "Exactly"	58.3%	58.3%	66.7%
		Operation	% answering "Exactly"	100.0%	91.7%	66.7%
		Similar to another technology	% answering "Yes"	91.7%	91.7%	91.7%
	Tuner	Appearance	% answering "Exactly"	91.7%	75.0%	41.7%
		Location	% answering "Exactly"	58.3%	66.7%	41.7%
		Operation	% answering "Exactly"	91.7%	91.7%	58.3%
		Similar to another technology	% answering "Yes"	100.0%	91.7%	91.7%
Set alarm				**(n=8)**	**(n=5)**	**(n=5)**
	alarm mode	Appearance	% answering "Exactly"	12.5%	60.0%	0.0%
		Location	% answering "Exactly"	0.0%	60.0%	0.0%
		Operation	% answering "Exactly"	50.0%	80.0%	20.0%
		Similar to another technology	% answering "Yes"	62.5%	80.0%	60.0%

*Control similarity to other technologies***.** As with the Kindle and the Flip, visual inspection of judgments of fit for the alarm clock controls reveals that similar technologies were not always reported by participants for all controls. For the alarm clock, however, judgments by all participants were similar and high (>75%) for five controls. For the alarm mode control, the range of judgments was 60-80% for the three groups, which was also high. Chi-square analysis performed to identify differences in the distribution of participant judgments about similarity of controls to another technology revealed no significant differences (all p's>.05). Thus, participants' self-reported experience with individual controls mimicked the significant, similar experience of alarm clocks overall.

*Control knowledge by dimension***.** The second set of questions about control knowledge was whether control knowledge differed by dimension. Due to the small sample size per group, statistical analysis of other controls was not possible. Visual inspection of Table 9.18, however, reveals that the dimensions were judged differently by participants in most cases. For example, over 80% of younger adults judged that the power control operated exactly as expected, but only 25% judged that it was located exactly as expected and fewer than 10% judged that it appeared exactly as expected. Given that over 90% of younger adults reported that this power control was similar to another technology, the large gap between the operation and other two dimensions suggests that younger adults had specific expectation for power control location and appearance that were different from the alarm clock. Even among common controls like the volume and tuner control, different participant judgments across dimensions suggest that these dimensions of control knowledge are perceived. The successful performance by all of these participants, however, suggests that participants can work around differences if a control is exactly as expected in one dimension

Age and experience differences in control knowledge. The last set of questions returns to the issue of age or experience differences in prior knowledge. Chi-square analysis was performed on each dimension of the volume and tuner controls identify differences in the distribution of participant judgments about dimensions of control knowledge. No significant differences were found (all p's>.05). Due to the small sample size per group, statistical analysis of other controls was not possible. Visual inspection of Table 9.18, however, reveals that a higher percentage of high tech older adults judged the set time and set alarm controls to be an exact fit than younger adults or low tech older adults. It was particularly interesting to note that many low tech older adults were successful in the set time and set alarm tasks in spite of low perceptions of exact fit for the alarm time/clock set and alarm mode. This difference suggests effective use of knowledge in the world, whereby technology labels and other information are clear enough to be used correctly even by novice users.

Alarm Clock Summary. Evaluation of alarm clock interactions was expected to identify performance and experience differences for technologies on which participants would share similar prior experience. The first overall finding was that participants in all groups reported significant, similar experience with alarm clocks. Secondly, several participants in each group performed all tasks successfully, and several participants performed at least one task optimally. Thirdly, task performance seemed to be most similar across groups in the “listen to radio” task in which no significant time, number of interactions, success rate, or error differences were found for age and experience. Participants also appeared to have very similar, and fairly high familiarity with all key dimensions of the radio controls, though younger adults may have expected a different type of power button. Older adults looked at the controls more for this task than younger adults, though this may be due to lower contrast for discriminating the controls or merely because looking is a standard aspect of their behavioral repertoire. Overall, in this radio task, participants in all groups committed errors but also recovered successfully from them. This supports the finding from Study 1 that prior experience may not be completely sufficient and may actually interfere with technology success, though interactive use of knowledge in the world and prior experience can typically help participants to be successful.

A second key finding is that age-related differences were observed for the set time and set alarm tasks. High tech older adults were slower and performed more actions than younger adults. They also made more errors and performed more looks to examine information on the technology. More time may have been particularly needed to detect and correct errors, though it is unclear whether the reason was insufficient prior knowledge or other age-related declines. For instance, several older adults commented that they did not know what the “hold” function on the alarm time/ clock set control was for, but no younger adults commented on this setting other than describing it positively as the control was returned here after setting the clock. Several older adults also commented that they could not tell where the notches were aligned on the alarm mode and the alarm time/clock set switches. Both notches were only indentations that were the same color as the switch, so it is likely that lower contrast sensitivity may have contributed to this error.

On the other hand, individual differences in performance suggest that younger adults were not better in all aspects of these tasks. Several younger adults set the incorrect alarm mode, set incorrect times, and had problems interpreting display feedback such that they did not finish a task successfully. Other younger adults who finished the task did not judge the controls to be exactly as they expected, presumably from prior experience. High tech older adults, though, were slightly more likely to report that controls were exactly as they expected in at least one dimension, suggesting more specific facilitative knowledge on some controls. Yet, this knowledge may be based on specific prior experiences that were not shared across the group.

A limited number of experience-related differences were observed in performance for the set time and set alarm tasks. Both older adult groups made errors on these tasks, though low tech older adults made more errors. Several high tech older adults performed optimally on the set time task. For several of the clock-related controls, high tech older adults specifically reported that these controls were exactly as they suggested, indicating that they needed little knowledge on the technologies. Low tech older adults, however, reported slightly less that these controls were exactly as they expected. The slower time for low tech older adults on the set time task validates individual comments such as “I don’t just push buttons unless I know what they are for.” Thus, their behavioral repertoire for new technologies may include more looks to thoroughly examine the controls before acting rather than just working through the tasks using trial and error as high tech older adults seemed to do. This type of thorough examination with minimal specific expectations may actually interfere with error-free operation, though, as participants try to discover the meaning for all functions equally rather than using their cognitive resources first to focus on the task goal. Although low tech older adults reported relatively less specific prior knowledge and committed relatively more errors, high tech older adults were also observed to perseverate with controls not needed for the task at hand. Thus, general technology knowledge did not completely facilitate performance for high tech older adults, and low technology experience did not completely eliminate successful task completion for low tech older adults.

Lastly, no significant age or experience differences were found for cognitive workload, perceived success, or perceived satisfaction with the alarm clock in spite of the different performance levels. Given that several participants used the alarm clock after other technologies in which they may have had more problems, it is possible that these comparisons were viewed by them as relative. On the other hand, with everyday technologies, it is also possible that they do not expect error-free performance and their responses only indicate that they did as well as they typically do on new exemplars of familiar technologies.

Summary of findings across devices.

This study identified five key findings about the role of prior knowledge and age on everyday technology interaction. First, knowing the repertoire of similar technologies helped predict the differential success for each technology by participant group, but it did not fully account for the differences in performance. For instance, two-thirds of younger adults performed optimally, quickly and with low inter-individual variability on the first two Flip tasks. This performance level was higher than high tech older adults who had similarly high general technical experience but less frequent and recent experience with digital camcorders. On the other hand, over 50% of low tech older adults completed each task on the novel Kindle in spite of their low general technical knowledge and their low knowledge of similar technologies like reading any electronic articles or books.

Additional information uncovered through examining participants' judgments of fit of technology controls with their expectations suggests that understanding prior experience with the knowledge in the world (on the device) may also be helpful. Through comparison of high tech older adults' judgments of fit for the play and delete with younger adults, it was suggested that high tech older adults may be using a video player as a reference for these controls rather than a camcorder. Because high tech older adults reported recent and frequent experience with video players, this technology may have been more accessible for them than another video camcorder. Of course, using a different reference technology may be problematic if it elicits interference to correct use, but the low costs of incorrect use on everyday technologies typically make any reasonable option worth trying.

The second key finding also concerns the participants' judgments of fit. The different judgments across control dimensions (i.e., appearance, location, operation) on every device suggest that designers may need to discriminate the type of information users need for correct usage. Among successful performers, the operation dimension usually received the highest percentage of "exact fit" judgments. As might be expected, then, users may primarily need to know how to interact with a control and what is likely to happen when a control is activated. This information may help reduce participant frustration and memory load because the only verification necessary is determining if the interaction operated as expected. Note, however, that judgment differences also suggest that other factors are important. Older adults in both experience groups had difficulty finding the power control on the Flip because they said that they did not recognize the power symbol on the power button. Participants in all groups also reported that the location of items like the Flip volume was not in the expected location, and video review suggested that participants continued to search in expected locations if they had high confidence in this location even though other possible controls were directly in front of them.

The third key finding is that participants seem to expect to make errors and to recover from errors in their initial interactions with everyday technologies. For example, participants in every group made errors on the very common "listen to the radio" task on the alarm clock, but they also recovered successfully. Of course, all participants had prior alarm clock experience, but it did not eliminate the errors completely. Instead, the consistent, high experience across groups may have been most important in providing participants with information about interpreting feedback to guide error recovery. Thus, prior experience may be most helpful in eliciting technology goals, general task flow, and helping participants know what kind of feedback to expect. Previous researchers have suggested that one reason that older adults have difficulty recovering from errors is that they do not appropriately use display guidance as well as younger adults (Kang & Yoon, 2008). For novel devices in which prior experience may be missing completely or comprised of experience with several different technologies, design that facilitates error recovery by setting participant expectations about what will happen with a particular control may be particularly needed.

The fourth key finding is that equating general technology experience for older adults does not completely eliminate age differences in performance. For each technology, younger adults performed more successfully than high tech older adults on at least one task. The different types of errors reported on the alarm clock by high tech older adults are indicative of the age-related declines that can affect performance. Among these errors are inability to clearly read control labels (perceptual decline) and perseveration in use of alarm reset to set time (lower working memory). On novel technologies, these declines may be exacerbated because participants must track their own actions (especially for unfamiliar controls like Kindle scroll) and look for unfamiliar feedback on novel displays that may particularly seem cluttered until they are understood. High tech older adults may have an advantage over low tech older adults, though, because their prior technology experience may at least help them recognize portions of a display to assess errors and interpret feedback.

The fifth key finding was that older adults appear to have adopted a different interaction strategy than younger adults, possibly to accommodate perceived declines though awareness of the declines may not be explicit. As identified in Study 1, low tech older adults identified that a focused attention approach to using technologies can help them be successful even with new technologies, but this approach was not reported by high tech older adults in Study 1. On the alarm clock on Study 2, however, high tech older adults were observed to use more significantly more looks than younger adults to complete the same tasks. The number of looks was not different between high tech and low tech older adults, suggesting that the looks were indicative of a strategy to more carefully examine controls before interacting with them. This behavior may help older adults to set expectations for what is likely to happen from interaction with a particular control. Although this behavior did not protect the older adults from making errors, it may have helped them detect the errors before advancing too far in the wrong direction. This would be less helpful, though, if the knowledge on the technology was not carefully evaluated for eliciting ambiguous expectations.

Discussion.

This study's findings are consistent with Study 1 in reporting that prior experience is important for everyday technology use. The additional contribution of the current study is that it describes that an effective evaluation of the specific types of knowledge potentially elicited by knowledge on the technology is also crucial for everyday technology design. Most participants successfully completed the majority of the tasks, though with different levels of success on the different technologies. Participants with higher self-reported relevant experience generally performed better. In particular, younger adults achieved the highest level of success on all technologies, though some high tech older adults were also very successful and even performed optimally on some tasks on the newer technologies. Some low tech older adults also completed many tasks successfully, but few performed optimally on any task. Other low tech older adults, however, were only partially successful on many tasks. Overall, more inter-individual variability was observed in the performance of older adults.

Thus, prior experience did not fully account for performance differences. Based on an assumption that participant expectations for control operation were derived from their prior experience, the judgments of successful participants on exact fits between their expectations and specific dimensions of a technology control were examined. This examination revealed that not all successes were due to exact fits with prior experience. In fact, only a percentage of perfect fit judgments were made for any dimension even though the participant was successful in completing the task. This finding suggests that information on the technology (knowledge in the world) was also used.

As the data were examined further, it was noted that differences between dimensions for each control could be fairly dramatic. These differences suggest that participants may be using multiple reference sources, but the dimension receiving the ratings of highest fit was operation.

With this dimension, participants were rating whether the control fit their expectations of how to interact with it and what should happen after the interaction to confirm that the control was used properly. Participant ratings of fit of control location with their expectation were also important for understanding participant interactions because location seemed to predict behavior both when it met expectations and when it did not. This may be because spatial memory has been found to contribute to computer-based performance (e.g., Vicente, Hayes, & Williges, 1988) such that it is a highly salient attribute for a control. The conclusion from these findings was that the controls elicited specific knowledge for a participant that helped them in some manner, allowing gaps in other dimensions to be less important. Thus, consideration of the knowledge provided by dimensions of controls may help designers to elicit the appropriate information to help a user proceed.

The effectiveness of this approach is supported by older adults who carefully inspected many alarm clock controls before activating them, particularly when they were trying to recover from an error. This strategy suggests that participants try to set specific expectations of the control operation for themselves in advance of control operation, perhaps so that they only have to recall a single sequence of action/feedback response. A specific version of this approach that may be useful for novel technologies is suggested by low tech older adults. As described in Study 1, these participants exhibited a specific technology approach in which they could focus their attention on a single technology with no interruptions. Typically, they slowed down, examined options before selected them, and were more aware of the overall technology to help them locate unknown feedback. Additional coding and observation of the recorded videos can confirm whether this approach was used more broadly, even by younger adults in particular situations. Specific video reviews could also assess more directly how participants behaved when their expectations for particular controls were not met. Overall, though, findings from this chapter support a more integrated approach to incorporating knowledge in the world with knowledge in the head to enable a more diverse user group to successfully use everyday technologies.

Chapter 10: Discussion

General Summary.

The purpose of this study was to investigate the effects of prior experience and age on HTI, particularly with new and infrequently used technologies. Two studies were designed to systematically collect information that could provide theoretical and practical support for improved design due to better understanding and prediction of relevant knowledge use in the target population for these products.

Study 1.

The first study was designed to evaluate use of technologies and prior experience in the everyday life of participants of different ages and experience levels with three research questions. First, what are the technology repertoires for younger adults, expected to have generally high levels of technology experience, and older adults with either high or low levels of technology experience? This study identified typical technology repertoires for younger adults, high tech older adults, and low tech older adults (see Table 7.4). Analysis of these repertoires revealed that younger adults and high tech older adults use a similar number of technologies but with a higher average number of home health care and kitchen technologies among high tech older adults. This study also found that low tech older adults use fewer technologies than high tech older adults, but they still use a significant number of technologies. The primary difference between the types of technologies used by older adults with different experience levels was PC and internet technologies, though small differences were also indentified in shopping and communication technologies. The source of these differences may be lack of relevant prior experience, though the data also suggest that preferences play a role in technology adoption. The majority of technologies for all participant groups were used at least weekly.

Second, were participants successful in these everyday technology interactions? The data suggest that participants were usually successful. No significant age or experience differences were identified, though a non-significant pattern of more problems among frequent technologies for high tech older adults suggests data collection from more participants would help to examine if the low number of participants affected the total number and type of problems.

Third, what was the role of prior experience in everyday technology use? The data revealed that participants had relevant prior knowledge for the vast majority of their encounters, even for new technologies. Prior knowledge was the most important reason participants reported for successful use, though other reasons were also cited by all groups including only use of knowledge in the world. Low tech older adults uniquely attributed their success to a focused attention approach that reduced the possibility of distractions to success. Neither high tech older adults nor younger adults attributed their success to this approach, though participants from both groups offered examples of using focused attention and preparation for novel or complex tasks. Prior knowledge was also cited as the reason for half of problem encounters. Within this category of prior knowledge, participants cited insufficient prior knowledge as one problem cause, but younger adults also reported that interference from prior knowledge was the cause. Participants typically attributed problem recovery to the use of combined knowledge in the world and knowledge in the head (prior experience).

Study 2.

The second study was designed to directly investigate performance by participants of different ages and technology experience levels while interacting with three exemplar everyday technologies. Review of the interactions was also performed to examine use of prior experience and knowledge in the world. Most participants successfully completed the majority of the tasks, though with different levels of success on the different technologies. Participants with higher self-reported relevant experience generally performed better. In particular, younger adults achieved higher levels of success on all technologies, though some high tech older adults were also very successful and even performed optimally on some tasks on the newer technologies. Some low tech older adults also completed many tasks successfully, although there were few optimal performances. Other low tech older adults, however, were only partially successful on many tasks. In contrast to Langdon, Lewis, and Clarkson (2007), general technology experience did not fully eliminate age-related differences in performance. However, more inter-individual variability was observed in the performance of older adults.

One key factor leading to successful performance may have been appropriate use of prior knowledge. In particular, examining the interaction between knowledge in the head and knowledge in the world (on the technology) suggests that two features of prior knowledge are important. First, successful participants typically knew at least one dimension of a technology control to recognize that it would be appropriate for the task at hand. Even seemingly vague information such as control location or operation seemed sufficient for selection on these everyday technologies. Second, successful participants typically had a prior expectation for technology feedback to indicate that the control was appropriately used and therefore the task was progressing toward the goal. Fu and Gray (2004) had previously noted in an experimental study that participants preferred to use general interactive procedures with fast feedback rather than carefully examining possible options and selecting the optimal one, but this preference has not been previously described for more realistic use such as shown in this study.

As observed in this study, however, older adults may be less likely to follow this approach. Instead, they were observed to inspect most controls before selecting them. In fact, low tech older adults seemed unlikely to use general interactive procedures while monitoring fast feedback. If knowledge in the world was explicit enough to provide guidance on the operation or expected feedback, though, successful older adults did seem to select the control and continue if the feedback was as expected or perhaps recognized from another prior experience.

Limitations.

One important limitation of this study was the dependence on accurate self-report. Data collection for Study 1 was entirely based on self-report, and participants may not have reported all technology encounters if the everyday technology was not recognized. Although participants were also reminded on a daily basis to record each technology soon after the encounter, it is possible that they were not able to record at the time and forgot when the journal was accessible. Data gathered during the structured interview was also dependent on participant memory and attention to relevant details, but the full reason for encounter success or problem may not have been accessible at the time of the interview. For Study 2, participants' prior knowledge and relevant experience was also based on self-report. If participants did not accurately recall prior experience with specific technologies, they could not report this correctly in the background questionnaires.

A second limitation was the representativeness of users in the studies. For instance, the difficulties typically experienced by older adults may be underrepresented in both studies. Visual and hearing acuity were measured for all participants to establish participant groups representative of samples used in similar research. However, the wider population of older adults may experience more severe perceptual and cognitive age-related declines. As described in Appendix E, one older adult was excluded from analysis in Study 2 due to low visual acuity though he completed all aspects of the experiment. He exhibited more severe difficulties reading labels and display feedback than any other older adult. Thus, perceptual declines could lead to more problems than described in this study.

Overall, the older adults in these studies may have been different than older adults in poorer health who could not travel to the campus to participate. It is possible that these older adults would have lower technology experience than those included in the study, so there may be many older adults who have lower technology experience levels than the low tech older adult group here. Nonetheless, the fact that experience differences in technology usage were found even for the studied adults suggests that prior experience matters and must be considered for technology design. Lower technology experience would likely lead to less success, not more.

A more general limitation is based on the limited number of participants and selection of these participants, both of which may restrict the generalizability of study findings. Although both studies included at least the minimal number of participants prescribed for accurate usability studies (five: Nielsen, 2000), the amount of data collected from each participant precluded including enough participants to provide high power for the quantitative analysis. With this small number of participants, the representativeness of participants who were included may also limit generalizability. All younger adults, for instance, were full-time students at the same university, making them likely to be more homogeneous than other adults of the same age. More important for comparisons against older adults was that these younger adults had different living conditions, either living in dorms or living independently with furnishings likely acquired in the last several years since they entered college. In contrast, both groups of older adults had been living independently for many years, allowing them to accumulate many different technologies over decades. Thus, usage of technologies in some categories for Study 1 may differ between groups due to factors other than age and experience levels.

A third limitation is the representativeness of the problems reported in Study 1. Although participants were instructed and reminded on a daily basis to keep their journals with them, participants may not have reported all problems for a variety of reasons. First, they may not have been able to do so at the time (e.g., if they were driving), and they may not have remembered to write down the problem afterwards. Second, all problems may not have been equally salient, leading to higher reporting of some types of problems and lower reporting of other problems. For instance, problems in which a significant amount of time was required to resolve or work around a problem would likely have been highly salient, perhaps leading to the high number of system/product problems reported. On the other hand, common lapses such as typos, key mis-hits, and wrong menu selections may occur so frequently that the incidence and resolution are almost invisible to users. The fact that this type of problem was not reported (by any group of participants) suggests that participants either did not remember them to report them or that they did not think they were of interest to the researcher. Whatever the reason, lack of reporting can only mean that the conclusions about problem incidence, reasons, and use of knowledge do not apply to this problem type.

A fourth limitation of the study findings is the representativeness of the everyday technologies selected for Study 2. These technologies fit the everyday technology definition from ISO-20282-1. Their primary functions also place them in two different technology categories from Study 1, suggesting that they may be relevant for the study population. They cannot, however, represent all of the possible functions that may be of interest to participants. This difference in interest might differentially influence the effort of these participants to learn the technology. They also cannot represent all levels of complexity and interaction modes that may be familiar to people based on their individual past experiences. Thus, generalizing specific results to other everyday technologies may be limited, though the pattern of performance differences can at least provide guidance for methods of examining new technologies and potential designs.

A fifth limitation is that the problem incidence for Study 2 may be less representative of typical use of the exemplar technologies due to typical personal and motivational factors. For instance participants using the exemplar technologies in the lab were presumed to be fully awake and aware, though people may typically set alarms on alarm clocks when they are tired. This fatigue typically leads to more errors than would be likely in the lab. Similarly, people taking video pictures would typically intend to capture particular areas of a scene for future viewing rather than filming a static scene in a fairly generic room. A personal goal for filming may encourage people to attend more to the scene than in the lab environment, which may also lead to more errors than were found in the current study.

Questions for future research.

Although this study provided some insight on the use of knowledge in everyday technologies, several observations from the study also highlight opportunities for future research. In Study 1, younger adults appeared to be more intense users of PC and internet technologies than high tech older adults, but this inference was based on self-report that may be difficult to clearly monitor given the ease of accessing new web sites. PC monitors that objectively record every PC and Internet interaction may be useful to develop a more accurate understanding of usage similarities and differences.

In Study 2, high tech older adults and younger adults seemed to perform more successfully on the Kindle after the first task, but it is not clear if the better performance was due to overall technology learning or merely easier tasks. Additional review of a task sequence with a focus on differences in use of specific controls or completion of sub-tasks may enable evaluation of actual learning. Similarly, the extent of learned technology use versus accessibility from recent memory is also unknown. Comparisons of participant performance in the initial tasks (analyzed in the current Study 2) and performance in the “show a friend” task recorded approximately five minutes after these initial tasks may allow accurate assessment of learning.

A second question from Study 2 is to evaluate the role of metacognition in everyday technology use. For instance, some participants in Study 2 were observed to continue searching for specific labels of target functions based on their prior expectations (e.g., power buttons are labeled on/off) even though a power button (labeled with a symbol) was immediately in front of them. Other participants who also could not identify what the power symbol meant seemed more willing to accept that this may be the power button. Thus, differing confidence in prior experience may actually affect participants’ ability to observe likely options.

Theoretical contributions.

Findings from this study provide some empirical support for a current conceptual model for how prior knowledge is used in HTI (Jones, Farris, & Johnson, 2005). For example, continued use of the same controls and menus on the Kindle seemed to help some participants improve their interaction efficiency and develop a Kindle schema that was helpful even for completing novel tasks (i.e., task 3). As described above, however, it was not clear what was learned and incorporated into a new schema versus what was memorized. The fact that all high tech older adults were not successful in the third Kindle task, in spite of their having similar general technology schemas (measured in the technology screening score), also suggests that schemas may not provide the full answer to understanding prior knowledge access.

As suggested by the differences in fit of individual controls by component (i.e., appearance, location, operation) prior experience may be more closely associated with the type of activity being performed at the time. For example, participants may first realize with any technology that they must first power it on. If they think of this task as a series of activities (find the control, assess how to operate it, operate it), they may consider what the control might look like and where it might be located before starting to search for it. This approach is likely to particularly activate appearance information about how power buttons are labeled. If instead they think of the power on task as one activity that is hard to separate into sub-tasks, they may instead never explicitly consider these components but only move their finger to the likely power-on location with full preparation for activating it according to their expectation. This approach to the task is likely to activate spatial knowledge that may make expectations about location more salient than appearance. Thus, different approaches may actually require different knowledge in the world for successful use. The different behavior observed for different participant groups on the alarm clock suggests that these different approaches were used, but further coding of the Kindle and Flip must be completed to examine how knowledge is used when prior experience differs by group. It may be the case that Fu and Gray's (2004) fast, interactive strategy is used when prior experience is sufficient and is supported best by good fit with location expectations, whereas appearance information is more important for the more careful "examine and monitor" strategy exhibited by older adults in this study.

This study also provides some empirical support for Blackler's (2006) intuitive interaction continuum in Appendix A. The fact that low tech older adults successfully used technology controls even though they were not similar to other technologies suggests that other design elements such as population stereotypes must also be used in design. The continuum suggests that accessibility is the primary factor for determining which design element an individual will use, but accessibility does not explain how participants with similar relevant technology backgrounds (such as presented with the alarm clock and Flip) perform differentially on the same technology.

Findings from this study may also support another conceptual model that was derived from the above models for determining information sources on everyday technologies. As described in the organizational framework for intuitive human computer-interaction (O'Brien, Rogers, & Fisk, 2008) shown in Figure 10.1, metacognition mediates the use of knowledge in the head and knowledge in the world. Study 1 findings and participant comments suggest that the three "pie" slices around the middle map with participants descriptions of prior knowledge that were used in their success. "Seeking prior goals" maps to participant knowledge of technology goals and task goals. "Performing well-learned activities" maps to participant knowledge of how to do the common activities for a particular technology. "Determining what to do next" maps to the unique "approach" solution described by low tech older adults in Study 1, to the "advance preparation and focus" approach described by other participants in Study 1, and to the "examine and monitor" approach identified in Study 2. As the diagram suggests, metacognition (a feeling of knowing about prior knowledge) may determine what prior knowledge should be retrieved and used with the knowledge in the world for successful performance. Additional research is needed to describe how this model may work beyond the conceptual level, but this framework provides an approach to organizing research questions such as those described previously.

Figure 10.1. Organizational framework for intuitive human-computer interaction. In this framework, three "pie slices" represent a user's required cognitive activities. Bold labels for each slice summarize this cognitive activity in common language from the user's perspective. Other terms in each slice designate attributes identified in the literature review as characteristic of intuitive behavior that contribute particularly to the labeled cognitive activity.The inner and outer knowledge circles represent potential sources of information to guide the user's interaction. Bidirectional arrows between these circles and the slices represent the fact that knowledge is dynamic, with accessibility of particular knowledge elements dependent on prior activities and determining what will be subsequently available. The cognitive faculty of metacognition is proposed as a mechanism for managing these components and mediating the cognitive activities and knowledge in the head. (O'Brien, Rogers, & Fisk, 2008, p.1646).

Although this research may provide propel intuitive design development, it may provide more challenges than solutions for a broader design goal of universal design. This goal has been set by several global organizations, with one group defining it as "The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." (Center for Universal Design, 2008) Yet, the current research found that technology use between adults with similar technology backgrounds but different age ranges (younger adults and high tech older adults) had different problems and different approaches to using the same technologies in the same environment and context. New techniques for addressing these problems were proposed after identification of these differences, but it is unclear whether these techniques will fully mitigate the differences given some of the fundamental age-related changes that may be the basis for these problems. It is also unclear whether other differences between participant groups would require different solutions, a challenge which goes to the heart of the definition of universal design. Perhaps, however, if the proposed techniques mitigate age-related differences in technology use, they could be tested to assess the effect in facilitating usage for other participant groups.

Practical contributions.

One practical implication of this study is educating older adults about the focused attention approach to improve their success with everyday technologies. The fact that this approach was suggested by low tech older adults may lessen the value for some older adults. However, the fact that this approach was later identified using different language in the words of high tech older adults (e.g., “I sat down and read the manual completely first, then walked through the instructions step by step”) indicates the importance of focused attention for older adults who typically experience age-related declines. In particular, knowing the specific contributions of this approach may be helpful for older adults who see younger adults operating in trial and error fashion (as described by Fu & Gray, 2004) but often experience errors with the same, apparently simple technologies.

A second practical implication is guiding designers to effectively predict what prior experience may be retrieved in a particular situation. Study results suggest that assessing participant expectations for knowledge on the technology may elicit ratings that indicate whether sufficient information is known. In general, following participant expectations for control operation, location, and/or appearance can prepare participants to be successful with the control. If multiple expectations exist within a target user population, cuing specific technologies through technology design may be particularly helpful. Then, providing feedback that is visually salient, just-in-time, and meaningful can assure participants that the control selection was appropriate and that they can proceed to the next action (Chung & Byrne, 2008). As suggested by Study 2 findings about control design, feedback design should also consider participant expectations for appearance, location, and operation as set by experience with other technologies and especially by actions previously used on the current technology.

A third practical implication for this approach is improving the environmental support developed for older adults. As noted in several prior studies (e.g., Mitzner et al., 2008), older adults report that they prefer to use instructions and training for interacting with new technologies. Several problem encounters were reported in Study 1, however, in which participants could not resolve the problems because the instructions were insufficient. Findings from this study suggest other opportunities for improving instructions. In particular, users not only need to know what to do but how they will know when they have successfully completed and action and can proceed to the next step. For instance, participants who knew that a flashing, increasing number on the Flip display indicated successful recording could proceed to determining how to zoom in the picture. Participants who did not know what the flashing symbol meant often asked if the camera was recording or merely proceeded to the next step while intermittently turning on and off the recording without realizing what they were doing. Thus, instructional guidance about expected feedback may facilitate more success, particularly for older adults.

Overall, designers should be aware that prior experience may not be sufficient and may even interfere with successful use. As shown in Study 2 with the Kindle, participants with more general technology experience may have better foundations for learning new technologies and improving performance with continued use. Beyond that, however, designers should not guess about what users know and what will be used. Although data from this study suggest that people have a variety of experiences that are leveraged when interacting with new technologies, there were a surprising number of successful participants who noted that aspects of the technology were not as they expected. This failure was salient enough in Study 1 for participants to report interference with prior knowledge. In Study 2, failure to meet expectations was manifested in additional time and errors. These can lead users to judge that the technology is too complex for them to use (Maeda, n.d.) or just that it was not as good as it could have been, leading to poor word of mouth for technology acceptance. A better approach may be to identify optimal usage and focus design on guiding all participants to this optimal use. Asking optimal users to narrate what aspects of the design exactly matched their expectations, focusing on the components of the design that elicit relevant prior experience, may allow designs to be simplified without incorporating all possible paths that could be enabled, even though they might lead to user confusion.

Conclusion.

At the beginning of this study, my goal was to understand what technology experience older adults have across a range of general technology levels to enable everyday technologies to be created that would be usable because they used this technology experience. Through Study 1, I identified a representative technology repertoire for younger adults, high tech older adults, and low tech older adults that showed differences in expected areas. Through Study 1, I also glimpsed how technologies are typically used in their everyday lives, along with the problems experienced and their solutions. What surprised me most was discovering that many of the low tech older adults were quite adaptable and generally knowledgeable for the technology they needed to use. Their approach to successful technology use was quite simple: do it, and do it well. Although I also noted some instances of this preparation in high tech older adults, their prior experience may have diluted their recognition that the interaction required some openness to potential actions and feedback to guide them. In Study 2, I observed both high tech and low tech older adults using this unassuming approach that emphasized attending to the way that the technology was designed rather than imposing their expectations on it. Analysis of prior experience revealed that specific aspects of the technology design fit their prior experience and enabled them to complete the tasks successfully, using feedback iteratively to guide the next action. Thus, prior experience seemed to be successfully used most when it was used in conjunction with knowledge in the world (as Norman, 2002 suggested).

Therefore, the key aspect of the technology design may not be identifying all potentially relevant prior knowledge at the outset as I had expected. Instead, the key may be assessing prior knowledge at some level of detail and proposing an optimal path in the initial design. As the target users (who must be from the target population because of identifiable differences) interact, careful observations should be made of what information is used and what information is needed for successful use. Adjustments should be made to items on the optimal path to confidently guide new users at the appropriate time to complete the technology functions. Strong guidance such as this may facilitate universal design, if it is possible for a particular task and context.

In general, I discovered that identifying the prior technologies used by a participant group may be insufficient for good everyday technology design. It appears also to be necessary to understand when this prior knowledge is used and how this prior knowledge is used. For instance, the lower interference reported by high tech older adults (over younger adults) may be because they used context information more frequently to clarify if prior knowledge should be used or if knowledge in the world would be most relevant. An overall experience with technologies such that older adults realize that they often cannot remember their prior actions may also lead them to only use new technologies when they are not going to be distracted. Given that the nature of everyday technologies is that they will be used by many different people with few instructions and perhaps even little awareness of what the technology goal is, the best approach for all users is to expect that the technology will lead them to success if they give the task appropriate attention. But the other side of this approach is that designers also have to be confident that their design has the necessary components to make this happen. They may be able to obtain this assurance with their own unassuming approach to watching their target users' early interactions and really focusing on how knowledge is effectively used.

APPENDIX A: Intuitive Interaction Continuum

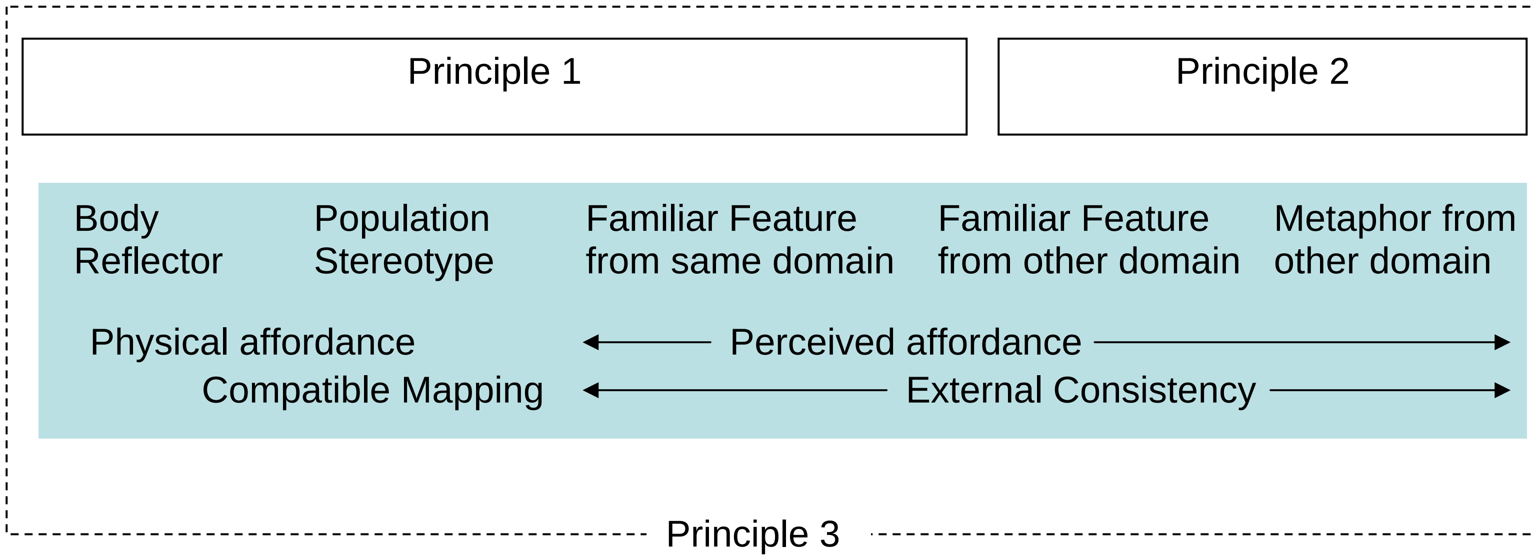


Figure A.1 The intuitive interaction continuum (Blackler, 2006, p. 236)

APPENDIX B: Technology Experience Assessment Process

Source data set

Demographic and technology experience questionnaires were administered over the years 2006-2008 in three geographically separate and ethnically diverse areas of the United States as part of the CREATE research program (www.create-center.org). Data were collected separately by laboratories at participating CREATE universities according to a standard protocol. Participants were screened for cognitive impairment according to the Short Portable Mental Status Questionnaire (criterion: ≤ 2 errors; (Pfeiffer, 1975) and the Weschler Memory Scale (Logical Memory subscale; age-adjusted criterion; (Weschler, 1997)).

Initial Calculation Method

Similar to Kang & Yoon (2008), a single measure was developed to represent everyday technology experience for participants. Based on prior research and an initial review of the technology usage among 65-75 year-old participants in CREATE data (e.g., O'Brien et al., 2008), questions were selected for inclusion in the measure for each of 4 core components:

- everyday technology frequency
- Internet frequency
- breadth of everyday technology use
- breadth of computer functional knowledge

These questions were selected to differentiate technologies used by more than 2/3 of participants vs. those used by fewer than 1/3 of participants. Responses to initial survey questions were coded and summed into a single score. This score was computed from 110 older adults (ages 65-75) in the CREATE survey. Boundaries for the top and bottom thirds for this population were calculated as shown in Table 6, with top and bottom thirds designated for high and low technology experience, respectively. Atlanta-area CREATE participants whose scores placed them into high and low experience groups were selected into a database subset for standard recruiting procedures in the Study 1.

Revised Calculation Method

All Study 1 participants, both from the CREATE database and other participants from the laboratory database, completed the same questionnaire to reflect their most recent technology experience. The Technology Experience score was recalculated and the pattern of responses was reviewed and compare with participants' listing of their everyday technologies. Particular attention was paid to items discriminating high technology and medium technology older adults and discriminating medium technology and low technology older adults. In addition, the review also revealed overlap between included questions as well as the opportunity to more precisely predict everyday technology experience from additional responses about use of computer applications in score calculations.

A revised calculation method was developed as shown in Table B.1. Scores were re-calculated using this method on the 110, 65-75 year old participants in the CREATE database. Review of the percentage of CREATE participants in the high, medium, and low technology groups determined by the new method showed that the resulting groups continued to represent approximately 1/3 of the database, as proposed.

Table B.1

Calculating Algorithm for Technology Experience Score

Category	Scoring procedure for each category	Score
Internet breadth	Count number of domains participant uses Internet	
	Translate raw count into code: range (0-4) 0 = 0; 1-2 = 1; 3-5=2; 6-8=3; 9-11=4	
Computer breadth	Count number of input device, basic operations, desktop applications , and coded breadth of windows applications by participant	
	Translate raw count into code: range (0-4) 0 = 0; 1-4 = 1; 5-8=2; 9-12=3; 13-17=4	
Entertain technology breadth	Count number of technologies used for entertainment	
	Translate raw count into code: range (0-3) 0 = 0; 1-3 = 1; 4-6=2; 7-9=3	
Transport technology breadth	Count number of technologies used for transportation	
	Translate raw count into code: range (0-3) 0 = 0; 1-3 = 1; 4-7=2; 8-11=3	
ATM frequency	Frequency of use	
	Translate frequency* into code: range (0-2) 0 = non-user; 1 = occasional user; 2 = frequent user	
Cell phone frequency	Frequency of use	
	Translate frequency* into code: range (0-2) 0 = non-user; 1 = occasional user; 2 = frequent user	
Self-service shopping kiosk frequency	Frequency of use	
	Translate frequency* into code: range (0-2) 0 = non-user; 1 = occasional user; 2 = frequent user	
Programmable home device frequency	Frequency of use	
	Translate frequency* into code: range (0-2) 0 = non-user; 1 = occasional user; 2 = frequent user	
Internet frequency	Frequency of use	
	Translate frequency into code: range (0-2) 0 =Never; 1 =5 hours or less/week; 2 = more than 5 hours/week	
Technology Score		

*Note: Non-users are those checking “not sure what it is” or “never” for the specific technology. Occasional users are those checking “once in a while” or “some of the time” for the specific technology. Frequent users are those checking “most of the time” or “always” for the specific technology.

APPENDIX C: TECHNOLOGY EXPERIENCE QUESTIONNAIRE

Note that this questionnaire had 2 cover pages that were deleted from this appendix.

TECHNOLOGY AND COMPUTER EXPERIENCE QUESTIONNAIRE

The purpose of this set of questions is to assess your familiarity and experience with technology. Please answer all questions by placing a check mark at the appropriate response.

1. How often do you communicate with other people (e.g., family members, friends, doctors, customer service representatives)?

   - ☐1 Daily
   - ☐2 Weekly
   - ☐3 Monthly
   - ☐4 Yearly
   - ☐5 Never

2. Within the last year, which of the following methods have you **used** for communication?

	Not sure what it is$_1$	Never$_2$	Once in a while$_3$	Some of the time$_4$	Most of the time$_5$	Always$_6$
1. Answering machine						
2. Cell phone						
3. Fax machine						
4. Internet (e.g., e-mail, chat room, videoconferencing)						
5. Telephone						
6. Videophone						

3. How often do you go shopping?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

4. Within the last year, which of the following have you **used** for shopping?

	Not sure what it is1	Never2	Once in a while3	Some of the time4	Most of the time5	Always6
1. Credit card						
2. Debit card						
3. In-store automated kiosk (e.g., self-checkout, price scanner, item locator)						
4. Internet (e.g., on-line purchasing, on-line product evaluation)						
5. Telephone						
6. Television shopping						

5. How often do you use customer service functions (e.g., technical support, product assistance, reservations)?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

6. Within the last year, which of the following have you **used** for customer service (e.g., technical support, product assistance, reservations)?

	Not sure what it is$_1$	Never$_2$	Once in a while$_3$	Some of the time$_4$	Most of the time$_5$	Always$_6$
1. Automated telephone menu system						
2. CD/DVD						
3. E-mail						
4. Fax machine						
5. Internet (e.g., on-line manuals, on-line interactive support, web site)						
6. Person on the telephone						

7. How often do you make financial transactions (e.g., bill paying, banking, investing/ financial planning, tax preparation)?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

8. Within the last year, which of the following have you **used** for financial transactions (e.g., bill paying, banking, investing/financial planning, tax preparation)?

	Not sure what it is$_1$	Never$_2$	Once in a while$_3$	Some of the time$_4$	Most of the time$_5$	Always$_6$
1. Automated telephone menu system (e.g., banking, credit card information)						
2. Automatic teller machine (ATM)						
3. Drive-through banking						
4. Internet (e.g., on-line banking, on-line bill paying, on-line investing)						
5. Person on the telephone						
6. Software (e.g., Quicken, spreadsheet, MS Money, TurboTax)						

9. How often do you engage in healthcare related activities for yourself or others (e.g., going to see a doctor, checking blood pressure, finding information about a disease or medication)?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

10. Within the last year, which of the following have you **used** for healthcare related activities for yourself or others?

	Not sure what it is1	Never2	Once in a while3	Some of the time4	Most of the time5	Always6
1. Automated telephone menu system						
2. Health information searching on the Internet						
3. Internet communication (e.g., e-mail, computer support groups)						
4. Medical-related Internet purchasing (e.g., medication or medical supplies)						
5. Person on the telephone						
6. Telemedicine (e.g., videoconferencing with doctors or nurses)						

11. How often do you use healthcare devices at home for yourself or others (e.g., glucose monitor, blood pressure monitor)?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

12. Within the last year, which of the following healthcare devices have you **used** in your home?

	Not sure what it is1	Never2	Once in a while3	Some of the time4	Most of the time5	Always6
1. Blood pressure measurement device						
2. Digital thermometer						
3. Electronic dental hygiene system (e.g., electric toothbrush, Waterpik)						
4. Emergency call system (e.g., Lifeline)						
5. Heating pads						
6. Infusion pump						
7. Monitoring device (e.g., glucose, apnea, cardiac)						
8. Nebulizers						
9. Oxygen equipment						

13. How often do you use public transportation (e.g., train, bus, subway)?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

14. How often do you drive?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

15. How often do you travel by airplane?

- ☐1 Weekly
- ☐2 Monthly
- ☐3 Quarterly
- ☐4 Yearly
- ☐5 Never

16. Within the last year, which of the following transportation-related systems have you **used**?

	Not sure what it is₁	Never₂	Once in a while₃	Some of the time₄	Most of the time₅	Always₆
1. Automated telephone menu system						
2. Automatic check-in station						
3. Automatic parking payment station						
4. Automatic ticket purchase station						
5. Cruise control in your car						
6. In-car navigation system (e.g., GPS, OnStar, Neverlost)						
7. On-line travel schedule						
8. Personal digital assistant (PDA)						
9. Person on the phone						
10. Remote control to start the car						
11. Travel direction/ map software (e.g., MapQuest, Streets & Trips, Keyhole)						

17. How often do you engage in leisure/hobby/entertainment-related activities?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

18. Within the last year, which of the following leisure/hobby/entertainment-related systems have you **used**?

	Not sure what it is$_1$	Never$_2$	Once in a while$_3$	Some of the time$_4$	Most of the time$_5$	Always$_6$
1. Books on tape (audio book)						
2. Computer/Video game (e.g., Gameboy, PlayStation, Nintendo, GameCube, X-Box)						
3. Digital photography (e.g., camera, camcorder)						
4. Fitness device (e.g., pedometer, pulse meter, golf swing enhancer, treadmill)						
5. Hobby-specific computer usage (e.g., Internet, Photoshop, genealogy software, patterns)						
6. MP3/IPOD						
7. Personal digital assistant (PDA)						
8. Recording and playback device (e.g., CD, DVD, VCR)						
9. TV set-top box (e.g., program TV, pay-per view movies, music stations, TiVo)						

19. How often do you engage in learning/educational/self-help activities?

- ☐1 Daily
- ☐2 Weekly
- ☐3 Monthly
- ☐4 Yearly
- ☐5 Never

20. Within the last year, which of the following learning/educational/self-help-related systems have you **used**?

	Not sure what it is$_1$	Never$_2$	Once in a while$_3$	Some of the time$_4$	Most of the time$_5$	Always$_6$
1. Computer-based instruction (e.g., CD, DVD, VCR)						
2. Computer support group (e.g., chat room, discussion forum)						
3. Digital or tape recorder						
4. Internet searching (e.g., Google, directories, URLs, newspapers)						
5. Language learning and translation systems						
6. Online library database/catalog						

21. On average, how many hours per day do you spend at home?

- ☐1 Less than 8 hours
- ☐2 8-11 hours
- ☐3 12-15 hours
- ☐4 16-19 hours
- ☐5 20-24 hours

22. Within the last year, which of the following home-based systems have you **used**?

	Not sure what it is1	Never2	Once in a while3	Some of the time4	Most of the time5	Always6
1. Garage door opener						
2. Microwave oven						
3. Home security system (e.g., visitor entry directory system, home alarm, gate access)						
4. Personal computer						
5. Programmable device (e.g., lights, thermostat, sprinkler, programmable food processor, programmable coffee maker)						
6. Robot (e.g., vacuum cleaner, lawn mower)						

23. On average, how many hours **per week** do you work (including volunteer work) in or out of the home? (For the purpose of this question you should not consider activities such as homemaking or family caregiving)

- ☐1 0
- ☐2 1 – 10 hours
- ☐3 11 – 20 hours
- ☐4 21 – 30 hours
- ☐5 31 – 40 hours
- ☐6 More than 40 hours

24. Within the last year, which of the following technologies have you **used** in the context of your work?

	Not sure what it is1	Never2	Once in a while3	Some of the time4	Most of the time5	Always6
1. Bar code scanner						
2. Cell phone						
3. Computer						
4. Copier/scanner						
5. Recording or playback device (e.g., CD, DVD, VCR)						
6. Electronic cash register (point of sale terminal)						
7. E-mail						
8. Fax machine						
9. Internet						
10. LCD projector						
11. Multifunction telephone system (e.g., with conferencing, speaker, transfer capabilities)						
12. Pager/Beeper						
13. Personal digital assistant (PDA)						
14. Voice recorder (e.g., dictaphone, digital recording system, handheld tape recorder)						

25. For each of activities listed in the table, please indicate how important technology is to the performance of the activity.

	Not at all important1	Somewhat important2	Neutral3	Important4	Very important5
1. Communication activities					
2. Customer service activities					
3. Financial transaction activities					
4. Healthcare related activities for yourself or others					
5. Home activities					
6. Learning/education/ self-help activities					
7. Leisure/hobby/ entertainment activities					
8. Shopping activities					
9. Transportation activities					
10. Use of healthcare devices in your home					
11. Work activities					

26. How much more training would you like to have in the use of technology?

- ☐1 None
- ☐2 A little
- ☐3 Moderate training
- ☐4 A lot

27. Have you had experience with computers?

☐1 Yes
☐2 No (Skip the rest of the questionnaire)

28. For each input device listed below, please indicate how much experience you have had with the device in the past year.

	Not sure what it is1	Never used2	Used once3	Used occasionally4	Used frequently5
1. Joystick					
2. Keyboard					
3. Light-pen					
4. Mouse					
5. Rotary input knob					
6. Speech Recognition System					
7. Touch screen with finger					
8. Touch screen with stylus					
9. Trackball					

29. For each basic computer operation listed below, please indicate how much experience you have had with the operation in the past year.

	Not sure what it is1	Never used2	Used once3	Used occasionally4	Used frequently5
1. Delete a file					
2. Insert a disk/CD/DVD					
3. Install software					
4. Open a file					
5. Save a file					
6. Set printer options					
7. Set monitor options					
8. Transfer files					
9. Use a printer					
10. Use cut-and-paste operations					

30. For each item listed below, please indicate how much experience you have had with the item in the past year.

	Not sure what it is$_1$	Never used$_2$	Used once$_3$	Used occasionally$_4$	Used frequently$_5$
1. Apple (Macintosh) operating system					
2. CD/DVD creation software					
3. Computer graphics (e.g., Photoshop, Harvard Graphics, AutoCAD)					
4. Conferencing software					
5. Database management (e.g., Access, Filemaker, Lotus 123)					
6. E-mail					
7. Home computer network (e.g., wire or wireless)					
8. Instant messaging					
9. Internet phone					
10. Presentation software (e.g., PowerPoint, Freelance)					
11. Programming package (e.g., Basic, C++, Fortran, Java)					
12. Spreadsheet (e.g., Excel, Quattro Pro)					
13. Statistical package (e.g., SPSS, SAS)					
14. UNIX/LINUX operating system					
15. Web design software (e.g., Java, HTML)					
16. Windows operating system					
17. Word processing (e.g., Microsoft Word, WordPerfect)					

31. For each windows operation listed below, please indicate how much experience you have had with the operation in the past year.

	Not sure what it is$_1$	Never used$_2$	Used once$_3$	Used occasionally$_4$	Used frequently$_5$
1. Change audio settings					
2. Change screen settings					
3. Change network settings					
4. Click icon					
5. Close a window					
6. Empty trash					
7. Manage multiple windows					
8. Move between windows					
9. Open a window					
10. Perform operations using right click on mouse					
11. Resize a window					
12. Scroll horizontally					
13. Scroll vertically					
14. Search for files					
15. Update the clock					
16. Use drop-down menu					
17. Use windows help system					

Internet Questionnaire

The purpose of this set of questions is to assess your familiarity and experience with the Internet. Please answer all questions by placing a check mark on or filling in the appropriate response.

1. About how many hours a week do you use the Internet?

   - ☐1 Never (Skip the rest of the questionnaire)
   - ☐2 Less than one hour a week
   - ☐3 Between 1 hour and 5 hours a week
   - ☐4 Between 6 hours and 10 hours a week
   - ☐5 Between 11 hours and 15 hours a week
   - ☐6 More 15 hours a week

2. How long have you been using the Internet?

   - ☐1 Less than 6 months
   - ☐2 Between 6 months and 1 year
   - ☐3 More than 1 year, but less than 3 years
   - ☐4 More than 3 years, but less than 5 years
   - ☐5 More than 5 years

3. Compared to a year ago, has your use of the Internet changed?

   - ☐1 No change
   - ☐2 Increase in use
   - ☐3 Decrease in use

4. If your use has changed, please explain why in a few words (e.g., training, equipment problems, frustration)

   ____

   ____

   ____

5. What was the **primary** method that you used to learn to use the Internet?

   - ☐1 I taught myself by exploring it on my own
   - ☐2 I read books on how to use the Internet
   - ☐3 I attended a class
   - ☐4 I learned from a friend or family member
   - ☐5 I used an online tutorial
   - ☐6 I used a CD or videotape
   - ☐7 Other ways (please specify below): ____________________
   - ☐8 ------ *None of the Above* --------

6. Please specify the frequency with which you have performed each of the following activities using the Internet in the past year.

	Never used$_1$	Used once$_2$	Used occasionally$_3$	Used frequently$_4$
1. Banking/Money management (e.g., pay bills online, buy or sell stocks)				
2. Communication (e.g., e-mail, instant messaging)				
3. Community information (e.g., find information about community events or religious services)				
4. Education (e.g., participate in on-line degree or training program, search for information about educational courses or materials, use instructional/training software)				
5. Employment (e.g., post resume or search for information about employment)				
6. Entertainment (e.g., purchase tickets for cultural or entertainment events, find information about TV or radio shows, cultural or entertainment events, or information related to hobbies)				
7. Government and official issues (e.g., access a government website to download standard forms or find out information about benefits and programs)				
8. Health information (e.g., find information about an illness or order medication or health product)				
9. News information (e.g., find information about the weather, read the newspaper)				
10. Shopping (e.g., purchase clothes, search for information about a product)				
11. Travel (e.g., make airline, train, hotel, or rental car reservations, search for maps, travel information)				

APPENDIX D: PARTICIPANT MATERIALS FOR STUDY 1

Contents:

D-1 Technologies shown in briefing meeting

On the day before Study 1 began, participants were shown two slideshows to orient them to everyday technologies. Technologies included in each are listed below.

Table D.1.
Technologies from "Day in the Life Video"(Neo Insight, 2007)

Alarm clock	Make coffee	Weather – internet
TV	radio	Online news
Toaster	thermostat	Traffic – online
Car	Car - heat	Car – radio
Pay at the pump	Voice mail	Email
Movie review	coffee – vending machine	Stocks – internet
Tax news - internet	Debit card swipe – pay for lunch	PDA - schedule
Power Point	Cell phone (call)	PDF paper
Soda – vending machine	Spell check - Word	Watch (timer)
Order supplies (internet)	Train ticket kiosk	ATM
Stove	Directions (Internet)	Microwave
Find number (internet)	CD player	VCR (program)
Book flight (internet)	Digital camera	TV listings (internet)
treadmill	Music - PC	Washing machine
TV	Weather - internet	dishwasher

Table D.2

Technologies shown in Power Point slide show

Card entry to parking deck and building	Keypad entry to home garage	Intercom
Parking lot kiosks	Touch Screen information kiosk	Parking meter
Pedestrian cross request	Emergency telephone	Microwaves
Coffee makers	Blender	Foreman grill
Toaster	Electric mixer	Vacuum cleaners
Crock pot	stove	Thermostat
Space heater	Electric blanket	Alarm clock
Iron	Sewing machine	Calculators
Personal response system (PRS)	Audio recorder	PDA
Presentation remote	PC	Printer
Webcam	Postal scale	Electronic time clock
Lawn mower	Flash light	Circular saw
Drill	Edge trimmer	Copiers
ATMs	Vending machines	Self-shopping kiosks
Airline check-in station	Public transport purchase kiosk	elevator
in-car GPS	Mapquest screen	Blood glucose meter
Treadmill	Stair-climber	Exercise bike
Blood pressure monitor	Hearing aids	Electronic toothbrush
Digital scale	iPod	Boom box
Digital cameras	Digital photo printer	Digital picture frame
TV	VCR	DVD player
Answering machine	Cell phones	Arcade video games
Handheld video games	TV-based video game consoles	Electronic book reader

D-2 Technology Inventory

One Day Inventory of All Technology Interactions
Inventory Instructions

For the daily journal, you are reporting only technologies that are new or infrequently used. On this inventory, however, we would like to collect all of your technology experiences in one day. This will help us understand the technology experiences that may be used in interacting with these new/infrequently used technologies.

- **On column 1 of this page, please record every technology you interact with on the first Friday of your 10-day reporting period. As with the 10-day journal, these technologies include any products or devices that have electricity or batteries, including computers, cell phones, hair dryers, microwave ovens, MP3 players, etc. If you use different computers (e.g., home computer, library computer), please add a separate line for each computer.**

- **In column 2 of this page, please record the applications or functions for the technology (e.g., checked email on gmail and GT zimbra, wrote paper in MS word).**

- **In column 3 of this page, please record the total amount of time you spent on that technology for the Friday of this inventory-keeping.**

Examples are provided in the first 3 rows of this inventory sheet.

Note: **If you had problems with any of these technologies, you should also report them on the daily journal using the journal format.**

On Page 5 of this document, you'll see where you can add any other typical technologies you *frequently or occasionally* use for daily activities though you did not use them on Day 1. Use the same format as above, and report any problems in the daily journal.

If you have any questions, please call Marita O'Brien at 678-613-7729, or email her at marita.obrien@gatech.edu**.**

Technology	Applications/ functions	**Total time used**
Home PC	**Read yahoo and GT mail** **Created/edited documents in Word** **Modified Powerpoint presentation** **Checked weather** **Read online mail** **Checked airfares at Delta**	4 ½ hours
Cell phone	**Called & talked with friends** **Added new contact** **Used alarm function**	45 minutes
Parking deck security	**Swipe buzz card to enter deck**	30 sec.

D-3 Daily Journal

(Please note that column size was reduced in this report to facilitate reading. Columns were adjusted in the diary to allow participants maximum space for "purpose used" and "Any problem" entries.)

Date	Time	Technology Item	Purpose used	Used before?	Instructions available?	Another person available to help?	Watch another person first?	Any problem?	If problem, was it resolved?	If problem, did it cost you time?	If problem, did it cost you money?	If problem, did it cost you anything else (besides money or time)?	If problem, please describe
				YES NO NOT SURE	YES NO NOT SURE	YES NO NOT SURE	YES NO	YES NO	YES NO	YES NO	YES NO		

D-4 Journal Instructions

Understanding Human-Technology Interactions
Journal Instructions

For the next ten days, you will be recording your daily experiences interacting with new and infrequently used technologies as well as new and infrequently used applications and features with frequently used technologies. These technologies include any products or devices that have electricity or batteries, including computers, cell phones, hair dryers, microwave ovens, MP3 players, etc.

You have been given a journal to record your experiences interacting with technologies each day. This journal includes spaces for you to record each experience, the purpose of each usage, and any problems you had with the technology. We are particularly interested in those experiences in which you experienced problems, so please make sure to describe what the problem was (e.g., did you expect the system to operate differently, did you have difficulty finding a menu option or feature?)

You may complete this journal in hard copy or electronic form (or both). Please, however, record the date and time for each experience to facilitate our organization and interpretation of this data. If you are using the electronic format, please save the document after every entry.

On the first day of the study (the first Friday), please also write down every technology you used on the technology inventory. The inventory sheet includes space for you to record each technology, the purpose of the usage, and the amount of time you used it. On other days of the study, please add any other typical technologies (those you use occasionally or frequently, though not on the first day of the study) to the technology inventory.

Please also record any problems with these and your experience with new/infrequently used technologies on the regular journal form on all days – Days 1-10 of the study.

You will be receiving a call every day to remind you about your participation in this study and to ask any questions. If you use email, a daily email reminder will also be sent. You may also call or email the researcher with questions, 678-613-7729, or marita.obrien@gatech.edu

Follow-up Interview

You will be conducting the journal entry from ____________ to _________. You are scheduled to return to the lab on ______________________ for a structured interview and debriefing. Please bring the following items with you at that time:

- **Completed technology inventory**
- **Completed journal**
- **Contact sheet**
- **Demographics form**
- **Technology form**

If you use the electronic form of the journal, please email this to marita.obrien@gatech.edu **after the last entry day.**

Item Descriptions:

Date & Time: **date and time for each entry (e.g., 9/10, 9 AM)**

Technology Item: **list the technology (electric or battery operated). If you have multiple different ones (e.g., home PC, library shared MAC), provide a description that differentiates these. Also, describe separately if you are borrowing someone else's device for this particular event even though you own one (e.g., took a picture with a friend's cell phone).**

Purpose used: **list the goal you were trying to achieve for the technology (e.g., make coffee). This may be more elaborate for multi-purpose items like a home PC. For these multi-purpose items, list the applications (e.g.,**

read online news, research using library database, write paper with Word).

Used before? **Note whether this specific device has been used for same purpose (yes/no/not sure are allowed answers). This should refer to use of this specific device (i.e., have used friend's phone for picture-taking, not just "any camera-enabled phone")**

Instructions available? **Note whether any instructions were available to help you use the technology (yes/no/not sure are allowed answers). Instructions may include a help function, instructions on the display, a manual, a quick-start guide in the vicinity, as well as other examples.**

Another person available? **Note whether there is another person that could help you use the technology successfully (yes/no/not sure are allowed answers). This person may be an employee of the organization or store.**

Watch another person first? **Note whether you observed someone else use the technology. You may not have observed the details of their interaction, but if you saw that they were successful (or unsuccessful) in using the technology for a task (yes/no are allowed answers).**

Any problem? If so, please describe. **If you had no problems, "no" is sufficient. If you had problems, briefly describe the problem (e.g., couldn't find "rewind" function).**

If problem, was it resolved? **Even though you may have had a problem using the device, were you ultimately able to get your task accomplished or reach your goal? (yes/no are allowed answers). Respond yes if you were successful, regardless of whether you had to use a manual or another person to accomplish this goal.**

If problem, did it cost you time? **Report whether you had to spend additional time working on your goal or task than you would have without the problem. (yes/no are allowed answers).**

If problem, did it cost you money? **Report whether you had to spend additional money to accomplish your goal or task than you would have without the problem. (yes/no are allowed answers).**

If problem, did it cost you anything besides time or money? **Report any other costs (e.g., frustration) that were a result of your problem.**

If problem, please describe. **Briefly describe what happened in this incident.**

NOTE**: If you have been using a computer for several hours successfully, using mostly familiar applications, but then visit a unique web site or one you don't visit often, please complete a separate entry for each unique or infrequent application (though you can generically note which PC it is).**

D-5 Structured Interview

Prior Experience and Technology Interaction Structured Interview

Remind participants that, as noted in the consent form, this interview will be audio recorded and transcribed, but personally identifiable information will be removed.

A. Week typicality

1. Describe the nature of this time period, especially noting the typicality of this week.
2. Please rate the typicality of this time period

Completely unusual				Completely typical
1	2	3	4	5

3. Did you have guests this time period? If so, which days?
4. Did you travel (out of town) during this time period? If so, which days?
5. Were you ill or injured during this time period? If so, which days?

B. For each journal entry for which participants answered NO for "Used Before" and NO for "Any problem"

1. What were you doing before you started to use the technology?
2. Were you doing anything else at the same time (including talking to someone else?)
3. Was this technology similar to another technology you've used? If so, which one? How was it similar?
4. Have you used a technology to complete this function before? If so, which one? Was this one similar to your prior one?
5. How recently have you used the similar technologies (questions 1 & 2 for this entry)?

Earlier today	Yesterday	Within this week	Within this month	Within Past few months	Within last year	More than 1 year ago

6. How frequently do you typically use the similar technology(s):

Every day	Several times a week	Once per week	Every few weeks	Every few months	Only ever used it once or twice	Never

7. Can you briefly describe the environment and context of use for this event?
    a. Location
    b. noise
    c. illumination
    d. user stress
    e. time restrictions
    f. presence of others

C. For each journal entry for which participants answered NO for "Used Before" and YES for "Any problem"

1. Is there any more information you can provide about the nature of the problem?
2. What were you doing before you started to use the technology?
3. Were you doing anything else at the same time (including talking to someone else?)
4. Were you able to resolve the problem? If so, how?
5. Was this technology similar to another technology you've used? If so, which one? How was it similar?
6. Have you used a technology to complete this function before? If so, which one? Was this one similar to your prior one?
7. Did you have any problems using the similar technologies (questions 1 and 2 for this entry)? Please describe.
8. How recently have you used the similar technologies (questions 1 & 2 for this entry)?

Earlier today	Yesterday	Within this week	Within this month	Within Past few months	Within last year	More than 1 year ago

9. How frequently do you typically use the similar technology(s):

Every day	Several times a week	Once per week	Every few weeks	Every few months	Only ever used it once or twice	Never

10. Can you briefly describe the environment and context of use for this event?
    a. Location
    b. noise
    c. illumination
    d. user stress

e. time restrictions
f. presence of others

11. As you think back on this event again, can you identify what was problematic with your interaction?
12. Were there any costs (lost time, money, injury, frustration, etc.) to you due to the problem?

D. For each journal entry for which participants answered YES for "Used Before" and YES for "Any problem"

1. Is there any more information you can provide about the nature of the problem?
2. What were you doing before you started to use the technology?
3. Were you doing anything else at the same time (including talking to someone else?)
4. Were you able to resolve the problem? If so, how?
5. Have you had problems with this technology for this purpose in the past?
   a. If so, please describe.
   b. How often (%) do you think you have problems with this technology?
   c. Do you have the same problem with this technology or different problems?
6. How recently have you used this technology (before this time)?

Earlier today	Yesterday	Within this week	Within this month	Within Past few months	Within last year	More than 1 year ago

7. How frequently do you typically use the similar technology(s):

Every day	Several times a week	Once per week	Every few weeks	Every few months	Only ever used it once or twice	Never

8. How recently have you used similar technologies?

Earlier today	Yesterday	Within this week	Within this month	Within Past few months	Within last year	More than 1 year ago

9. How frequently do you typically use the similar technology(s):

Every day	Several times a week	Once per week	Every few weeks	Every few months	Only ever used it once or twice	Never

10. When was the first time you used this technology?
11. Were you successful using this technology the first time using it?
12. Was this technology similar to another technology you've used? If so, which one? How was it similar?
13. Have you used a different technology to complete this function before? If so, which one? Was this one similar to your prior one?
14. Did you have any problems using the similar technologies (questions 1 and 2 for this entry)? Please describe.
15. How recently have you used the similar technologies (questions 1 & 2 for this entry)?
16. Can you briefly describe the environment and context of use for this event?
    a. Location
    b. noise
    c. illumination
    d. user stress
    e. time restrictions
    f. presence of others
17. Is this a similar environment and context of use in which you've used this in the past? If not, what was different?
18. As you think back on this particular event again, can you identify what was problematic with your interaction?
19. Were there any costs (lost time, money, injury, frustration, etc.) to you due to the problem?
20. Can you identify what was problematic with your interaction?

D-6 Exit Interview

Exit Interview

Now that you have completed our study, we would like you to answer a few questions about your experience in the study. There are no right or wrong answers, please just provide your opinion.

For each multiple choice question, please circle the number that best corresponds to your answer, or, for open-ended questions, write in your response.

1. Entering the technology interactions was easy.

1	**2**	**3**	**4**	**5**
Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

2. Did this journal entry process interfere with your life?

1 Yes **2** No

If yes, how?

____
____
____

3. Do you think that this journal entry process changed your behavior?

1 Yes **2** No

If yes, how?

____
____
____

4. Do you have any other comments about this study?

____
____
____
____
____

D-7 Participant debrief

Understanding Human-Technology Interaction
Debriefing Information

Thank you very much for participating in this study. We could not conduct our research without the help of volunteers like you.

The purpose was to understand your daily experiences interacting with new and infrequently used technologies over a ten-day period, particularly when you encountered problems or difficulties. We reviewed these experiences in our final interview to understand how you used them without training and particularly how you overcome problems.

From your specific experiences, we hope to refine the data collection process so we can gather data from a broader sample of individuals like you. Given particularly the different experiences adults of different ages are likely to have, we will be gathering data from younger and older adults. Then, we can review all of the experiences to examine the potential roles of prior experience, system/device design, and context on problems people like you may encounter. We hope that this information can be used to guide system and product designers in creating technology that is easier and safer to use.

Thank you for your time and cooperation. If you have any questions, please feel free to contact us.

Human Factors and Aging Lab
Georgia Institute of Technology
Dr. Arthur D. Fisk (404) 894-6066
Dr. Wendy A. Rogers (404) 894-677

Appendix E: Participant Exclusion Description

Study 1

A total of seven participants, one younger adult and six older adults, were replaced during this study. The younger adult was replaced due to a missing journal from the participant file. Three older adults were replaced because their scores placed them in the medium technology group. One older adult could not return for the structured interview due to unexpected travel. One older adult was older than 75 though he had self-identified as within the age range in the telephone screening. One older adult could not hear at the 3000 hz required in either ear and was taking a medication typically prescribed to slow memory decline. If a participant was excluded for any reason, another participant from the same age and technology experience group was tested using the same procedures. Data from the replacement participant were also analyzed using the same processes and criteria before it was accepted into the study. All data have been retained in study archives.

Study 2

A total of nine participants, one younger adult and eight older adults, were replaced during this study. The younger adult was replaced because of technical difficulties with the recordings. Six older adults were replaced because their scores placed them in the medium technology group. One older adult could not read at the 20/40 required near vision level. One older adult had cognitive ability scores that were more than three standard deviations below the mean for this age group. If a participant was excluded for any reason, another participant from the same age and technology experience group was tested using the same procedures. Data from the replacement participant were also analyzed using the same processes and criteria before it was accepted into the study. All data have been retained in study archives.

Appendix F: Study 1 Coding Descriptions

Technology Categorization Descriptions

Table F.1.

Categories assigned for grouping technologies used by participants in Study 1.

Category	General Description	Examplars
Computer and internet technologies	Technologies reported that are executed on personal computers including the computers themselves, as well as software and Internet applications. Includes hardware supporting primary functions.	Home PC, friend's laptop, mini-hard drive, wireless router, common desktop applications, unusual web site.
Entertainment and leisure technologies	Technologies used for entertainment and leisure, including all used for hobbies, playing games, and listening to music unless on a computer or communication device such as an iPhone.	Video games, electric guitar, bowling touch screen, TV, card shuffling device, metronome.
Home health care technologies	Technologies specifically used for medical treatment, though not necessarily prescribed.	Blood glucose monitor, blood pressure monitor
Kitchen technologies	Technologies used in preparing, cooking, storing, and serving food as well as cleaning food preparation and serving items.	Microwave oven, blender, stove, garbage disposal, electric fry pan, deep freezer
Non-computer office technologies	Technologies used to organize and manage information associated with personal and work tasks	Printer, calculator, paper shredder, fax machine, Microfilm reader, projector touch screen
Other home technologies	Technologies used in individual residence but not included in other categories.	Alarm clock, home security system, washing machine, sewing machine, space heater, vacuum cleaner, drill
Personal care and fitness technologies	Technologies used for personal beauty and body maintenance.	Treadmill, step machine, hair dryer, digital scale, electric toothbrush, heating pad.
Shopping and purchase technologies	Technologies used in buying and selling items, except for applications on personal computer or communication technologies.	ATM, self-service shopping kiosk, parking meter, movie ticket kiosk, public transport ticket purchase machine, vending machine
Telephone and communication technologies	Technologies used primarily for communicating with other people.	Cordless home phone, cell phone, automated response system, iPod touch, answering machine.
Transportation technologies	Technologies used to move self and others, including technologies used within the transport technology.	Car, GPS, CD Player, elevator, Public transport stop request button, garage door remote opener.

Table F.2.

Coding Scheme for Knowledge use in Successful Encounters

Code	Description	Sample participant quotes
Approach	Participant mentions that they were successful because they controlled/optimized environment (does not include getting instructions)	"I waited until no one else was around" "I only started the project when I had no other deadlines or likely interruptions" "Oh, I guess because I was just kind of taking my time and paying attention to what I was doing."

Code	Description	Sample participant quotes
Combination	Participant mentions that they were successful with the technology because they used knowledge in their head and knowledge in the world, typically using strategies such as trial and error, familiarization, or systematic testing. Often also includes learning and problem-solving, or combination of participant's prior knowledge and use of technology feedback. Knowledge is often generated/extended based on the interaction. includes how system feedback is used along with prior knowledge	"Seek and find" "I just kind of figure it out." "Well, I know how to use it and the instructions are there." "If you've got experience with other web sites and you know how to read, you can use this one"
Knowledge in head	Participant mentions that they were successful with the technology because of prior experience, familiarity, similarity to other devices. Participants often seem to say "it was easy because" and then cite the relevant experience. Participant says that they were successful because they knew what to do, which could include describing what they needed to know to be successful such as a specific button to push or how to interact with the device. Participant describes what the knowledge is vs. more general & experiential "I'd done it before"	"I've done it many times before" "I've just used other digital cameras" "All you had to do was wave your hand, it's the only function on it" "I remembered my password." "I know when the problem has to do with the router, so that's why..." "Last time I used this microwave, we burned the popcorn so I knew not to use the popcorn button."
Knowledge in the world - Device	Participant says that they were successful because of information on the technology itself. Includes use of wizards and that the design allowed them to be successful. Includes participant description of specific aspect of the device that was helpful (e.g., only a few options), without reference to prior experience.	"Good design by Canon" "They had a nice start-up package." "You couldn't, you couldn't do a lot with it. You could do enough. It was pretty guided." "The screen told you exactly what to do"
Knowledge in the world - Instructions	Participant mentions that they were successful because they read and/or followed instructions. Participant may describe what was in the instructions that told them what to do, and they do not describe any more elaboration of the instructions (effort/ figuring out after reading instructions constitutes combination)	"I followed the instructions exactly"
Knowledge in the world - Person	Participant mentions that they were successful because they watched other users first or just did what others did or asked others, or that another person completed the task.	"My TA was there explaining things." "The valet showed me how to do it"
Low Effort	Participant mentions that they were successful because they got the result they expected. Includes describing result as opposed to anything specifically about the technology or process. Also includes participant saying nothing but that it was easy, assuming that they were unaware of process (and had no need to monitor the process) until they achieved their goal.	"a very simple machine" "Well, the music was soothing and quiet" "It was easy"
Unknown	Participant is not sure why they were successful	"I have no idea"
Other	Other general success strategy comment not coded above	

Table F.3.

Coding Scheme for Assigning Fault Type

Code	Description	Sample participant quotes
Combination [of knowledge in the head and knowledge in the world]	Participant describes problems due to knowledge problems in their head as well as information in the world.	"I'm used to newer technologies, and this old game didn't cut it… It should have given me more information to figure out what to do" "I had to make the text larger… but then it still didn't fit the screen, and I had to figure out how to scroll around"
Knowledge in Head - Insufficient	Participant notes that they were unsuccessful because of a lack of relevant knowledge during the interaction. Includes not remembering process, rules, codes, etc. at the appropriate time for device interaction	"It worked fine, but I'm just not familiar with it yet." "I forgot my password"
Knowledge in Head – Interfering	Participant describes problems due to interfering knowledge from their previous experience and the current environment. Includes things like the standard process did not work here. Participant implies that their prior knowledge is sufficient for something else, but not here	I" think maybe I forgot to click and save as I was supposed to… maybe because this was a Mac?" "Speaking the way the system seems to want just isn't natural" "They changed what it used to be and it just doesn't make sense now."
Knowledge in World	Participant describes information on the technology, instructions or demonstration that did not make sense to them, causing problems with technology usage. Participant notes that expected information in the world/technology use guidance was not available for them to use the device correctly. Participant describes inconsistency between 2 outside sources such as between instructions and device labels.	"It wasn't clear how to put my card into the kiosk to pay." "We sometimes hit the wrong button because each remote is different." "There's no instruction for the specific required sequence."
Product/system	Participant describes hardware or software problems with the technology. Also includes other system problems such as transport system.	"Every couple of months they just break – I think they're pretty cheap." "The pages printed crooked." "The system just froze."
Not sure	Participant says they do not know the reason for the problem.	"I really don't know, it was only the second time I'd used it" "Maybe it was a bad link, or too many users trying to log into the website. I don't know"
Other attribution	Other fault type not mentioned above	"If I'd been paying attention to the battery, I might have noticed it before it died" "When my stepson was here at Christmas, we installed the wireless thing and had to pull the set out back and forth… The printer became disconnected"

Table F.4.

Coding Scheme for Assigning Knowledge in Problem Resolution

Code	Description	Sample participant quotes
Combination	Participant describes strategy as using combination of external (e.g., instructions) and internal (self) information to solve the problem, i.e., solution was combination of their knowledge what they've learned from something else. Includes trial and error.	"She kind of helped you set it up and then you're on your own" "And I was working it myself before but then after I couldn't work it, I gave it over to Bill." "Trial & Error" "Just kept working. I eventually got there in due time."
External	Participant describes information on the device that told them how to solve the problem. Participant describes use of the instructions as the primary source for solution guidance. Participant describes reliance on another person or persons (through asking, watching, etc.) for solution guidance. Note that this should be selected even if participant tried to solve the problem themselves but ultimately referred to instructions or person to resolve the problem (and they just followed the instructions or let the person do it).	"I noticed that there was a start button and pushed that" "I didn't listen to her to get the complete instructions because she said she was going to mail me instructions telling me" "Looked on the Internet" "I called AT&T" "My brother came in and did it for me."
Not mentioned	Participant does not describe their resolution strategy	
Self – Prior solution	Participant describes using a solution that has worked in the past for resolution, even though it may not have been used for this specific technology before. Includes system resets and restarts.	"I turned it off and on" "When I got home I plugged it in it for about a couple of hours." "Sometimes I just have to restart it"
Self – Replace product	Participant describes buying a replacement product to achieve their goal.	"I just bought a new one"
Self – Selected Alternate	Participant describes changing to another technology (or manual mode) to achieve the system goal. Requires knowledge of alternates, including prerequisites, timing, duration, etc.	"I just sent it to another printer." "I spoke with a customer service person"
Unknown	Participant is not sure how the problem was resolved	"After 5 minutes it just went away."
Other	Other general problem-resolution strategy comment not coded above. Note that this frequently came down to "waiting"/ "time"	

APPENDIX G: PARTICIPANT MATERIALS FOR STUDY 2

Contents: Note that sample materials are taken from Flip; sample materials from Alarm Clock and Kindle are available in study archives.

Technologies shown in study orientation
Technology screening questions
Study instructions
Cognitive Workload Survey
Device Attitudinal Survey
Device Usage Survey
Device Structured Interview
Technology Background Questionnaire
Exit Interview
Debrief

Appendix G-1 Technologies shown in study orientation

As part of the study orientation, participants were shown a researcher-narrated slide show presenting the technologies listed below in the order shown.

Table G.1.

Power Point slide show for Study 2 (order from left to right)

Card entry to parking deck and building	Keypad entry to home garage	Intercom
Gated entrance resident directory	Touch Screen information kiosk	Parking meter
Emergency telephone	Parking lot kiosks	ATM
Grocery self-checkout	Vending machines	Train station purchase kiosk
Airline self-service check-in kiosks	In-car navigation system	Mapquest web page
Elevator	Access card slot for restricted elevator access	Microwaves
Coffee makers	Foreman grill	Blenders
Cuisinart	Toaster	Mixer
Press-n-seal machine	Crock pot	Stove top
Vacuum cleaners	Space heater	Thermostat
Electric blanket	Alarm clock	Ipod
Boom box	Video camera	Small Digital camera
Complex digital camera	Photo printer	Digital picture frame
Portable Video player	TV with remote	VCR
Satellite TV	Answering Machine	Portable phone
Cell phones	Arcade video games	Bowling alley with touch screen scoring
Handheld video games	PC-based video games	TV-based video games
MegaTouch game player	Electronic book reader	Calculators
10-key adding machine	PDAs	Presentation Remote
PC	Printers	Electronic time clock
Copiers	Audio recorder	Electronic postal scale
Garden tools	Electronic saw	Cordless drill

G-2 Technology screening questions

Technology screening questions were selected based on Table B.1 in Appendix B, with additional questions selected to reduce focus on discriminatory items. This script shows the technology experience portion of the recruiting participant recruiting script.

Technology Experience Script

1. Do you use a cell phone? YES / NO
2. Do you use a microwave oven? YES/ NO
3. Do you use an ATM (automated teller machine)? YES / NO
4. Have you ever used a self-checkout machine at the grocery store? YES / NO
5. Do you listen to books on tape? YES / NO
6. Do you use a digital camera? YES / NO
7. Do you use any programmable devices like a programmable thermostat or coffee maker? YES/ NO
8. Have you ever used a copier? YES / NO

Total YES for #1, 3, 4, 7. TOTAL ____________

A. Do you ever use a computer? YES / NO
If YES, what do you use it for? (circle all items mentioned)
a. Check email
b. Play games (e.g., Solitaire, Bejeweled)
c. Create graphics (anything graphical like Powerpoint, Paint, etc.)
d. Write letters/documents, etc. (i.e., Word or WordPerfect)
f. Pay bills/ manage money (e.g., TurboTax, Quicken)
g. Use Excel to manage group of people (i.e., calling list for book club, tennis team) or anything else
h. create/maintain web pages (html)
i. add others (only add points if they seem specialized, not just specific versions of the above)____

Total circled: ___________

B. Do you use the internet? (YES / NO)
If Yes, how much do you use it each week?
- less than 1 hour/week (1 pt)
- 1-5 hours/week (2 pt)
- 6-10 hours/week (3 pt)
- 11-15 hours/week (4 pt)
- more than 15 hours/week (5 pt)

Total Points (count # of pt) __________

C. If YES, what do you use the internet for? (check all that they say)
- banking/money management
- communication (email/instant messaging)
- community info (like community meetings, religious services)
- education (including for instruction about technologies)
- entertainment (including checking movie times)
- games (e.g., online chess, Simcity, World of Warcarft)
- government & official uses
- social networking (e.g., facebook)
- health information
- news information
- shopping
- travel

Total Internet breadth (count) ________

G-3 Study Instructions

GENERAL INSTRUCTIONS FOR DEVICE USAGE

I would like for you to use this device for several tasks I will give you. Remember that the blue mat is your workspace.

Please tell me out loud what you're looking at and doing as you complete the assigned tasks.

Try to figure out how to complete the tasks on your own.

You can work at your own pace as you usually would when interacting with everyday technologies like this.

I'll give you the tasks one at a time on a card. Please read the entire task out loud before beginning.

G-4 Cognitive Workload Survey [sample from Flip camera]

Circle your rating at the point that best indicates your experience with the Flip.
Mental Demand: How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)?

1 2 3 4 5 6 7 8 9 10
Low High

Physical Demand: How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)?

1 2 3 4 5 6 7 8 9 10
Low High

Temporal Demand: How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred?

1 2 3 4 5 6 7 8 9 10
Low High

Effort: How hard did you have to work (mentally and physically) to accomplish your level of performance?

1 2 3 4 5 6 7 8 9 10
Low High

Frustration Level: How insecure, discouraged, irritated, stressed and annoyed did you feel during the task?

1 2 3 4 5 6 7 8 9 10
Low High

Performance: How successful do you think you were in accomplishing the goals of the task?

1 2 3 4 5 6 7 8 9 10
Low High

How satisfied are you with your performance in accomplishing these goals?

1	2	3	4	5	6	7	8	9	10
Low									High

G-5 Device Attitudinal Survey [Sample from Flip camera]

Circle the number of your rating for each aspect of your experience with the Flip.

A. Enjoyment

1. Fun	1	2	3	4	5	6	7	Boring
2. Pleasant	1	2	3	4	5	6	7	Unpleasant
3. Positive	1	2	3	4	5	6	7	Negative
4. Pleasurable	1	2	3	4	5	6	7	Painful
5. Exciting	1	2	3	4	5	6	7	Dull
6. Wise	1	2	3	4	5	6	7	Foolish
7. Enjoyable	1	2	3	4	5	6	7	Unenjoyable

B. Ease of Use

1. Simple	1	2	3	4	5	6	7	Difficult
2. Elegant	1	2	3	4	5	6	7	Clumsy
3. Easy	1	2	3	4	5	6	7	Complex

C. Appearance

1. Attractive	1	2	3	4	5	6	7	Unattractive
2. Delightful	1	2	3	4	5	6	7	Repulsive
3. Gorgeous	1	2	3	4	5	6	7	Ugly

4. Striking 1 2 3 4 5 6 7 Plain

D. Preference

1. If it was completely your choice, would you use the Flip for the tasks you just completed? (Circle your rating)

Absolutely Not			Maybe			Absolutely Yes
1	2	3	4	5	6	7

2. Is there another device you have used to complete these tasks that you would prefer to use? YES NO

3. If YES, which device or technology is preferred and why?

____

____

____

____

4. Was there anything about this Flip that you particularly liked?

____

____

____

____

G-6 Device Usage Survey [sample from Flip camera]

Instructions

In this survey, we would like for you to consider how your prior experience, knowledge, or aspects of the device may have been helpful for several functions you may have used on this Flip camera.

Your prior experiences may come from many different areas, including other technologies or non-technological products.

If you do identify any prior experiences, you may describe up to 3 of these prior experiences for each function.

There are no right answers, and you may in fact have no prior experiences that were useful for you.

You may also find that the same experience(s) helped you with multiple functions which is perfectly OK. Just list them again.

There are 6 functions included in the survey. Just circle or check your response to each question.

[PLEASE WAIT FOR THE RESEARCHER BEFORE TURNING THE PAGE]

A. Power

a. Did you use the power function? YES / NO If NO, go to Page 5

b. Did the power control look as you expected it to look?

Not at all					Exactly
1	2	3	4	5	6

c. Was the power control located where you expected it to be?

Not at all					Exactly
1	2	3	4	5	6

d. Did the power control work as you expected it to?

Not at all					Exactly
1	2	3	4	5	6

---

e. Was this function similar to another product or technology? YES / NO
If YES, which one comes to mind first?
____

f. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

g. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ___________________________________

Power (continued) 

h. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

i. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

j. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ______________________________

k. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

l. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

m. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ______________________________

B. Record

a. Did you use the record function? YES / NO If NO, go to Page 7

b. Did the record control look as you expected it to look?

Not at all … Exactly

1 2 3 4 5 6

c. Was the record control located where you expected it to be?

Not at all … Exactly

1 2 3 4 5 6

d. Did the record control work as you expected it to?

Not at all … Exactly

1 2 3 4 5 6

---

e. Was this function similar to another product or technology? YES / NO

If YES, which one comes to mind first?

____

f. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

g. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ___________________________

Record (continued)

h. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

i. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ____________

j. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?_______________ ___________________________

---

k. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

l. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ____________

m. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?_______________ ___________________________

C. Play

a. Did you use the play function? YES / NO If NO, go to Page 9

b. Did the play control look as you expected it to look?

Not at all					Exactly
1	2	3	4	5	6

c. Was the play control located where you expected it to be?

Not at all					Exactly
1	2	3	4	5	6

d. Did the play control work as you expected it to?

Not at all					Exactly
1	2	3	4	5	6

---

e. Was this function similar to another product or technology? YES / NO
If YES, which one comes to mind first?

____

f. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

g. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ _____________________________

Play (continued)

h. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

i. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

j. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ______________________________

---

k. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

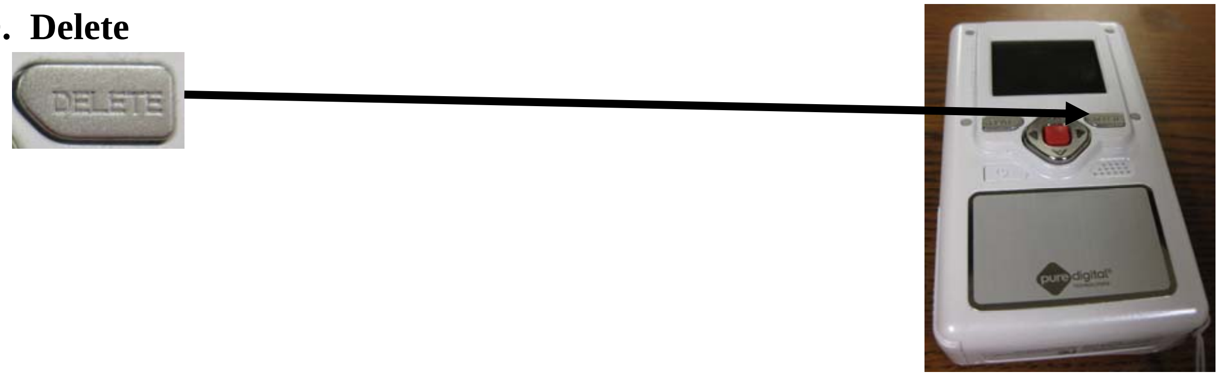
l. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

m. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ______________________________

D. Delete



a. Did you use the delete function? YES / NO If NO, go to Page 11

b. Did the delete control look as you expected it to look?

Not at all					Exactly
1	2	3	4	5	6

c. Was the delete control located where you expected it to be?

Not at all					Exactly
1	2	3	4	5	6

d. Did the delete control work as you expected it to?

Not at all					Exactly
1	2	3	4	5	6

---

e. Was this function similar to another product or technology? YES / NO
If YES, which one comes to mind first?

____

f. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

g. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ______________________________

Delete (continued)

h. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

i. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ____________

j. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?_______________ ___________________________

---

k. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

l. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ____________

m. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?_______________ ___________________________

E. Previous/Next Video

a. Did you use the previous/next video function? YES / NO If NO, go to Page 5

b. Did the previous/next video controls look as you expected them to look?

Not at all					Exactly
1	2	3	4	5	6

c. Were the previous/next video controls located where you expected them to be?

Not at all					Exactly
1	2	3	4	5	6

d. Did the previous/next video controls work as you expected them to?

Not at all					Exactly
1	2	3	4	5	6

---

e. Was this function similar to another product or technology? YES / NO
If YES, which one comes to mind first?

____

f. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

g. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?_______________ ___________________________

Previous/Next Video (continued)

h. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

i. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

j. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ____________________________

---

k. Are there any other products or technologies this is similar to?
YES / NO
If YES, which one comes to mind next?
____

l. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

m. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ____________________________

F. Volume

a. Did you use the volume function?
YES / NO If NO, you are finished

b. Did the volume control look as you expected it to look?

Not at all					Exactly
1	2	3	4	5	6

c. Was the volume control located where you expected it to be?

Not at all					Exactly
1	2	3	4	5	6

d. Did the volume control work as you expected it to?

Not at all					Exactly
1	2	3	4	5	6

---

e. Was this function similar to another product or technology? YES / NO
If YES, which one comes to mind first?
____

f. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

g. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ______________________________

Volume (continued)


h. Are there any other products or technologies this is similar to?

YES / NO

If YES, which one comes to mind next?

____

i. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

j. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ______________________________

---

k. Are there any other products or technologies this is similar to?

YES / NO

If YES, which one comes to mind next?

____

l. When was the last time you used the above item? (check one, if applicable)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? _____________

m. How frequently do you use this item? (check one, if applicable)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Never If never, how are you familiar with the item?________________ ______________________________

Appendix I

G-7 Device Structured Interview (sample from Flip camera)

Structured Interview Guide

A. Power Function
   1. If function not used, what do you think it would do?
   2. What was your expectation for how the function would look? Why?
   3. What was your expectation for where the function would be? Why?
   4. Why did/did it not work as you expected?
   5. For each item listed as similar, what makes [item] similar to Power on this?
      [if no answer –prompt for - appearance (form/color)
      - label (and icon) - location
      - function - interaction type]
   6. For each item listed as similar, how is it different?
   7. Overall, how similar is this item to the function on this Flip:
      SLIGHTLY SOMEWHAT EXACTLY
   8. If there are no similarities, what helped you to use the function successfully?

B. Record Function
   1. If function not used, what do you think it would do?
   2. What was your expectation for how the function would look? Why?
   3. What was your expectation for where the function would be? Why?
   4. Why did/did it not work as you expected?
   5. For each item listed as similar, what makes [item] similar to Power on this?
      [if no answer –prompt for - appearance (form/color)
      - label (and icon) - location
      - function - interaction type]
   6. For each item listed as similar, how is it different?
   7. Overall, how similar is this item to the function on this Flip:
      SLIGHTLY SOMEWHAT EXACTLY
   8. If there are no similarities, what helped you to use the function successfully?

C. Play Function
   1. If function not used, what do you think it would do?
   2. What was your expectation for how the function would look? Why?
   3. What was your expectation for where the function would be? Why?
   4. Why did/did it not work as you expected?
   5. For each item listed as similar, what makes [item] similar to Power on this?
      [if no answer –prompt for - appearance (form/color)
      - label (and icon) - location
      - function - interaction type]
   6. For each item listed as similar, how is it different?
   7. Overall, how similar is this item to the function on this Flip:
      SLIGHTLY SOMEWHAT EXACTLY
   8. If there are no similarities, what helped you to use the function successfully?

Appendix I

D. Delete Functions
   1. If function not used, what do you think it would do?
   2. What was your expectation for how the function would look? Why?
   3. What was your expectation for where the function would be? Why?
   4. Why did/did it not work as you expected?
   5. For each item listed as similar, what makes [item] similar to Power on this?
      [if no answer –prompt for - appearance (form/color)
      - label (and icon) - location
      - function - interaction type]
   6. For each item listed as similar, how is it different?
   7. Overall, how similar is this item to the function on this Flip:
      SLIGHTLY SOMEWHAT EXACTLY
   8. If there are no similarities, what helped you to use the function successfully?

E. Previous/Next Video Functions
   1. If function not used, what do you think it would do?
   2. What was your expectation for how the function would look? Why?
   3. What was your expectation for where the function would be? Why?
   4. Why did/did it not work as you expected?
   5. For each item listed as similar, what makes [item] similar to Power on this?
      [if no answer –prompt for - appearance (form/color)
      - label (and icon) - location
      - function - interaction type]
   6. For each item listed as similar, how is it different?
   7. Overall, how similar is this item to the function on this Flip:
      SLIGHTLY SOMEWHAT EXACTLY
   8. If there are no similarities, what helped you to use the function successfully?

F. Adjust Volume
   1. If function not used, what do you think it would do?
   2. What was your expectation for how the function would look? Why?
   3. What was your expectation for where the function would be? Why?
   4. Why did/did it not work as you expected?
   5. For each item listed as similar, what makes [item] similar to Power on this?
      [if no answer –prompt for - appearance (form/color)
      - label (and icon) - location
      - function - interaction type]
   6. For each item listed as similar, how is it different?
   7. Overall, how similar is this item to the function on this Flip:
      SLIGHTLY SOMEWHAT EXACTLY
   8. If there are no similarities, what helped you to use the function successfully?

Appendix I

G-8 Technology Background Survey

Circle your response to each question.

Flip Camcorder

1. Have you ever used a Flip camcorder before this study? YES / NO

1a. If YES, was it the same as the study version or a different one? YES / NO

Camcorders

2. Have you ever used another video camcorder before this study? YES / NO

2a. If YES, approximately how many different video camcorders have you used in your lifetime (not including the Flip from this study)?

1 2-5 more than 5

2b. If YES, please list camcorders you have used in the past

____

____

____

2c. If YES, when was the last time you used a camcorder before this study? (check one)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ______________

2d. If YES, how frequently do you use a camcorder? (check one)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Used to use occasionally
	Used to use frequently

Video player

3. Have you ever used a video player (e.g., VCR, DVD player)? YES / NO

3a. If YES, approximately how many different video players have you used in your lifetime?
1 2-5 more than 5

3b. If YES, please list video players you have used in the past

____

____

____

3c. If YES, when was the last time you used a video player before this study?
(check one)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ____

3d. If YES, how frequently do you use a video player? (check one)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Used to use occasionally
	Used to use frequently

Digital Camera

4. Have you ever used a digital camera? YES / NO

4a. If YES, approximately how many different digital cameras have you used in your lifetime?

1 2-5 more than 5

4b. If YES, please list digital cameras you have used in the past

____

____

____

4c. If YES, when was the last time you used a digital camera before this study? (check one)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ______________________

4d. If YES, how frequently do you use a digital camera? (check one)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Used to use occasionally
	Used to use frequently

Audio Recorder

5. Have you ever used an audio recorder? YES / NO

5a. If YES, approximately how many different audio recorders have you used in your lifetime?

1 2-5 more than 5

5b. If YES, please list audio recorders you have used in the past

____

____

____

5c. If YES, when was the last time you used an audio recorder before this study? (check one)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ______________________________

5d. If YES, how frequently do you use an audio recorder? (check one)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Used to use occasionally
	Used to use frequently

Kindle Reader

6. Have you ever used a Kindle book reader before this study? YES / NO

6a. If YES, was it the same as the study version or a different one? YES / NO

Electronic Book Readers

7. Have you ever used another electronic book reader (before this study)? YES / NO

7a. If YES, approximately how many different electronic book readers have you used in your lifetime (not including the Kindle in this study)?

1 2-5 more than 5

7b. If YES, please list electronic book readers you have used in the past

____

____

____

7c. If YES, when was the last time you used an electronic book reader before this study? (check one)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ____________________________________

7d. If YES, how frequently do you use an electronic book reader? (check one)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Used to use occasionally
	Used to use frequently

Reading on Web

8. Have you ever read books or articles on the web? YES / NO

8a. If YES, approximately how many different web sites you have you used for articles or books on the web in your lifetime?

1 2-5 more than 5

8b. If YES, please list web sites or other sources you have used in the past.

____

____

____

8c. If YES, when was the last time you read an article or book on the web before this study? (check one)

	Earlier today
	Yesterday
	Within this week
	Within this month
	Within past few months
	Within last year
	More than 1 year ago How long ago? ______________________________

8d. If YES, how frequently do you read an article or book on the web? (check one)

	Every day
	Several times a week
	Once per week
	Every few weeks
	Every few months
	Once per year
	Only used once or twice
	Used to use occasionally
	Used to use frequently

Alarm Clock

9. Have you ever used the Sony alarm clock in this study before?
YES / NO / NOT SURE

10. Have you ever used another alarm clock before this study?
YES / NO

10a. If YES, approximately how many alarm clocks have you used in your lifetime?

1 2-5 more than 5

10b. If you use an alarm clock now, how similar is your alarm clock to the Sony clock from this study?

Not at all					Exactly
1	2	3	4	5	6

Appendix I

G-9 Exit Interview

Now that you have completed our study, we would like you to answer a few questions about your experience in the study. There are no right or wrong answers, please just provide your opinion.

1. Please rate the ease of use for each device

Flip Video	Easy to use	1	2	3	4	5	6	7	Hard to use
Kindle	Easy to use	1	2	3	4	5	6	7	Hard to use
Alarm Clock	Easy to use	1	2	3	4	5	6	7	Hard to use

2. Do you think that being video recorded changed how you would have normally interacted with the technologies or devices?

Not at all 1 2 3 4 5 6 7 Completely different

3. Do you think that narrating your interactions changed how you would have normally interacted with the technologies or devices?

Not at all 1 2 3 4 5 6 7 Completely different

4. For each of the three scenarios (A, B, C) described below, check your first and second preferences for learning to use the device mentioned

A. Imagine you have just bought a new cell phone. What would be your FIRST choice for learning to use the new cell phone?

__ demonstration by another person
__ formal group class
__ informal group of other users
__ one-on-one instruction
__ online (includes help screens, tutorials and information at company web site)
__ paper reference sheet or manual
__ trial and error
__ Other ways (please specify)____

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What would be your SECOND choice for learning to use the new cell phone?
__ demonstration by another person
__ formal group class
__ informal group of other users
__ one-on-one instruction
__ online (includes help screens, tutorials and information at company web site)
__ paper reference sheet or manual
__ trial and error
__ Other ways (please specify)____

If you would be learning from someone else in either choice, whom would that be?
__ customer service representative of cell phone company
__ family member
__ friend
__ instructor
__ salesperson at the store
__ Other ways (please specify)_____________

B. Imagine you have just bought a new medical device recommended by your doctor to improve your health. What would be your FIRST choice for learning to use the new medical device?
__ demonstration by another person
__ formal group class
__ informal group of other users
__ one-on-one instruction
__ online (includes help screens, tutorials and information at company web site)
__ paper reference sheet or manual
__ trial and error
__ Other ways (please specify)____

What would be your SECOND choice for learning to use the new medical device?
__ demonstration by another person
__ formal group class
__ informal group of other users
__ one-on-one instruction
__ online (includes help screens, tutorials and information at company web site)
__ paper reference sheet or manual
__ trial and error
__ Other ways (please specify)____

If you would be learning from someone else in either choice, whom would that be?
__ family member
__ friend
__ instructor
__ medical professional
__ representative of device manufacturer
__ Other individuals (please specify)_____________

C. Imagine you are going to a movie at a theater that has a ticket purchase kiosk right near the entrance. The line to buy a ticket from a person is quite long and you are already running a bit late. What would be your FIRST choice for learning to use the ticket purchase kiosk to buy a ticket?
__ demonstration by another person
__ formal group class
__ informal group of other users
__ one-on-one instruction
__ online (includes help screens, tutorials and information at company web site)
__ paper reference sheet or manual
__ trial and error
__ Other ways (please specify)____

What would be your SECOND choice for learning to use the movie ticket kiosk?
__ demonstration by another person
__ formal group class
__ informal group of other users
__ one-on-one instruction
__ online (includes help screens, tutorials and information at company web site)
__ paper reference sheet or manual
__ trial and error
__ Other ways (please specify)____

If you would be learning from someone else in either choice, whom would that be?
__ customer service representative of theater
__ family member
__ friend
__ other moviegoer
__ Other ways (please specify)_____________

Appendix I

5. Do you have any other comments about this study?

____

____

____

____

____

____

____

____

G-10 Debrief

Understanding Human-Technology Interaction

Debriefing Information

Thank you very much for participating in this study. We could not conduct our research without the help of volunteers like you.

The purpose was to understand how you use prior knowledge and experience to guide you in interacting with new everyday technologies. We asked you to interact in three ways with three examples of these technologies. For each technology, we asked you to describe the technology, to complete three tasks, and to demonstrate the functionality you had learned to a friend. We also asked you to answer set questions to help you recall this prior experience. Your interactions and our conversations were video-recorded for further analysis.

Given particularly the different experiences adults of different ages are likely to have, we will be gathering data from younger and older adults.
Then, we can review all of the experiences to examine the potential roles of prior experience, system/device design, and other factors on problems people like you may encounter. We hope that this information can be used to guide system and product designers in creating technology that is easier and safer to use.

Thank you for your time and cooperation. If you have any questions, please feel free to contact us.

Human Factors and Aging Lab
Georgia Institute of Technology
Dr. Arthur D. Fisk (404) 894-6066
Dr. Wendy A. Rogers (404) 894-6775

APPENDIX H: BACKGROUND QUESTIONNAIRE

Note that this document had 2 cover pages that were deleted from this version.

Demographics Questionnaire

Gender: Male ☐1 **Female** ☐2 **Date of Birth: __ __ / __ __ / __ __** **Age: _______**

1. What is your highest level of education?

☐1 No formal education
☐2 Less than high school graduate
☐3 High school graduate/GED
☐4 Vocational training
☐5 Some college/Associate's degree
☐6 Bachelor's degree (BA, BS)
☐7 Master's degree (or other post-graduate training)
☐8 Doctoral degree (PhD, MD, EdD, DDS, JD, etc.)

2. Current marital status (check one)

☐1 Single
☐2 Married
☐3 Separated
☐4 Divorced
☐5 Widowed
☐6 Other (please specify) ___________________

3. Do you consider yourself Hispanic or Latino?

☐1 Yes
☐2 No

3 a. If "Yes", would you describe yourself:

☐1 Cuban
☐2 Mexican
☐3 Puerto Rican
☐4 Other (please specify) __________________

4. **How would you describe your primary racial group?**

☐1 No Primary Group
☐2 White Caucasian
☐3 Black/African American
☐4 Asian
☐5 American Indian/Alaska Native
☐6 Native Hawaiian/Pacific Islander
☐7 Multi-racial
☐8 Other (please specify) ______________________

5. **In which type of housing do you live?**

☐1 Residence hall/College dormitory
☐2 House/Apartment/Condominium
☐3 Senior housing (independent)
☐4 Assisted living
☐5 Nursing home
☐6 Relative's home
☐7 Other (please specify) ________________

6. **Which category best describes your yearly household income. Do not give the dollar amount, just check the category:**

☐1 Less than $5,000
☐2 $5,000 - $9,999
☐3 $10,000 - $14,999
☐4 $15,000 - $19,999
☐5 $20,000 - $29,999
☐6 $30,000 - $39,999
☐7 $40,000 - $49,999
☐8 $50,000 - $59,999
☐9 $60,000 - $69,999
☐10 $70,000 - $99,999
☐11 $100,000 or more
☐12 Do not know for certain
☐13 Do not wish to answer

7. **Is English your primary language?**

☐1 Yes
☐2 No

7 a. If "No", What is your primary language? ________________________

8. **What is your primary mode of transportation? (Check <u>one</u>)**

☐1 Drive my own vehicle
☐2 A friend or family member takes me to places I need to go
☐3 Transportation service provided by where I live
☐4 Use public transportation (e.g., bus, taxi, subway, van services)

<u>Occupational Status</u>

9. **What is your primary occupational status? (Check <u>one</u>)**

☐1 Work full-time
☐2 Work part-time
☐3 Student
☐4 Homemaker
☐5 Retired
☐6 Volunteer worker
☐7 Seeking employment, laid off, etc.
☐8 Other (please specify) ____

10. **Do you currently work for pay?**

☐1 Yes, Full-time
☐2 Yes, Part-time
☐3 No

10 a. If "Yes", what is your primary occupation? ______________________________

<u>If retired:</u>

11. What was your primary occupation? ___________________________

12. What year did you retire? ______________________

Health Information

1. In general, would you say your health is:

☐1 Poor ☐2 Fair ☐3 Good ☐4 Very good ☐5 Excellent

2. Compared to other people your own age, would you say your health is:

☐1 Poor ☐2 Fair ☐3 Good ☐4 Very good ☐5 Excellent

3. How satisfied are you with your present health?

☐1 Not at all satisfied ☐2 Not very satisfied ☐3 Neither satisfied nor dissatisfied ☐4 Somewhat satisfied ☐5 Extremely satisfied

4. How often do health problems stand in the way of your doing the things you want to do?

☐1 Never ☐2 Seldom ☐3 Sometimes ☐4 Often ☐5 Always

5. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? Check <u>one</u> box for each type of activity.

	Limited a lot1	**Limited a little**2	**Not limited at all**3
a. Bathing or dressing yourself			
b. Bending, kneeling, or stooping			
c. Climbing **one** flight of stairs			
d. Climbing **several** flights of stairs			
e. Lifting or carrying groceries			
f. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf			
g. Vigorous activities, such as running, lifting heavy objects, or participating in strenuous sports (e.g., swimming laps)			
h. Walking **more than a mile**			
i. Walking **one block**			
j. Walking **several blocks**			

6. Are you on post-menopausal estrogen replacement therapy?

☐1 Yes ☐2 No ☐3 Not applicable

7. For each of the following conditions please indicate if you have ever had that condition in your life, have the condition now at this time or never had the condition. Check one box for each condition.

I...1.1.1 Condition	**In your lifetime$_1$**	**Now$_2$**	**Never$_3$**
a. Arthritis			
b. Asthma or Bronchitis			
c. Cancer (other than skin cancer)			
d. Diabetes			
e. Epilepsy			
f. Heart Disease			
g. Hearing Impairment			
h. Hypertension			
i. Stroke			
j. Vision Impairment			
k. Other significant illnesses (please list)			

CES-D SCALE

INSTRUCTIONS FOR QUESTIONS: Below is a list of the ways you have felt or behaved. Please circle how often you have felt this way in the past week.

0 = Rarely or None of the Time (Less than 1 Day)
1 = Some or a Little of the Time (1 – 2 Days)
2 = Occasionally or a Moderate Amount of the Time (3 – 4 Days)
3 = Most of the Time (5 – 7 Days)

During the past week:

1. I was bothered by things that usually don't bother me.	0	1	2	3
2. I did not feel like eating, my appetite was poor.	0	1	2	3
3. I felt that I could not shake off the blues even with help from my family or friends.	0	1	2	3
4. I felt that I was just as good as other people.	0	1	2	3
5. I had trouble keeping my mind on what I was doing.	0	1	2	3
6. I felt depressed.	0	1	2	3
7. I felt that everything I did was an effort.	0	1	2	3
8. I felt hopeful about the future.	0	1	2	3
9. I thought my life had been a failure.	0	1	2	3
10. I felt fearful.	0	1	2	3

GO ON TO THE NEXT PAGE.

0 = Rarely or None of the Time (Less than 1 Day)
1 = Some or a Little of the Time (1 – 2 Days)
2 = Occasionally or a Moderate Amount of the Time (3 – 4 Days)
3 = Most of the Time (5 – 7 Days)

During the past week:

11. My sleep was restless.	0	1	2	3
12. I was happy.	0	1	2	3
13. I talked less than usual.	0	1	2	3
14. I felt lonely.	0	1	2	3
15. People were unfriendly.	0	1	2	3
16. I enjoyed life.	0	1	2	3
17. I had crying spells.	0	1	2	3
18. I felt sad.	0	1	2	3
19. I felt that people disliked me.	0	1	2	3
20. I could not get "going."	0	1	2	3

Computer Questionnaire 1

Please place an "X" on the appropriate response.

1. I feel comfortable with computers.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

2. Learning about computers is a worthwhile and necessary subject.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

3. Reading or hearing about computers would be (is) boring.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

4. I know that if I worked hard to learn about computers, I could do well.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

5. Computers make me nervous.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

6. I don't care to know more about computers.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

7. Computers would be (are) fun to use.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

8. I don't feel confident about my ability to use a computer.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

9. Computers are <u>not</u> too complicated for me to understand.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

10. I think I am the kind of person who would learn to use a computer well.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

11. I think I am capable of learning to use a computer.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

12. Learning about computers is a waste of time.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

13. Computers are confusing.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

14. Computers make me feel dumb.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

15. Given a little time and training, I know I could learn to use a computer.

1	2	3	4	5
Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Agree**

Have you had any experience with computers?

☐1 Yes ☐2 No

If NO, Skip Computer Questionnaire 2.

Computer Questionnaire 2

Listed below are a series of statements that reflect the way that people feel about their experience(s) with computers. Please indicate whether you agree or disagree with each statement by placing an "X" on the appropriate response.

1. When using a computer, I prefer to learn through trial and error.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

2. In the past, computers have made my task(s) far simpler.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

3. I have generally enjoyed learning how to use computer software.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

4. In situations where I have had to learn how to use a computer system, I have found the operating manuals difficult to understand.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

5. I feel inadequate when receiving training at the computer.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

6. I usually get frustrated when using a computer.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

7. In the past I have felt anxious when required to use certain software.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

8. I am reluctant to ask for help when using a computer.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

9. I enjoy exploring new applications/uses for the computer or software.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

10. Other people seem to be more skillful at using a computer than myself.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

11. I usually get frustrated when using certain software.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

12. From past experience, I would prefer to learn a new computer software package on my own.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

13. I am usually curious to use the latest version computer software.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

14. Computer support staff talk in computer jargon with which I am unfamiliar.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

15. I have not received sufficient training at the computer.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

16. Instead of asking for assistance with a computer-related problem, I prefer to try and solve it myself.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

17. When seeking advice from computer support staff (technician), I am often unable to state clearly what my query or question is about.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

18. I often feel scared when using a computer.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

19. When I seek advice about a computer-related question, I feel stupid when I am told that the answer is simple.

1	2	3	4	5	N/A
Strongly	**Mostly**	**Uncertain**	**Mostly**	**Strongly**	**Not**
disagree	disagree		agree	agree	applicable

20. I often feel concerned that I might do damage to the computer if I make a mistake.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

21. I feel incompetent when having to ask for computer assistance.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

22. The training I have received in computer usage has been very beneficial.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

23. When I cannot understand how to use computer software, I evaluate my own performance in a negative way.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

24. I feel quite powerless when I am being instructed to use a computer or computer software for the first time.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

25. In the past, computer education has facilitated my understanding of computer software capabilities.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

26. In the past, I have had insufficient time at work to learn to use computer software.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

27. I often feel isolated from other people when using a computer.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

28. Most computer manuals need to be read from front to back to be understood.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

29. In the past, computer training has improved my ability to use computer software.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

30. I feel more at ease using a computer when alone than with a group of people.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

31. When I encounter a computer-related problem that I cannot resolve myself, I feel comfortable about asking an expert.

1	2	3	4	5	N/A
Strongly disagree	**Mostly** disagree	**Uncertain**	**Mostly** agree	**Strongly** agree	**Not** applicable

I...1.1.1.1.1 Medication Usage Details

Please list all medical products that you are currently taking. Include medicinal herbs, vitamins, aspirin, antacid, nasal spray, laxatives, etc., as well as prescription medications (copy names from label if possible). This information will be completely confidential.

EXAMPLE

Name of Medication: ______________ Zarontin ________________________________

Reason for taking: ____epilepsy___ Dosage (ea. time taken): ________500 mg________

How often do you take the medication? (circle one)

daily (every other day) weekly as needed

On days that you take the medication, how many times per day do you take it? ______3___

What time of day do you take the medication? morning, afternoon, evening_________

How long you have been taking the medication? _________5 years__________________Does this medication cause any problems? ____________makes me sleepy_______________

1. Name of Medication: ____

Reason for taking: ______________________ Dosage (ea. time taken): ________

How often do you take the medication? (circle one)

daily every other day weekly as needed

On days that you take the medication, how many times per day do you take it? _________

What time of day do you take the medication? ________________________________

How long you have been taking medication? ____________________________

Does this medication cause any problems? ______________________________________

____

Appendix I: Materials used for Coding Video Segments

Contents: Note that sample materials are taken from Flip; sample materials from Alarm Clock and Kindle are available in study archives.

Appendix I-1 Coding Sheet for Behavior Analysis

Table I.1
Code Descriptions for Behavior Analysis of Flip

Valid Device Actions

Pick up & look at screen	Participant picks up device and looks at screen before deciding what to do (note that this may be followed by/better categorized as an inspect)
Power	Participant presses power button on or off
Record	Participant presses the record (red) button
Arrow up/down	Participant presses the up/down arrows. Note that this is recorded once, and not repeated unless it is in the middle of other activities.
Move toward tractor	Participant moves flip closer to tractor to zoom in & try to read Deere label after having pressed the digital zoom (up) button.
Move around table	Participant moves flip around table as if they are recording after pressing record button
Framing	Participant holds camera and moves is slowly around table to bring appropriate items into picture screen (watch to distinguish between inspects where participant is looking for controls, feedback, etc.)
Play	Participant presses play button
Arrow right/left	Participant presses right/left arrow button. Note that this is recorded once, and not repeated unless in the middle of other activities.
Delete	Participant presses Delete key. Note that this IS recorded for each press (to allow distinction of the confirm press.

Invalid actions

Pick up & look through lens	Flip is oriented so that participant looks through the lens.
Move toward tractor	Participant moves flip closer to tractor to zoom in & try to read Deere label without having pressed digital zoom.
Move around table	Participant moves flip around table as if they are recording but without pushing record in advance.
Control misuse	Participant interacts with controls in ways that are incorrect for the task such as holding down the play or delete key, pushing left/right key in for the wrong task. Also includes touching the power but not holding it in. Note that it may be easier to mark in the area in valid actions for the specific control, but these should be circled, and also written here, with a label for referencing in error descriptions. These should be counted here for the summary – not under valid actions.
Other control actions	Participant interacts with any controls not listed under "actions" such as USB *open/close, battery compartment, touching the screen, pressing in top flap, and touching the silver panel at the bottom*.

Non-device actions	Participant interactions with anything other than device itself, including the tractor, looking at their watch or referencing the task cards.

Looks

Search device	Use this code for general searches, gross motions turning device around, especially to look for next needed control.
Inspect back	Participant looks carefully at back of Flip, but not seeming to focus on either the control panel or the display specifically
Inspect control panel	Participant carefully examines control panel with focused actions, such as pointing to different controls and/or reading off the names/symbols on them.

Inspect display	Participant describes feedback they are perceiving correctly. Description should be fairly specific, ie., “OK, power is on”, “ready”, “Delete video?” or “I hear a different voice; this isn’t my video.” Does NOT include general “Now, I need to zoom in” after record has been started. Includes incorrect feedback interpretations as well as statements “I can’t tell if it’s recording” that should be circled as misreads.
Audible feedback	Participant describes feedback received audibly such as things they hear in a video (“doesn’t sound very loud”), Flip turning on, etc.
Inspect others	Participant carefully examines other controls with focused actions, such as pointing to different controls and/or reading off the names/symbols on them.

Questions

Participant help request	Participant asks experimenter for help, e.g., “I don’t know what to do next”, “I’m stuck”, “What do I do next”
Participant question	Participant asks experimenter specific question about task or device, such as “do I push the red button” “is it recording?”

Prompts

Prompt: look	Experimenter asks participant what they see on the device.
Prompt: talk	Experimenter reminds participant to tell what they are doing.
Prompt: what	Experimenter asks participant what they are doing/looking for?
Prompt: task	Experimenter reminds participant to continue the task, i.e., what’s the next task? What does the direction say?
Exp. Remind directions	Experimenter reminds participant of next task, reading the task, or providing specific information such as the book they are looking for. (experimenter initiated)
Other answers	Experimenter provides other information to participant such as when the next break is. If participant asks a question – even about the task such as whether a particular video is the one they should delete, it should be coded here.

Interventions

Prompt: directive	Experimenter suggests a specific action with a specific control to the participant.
Prompt: where	Experimenter suggests a specific area on the device to look for next step or control.
Exp. Clarify directions	Experimenter clarifies the direction if participant seems to be interpreting task incorrectly, such as “you need to record a video” when participant only moves the camera around.
Other interventions	Experimenter touches device to get participant back on track, executes action, or gives participant specific action that they should not do.

Appendix I-2 Code Sheet Used for First Flip Task

Initial Use: Record & zoom

Optimal Path: *Power On* *Record On* *Arrow Up* *Record Off*

Valid Device Actions		TOTAL
Pick up & look at screen		
Power		
Record		
Arrow up/down		
Move toward tractor		
Move around table		
Framing		
Play		
Arrow right/left		
Delete		

Invalid actions		TOTAL
Pick up & look through lens		
Move toward tractor (before digital zoom)		
Move around table without record		
Control misuse		
Other control actions		

Non-device actions		

Looks		TOTAL
Search device		
Inspect control panel		
Inspect display		
Inspect others		

TOTAL _____

Questions

TOTAL

Participant help request		
Participant question		

Prompts

TOTAL

Prompt: look		
Prompt: talk		
Prompt: what		
Prompt: task		
Exp. Remind directions		
Other answers		

Interventions

TOTAL

Prompt: directive		
Prompt: where		
Exp. Clarify directions		
Other interventions		

Task: Record & zoom

Total Time: ________________________

Successful? YES/ NO/ PARTIAL NOT ATTEMPTED

Total number of participant valid actions ____________
Total number of participant invalid actions ____________
Total number of participant non-device actions ____________
Total number of participant looks ___________
Total number of participant questions ___________
Total number of participant actions ___________

Total number of experimenter prompts ___________
Total number of experimenter interventions ____________
Total number of experimenter actions ___________

Optimal PATH – *Write step in which participant reached the following milestone*
__ turn power on
__ Push record button (on)
__ Click up arrow (zoom)
__ Push record button (off)
Optimal path? YES/ NO

Extra Steps: ____________

Errors:
Total count from previous page: _________
Control misuse count: _____
Controls: ____
Feedback misreads count: _____
Steps: ____
Sequence errors count: _________
____
Others count: _____
__ Video shorter than 20 seconds
__ Tried to look through lens
__ Moved camcorder around vs. pushing record
__ Zoomed first by moving camera around
__ Pushed other areas of device (list specific)
____
__ Others
____
____
Total: _____

Comments: (only explain items that may affect task order or indicate task completion status)
____
____
____
____

Appendix I-3 Quick Coding Sheet

Initial Use: Record & zoom

Total Time: ________________________

Optimal Path: *Power On* *Record On* *Arrow Up* *Record Off*

Optimal PATH – *Check if completed on own, write P if cues needed, write D if directive needed to get to next milestone, X if not done*
__ turn power on
__ Push record button (on)
__ Click up arrow (zoom)
__ Push record button (off)
Optimal path? YES/ NO **If not optimal, what was going on? (e.g., ppt a little stumped by power button, but then on track)**

____
____
____

Successful? YES/ NO/ PARTIAL NOT ATTEMPTED
Directives needed for success? YES/NO
If not successful, why not?

____
____
____

Other Comments and observations:

____
____
____

Review and adjust volume

Total Time: ________________________

Optimal Path: *Play* *Arrow Up*

Optimal PATH – *Check if completed on own, write P if cues needed, write D if directive needed to get to next milestone, X if not done*
__ Hit Play
__ Hit volume up/down while listening
Optimal path? YES/ NO
If not optimal, what was going on? (e.g., ppt couldn't find video because not recorded in step 1)

____
____

Successful? YES/ NO/ PARTIAL NOT ATTEMPTED
Directives needed for success? YES/NO
If not successful, why not?

____
____

Other Comments and observations

____
____
____

Find and delete prior video

Total Time: ________________________

Optimal Path: *Arrow left* *Play* *Delete* *Delete* *Off*

Optimal PATH – *Check if completed on own, write P if cues needed, write D if directive needed to get to next milestone, X if not done*

__ Hit back arrow to prior video
__ Push play
__ Push delete
__ Push delete to confirm before timeout
__ Power off

Optimal path? YES/ NO

If not optimal, what was going on? (e.g.,, ppt did not know delete was also confirm/delete)

____
____
____

Successful? YES/ NO/ PARTIAL NOT ATTEMPTED

Directives needed for success? YES/NO

If not successful, why not?

____
____
____

Comments: (only explain items that may affect task order or indicate task completion status)

____
____
____

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