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Mobile Web Browsing with Aural Flows: An Exploratory Study

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Existing web applications force users focus their visual attention on mobile devices while browsing content and services while on the go. To support eyes-free, mobile experiences, designers can minimize interaction with a device by leveraging the auditory channel. Whereas acoustic interfaces have proven to be effective in reducing visual attention, a perplexing challenge is designing aural information architectures for the web. To address this problem, techniques to remodel existing information architectures as linear, aural flows were introduced and evaluated. Mobile web browsing with aural flows is exemplified in ANFORA News, a semiaural mobile site designed to browse large collections of news stories. An exploratory study involving frequent news readers (*n* = 20) investigated the usability and navigation experience with ANFORA News in a mobile setting. Initial evidence suggests that aural flows are a promising paradigm to support eyes-free mobile navigation while on the go, but users still require assistance and additional learning to fully master the aural mechanics of the flows while on the go. Future work will improve on the mechanisms to customize content and control the aural navigation.

1. INTRODUCTION

Accessing the mobile web while on the go is becoming increasingly pervasive as mobile users become more likely to multitask during digital media experiences. By 2011, nearly half of all American adults (47%) reported that they use their cell phones or tablet computers to access local news and information (Purcell, Rainie, Rosenstiel, & Mitchell, 2011). However, multitasking often occurs when people access the mobile web while engaged in another activity (e.g., walking or driving) when it is

distracting or even dangerous to look at the screen at all times. According to Watanabe, Okano, Asano, and Ogawa (2007),

> aural presentation of information is useful for not only blind users but also sighted users. Even sighted users encounter situations in which they cannot watch a PC monitor. Consider someone cooking in a kitchen, as they are unable to watch a PC monitor, it is better for them to receive the cooking hints aurally. (p. 2)

Existing visual interfaces often require highly focused attention and may not work well in these situations. Likewise, recent studies on the use of mobile devices during secondary tasks indicate that *aurally-based/audio-based* interfaces—although slower to use—are less distracting than visual interfaces (Brumby, Davies, Janssen, & Grace, 2011).

The popularity of audiobooks and audio guides (in the museum and tourism domains) represents an important need for aural interaction in specific contexts. Moreover, in the domain of web accessibility, solutions have been proposed to automate, auralize, and *replay* repetitive web tasks (such as paying the monthly bills; Borodin, 2008). The nature and structure of the information auralized by these applications, however, follow a very linear pattern (e.g., listening to a book page by page or chapter by chapter). At the same time, the information architectures of modern web applications are not linear and typically follow a hierarchical pattern, compounded by traversal links connecting content elements in a complex web structure (as shown in Figure 1).

An unsolved challenge then is to properly *auralize* such web information architectures in a way that users can still browse the application content in a more linear fashion, thus minimizing interaction with the device and facilitating more eyes-free experiences. To address this problem, we propose ANFORA (Aural Navigation Flows On Rich Architectures), a systematic approach to remodel web information architectures into a set of "aural flows." An aural flow is a design-driven, concatenated sequence of pages that can be listened to with minimal interaction required. Aural flow allows users to automate browsing tasks on top of web information architectures by creating a playlist that is based on the content in which they are most interested. Then, they can listen to, instead of read, selected content, so that users do not have to continuously interact with the screen as they navigate content. For example, a news website, such as nytimes.com, includes a number of topically driven categories
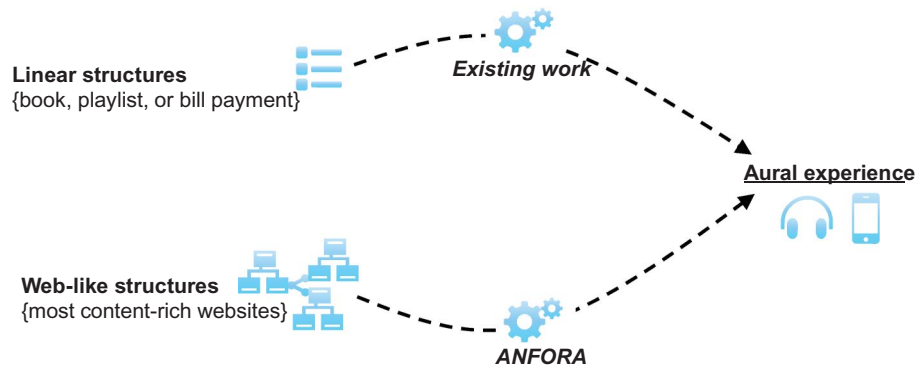
FIG. 1. ANFORA remodels complex web information architectures to make them suitable for aural browsing (color figure available online).

(e.g., Politics, Sports, Travel, Commentary, etc.) within which hundreds of related stories are provided. A site that makes use of ANFORA would allow users to choose categories of content based on their interests and time. ANFORA then generates custom aural flows based on the users' preferences and transforms text on information-rich web pages into a text-to-speech (TTS) presentation that users can listen to instead of read.

To investigate the potential of ANFORA, we applied our concept to the news domain because news websites are content intensive and employ complex navigation structures. News consumption on mobile devices is also increasing, making news content an interesting test bed for aural browsing. For example, consider a scenario in which a user wants to catch up with today's local news while walking on a city street. Visually scanning the pages of a news site, navigating to stories of interest, and then actually reading them while walking require a level of visual and cognitive concentration that makes it difficult to focus on other elements, such as traffic signals, moving cars, and passing crowds. Much of the interactivity required by the news is in direct conflict with the simple task of walking safely down a busy street. Thus, we prototyped and evaluated "ANFORA News," a mobile web application optimized for the iPhone and aimed at demonstrating how to turn the traditional visually governed experience of navigating news websites into a listening, or aural experience. We assert that well-designed "aural" interfaces can provide new ways to support appropriate eyes-free browsing of mobile web systems, making many of these distractions and obstacles unthreatening. Likewise, aural interfaces may improve the news consumption experience while on the go by making it more enjoyable and easier to execute.

Here we present the results of an exploratory study conducted to learn how well ANFORA can coexist with the physical and cognitive tasks inherent to the mobile experience and explore the strengths and weaknesses of ANFORA designs in regard to the user experience of listening to news. For this study, 20 participants engaged with the ANFORA News prototype while they walked through busy hallways of a large campus building. Participants were asked execute a number of listening tasks based on the ANFORA News capabilities and interface. Initial evidence from this preliminary study suggests that aural flows are a promising paradigm with some limitations and improvements to be made and can seed important future work to design aural web systems.

The remainder of the article is organized as follows. Section 2 reviews related work that focused on aurally navigating user interfaces. We also discuss research that indicates the need for novel mobile interaction paradigms for the news industry. Section 3 introduces the ANFORA framework to remodel existing web information architectures into aural flows. We present the design issues and the prototype of ANFORA News in Sections 4 and 5, respectively. The evaluation study is presented in Section 6, and the discussion and limitations of our work in Section 7, along with hints to future work. Finally, Section 8 draws the concluding remarks.

2. RELATED WORK

Zhang and Lai (2011) noted that there is a lot of research suggesting guidelines in the area of web adaptation for visual consumption on mobile handheld devices; however, there is little research in the area of web adaptation for aural consumption in mobile handheld devices. Yang, Ferati, Liu, Ghahari, and Bolchini (2012) explored aural browsing while on the go as means for navigating backward through previously viewed web pages on content-rich sites. With respect to this work, aural flows represent a way to minimize the visual interaction with the device screen. There are a number of studies focused on auralizing navigation architectures in different contexts, as well as research communities that are relevant to this study of ANFORA News. In the literature review that follows, we explore three related areas of study: aural navigation in other domains, the benefits of automated browsing, and opportunities for innovation in the news industry.

2.1. The Value of Aurally Navigated User Interfaces

A number of studies emphasize using audio interfaces over visual interfaces, as well as some of the reasons audio interfaces may be preferred. Recent studies show that audio interfaces

in the car are less distracting compared to traditional visual interfaces (Brumby et al., 2011). Users, however, select the modality according to their performance objectives. Li introduced the blindSight prototype, which helps users access calendars or contact lists through audio feedback so they don't have to look at a screen (Li, Baudisch, & Hinckley, 2008). This study shows how audio interfaces could allow users to quickly access and interact with a system while the user is engaged in another primary task. Zhao, Dragicevic, Chignell, Balakrishnan, and Baudisch (2007) also discussed five reasons visual feedback might not be feasible: "competition for visual attention, absence of a visual display, user disability, inconvenience, and reduction of battery life."

Likewise, a number of domains make use of audio navigation strategies, including audio museum navigation guides, audiobooks, audio wikis and eyes-free news navigation tools. Audio museum navigation guides allow users to carry a personal digital assistant in a museum to listen to information related to artwork. The structure of the audio information provided to the user is linear. Some of the examples of audio museum navigation guides include Ec(h)o (Wakkary & Hatala, 2007) and Multimedia Museum Guide (Zancanaro, Stock, & Alfaro, 2003), both of which allow the user to pause, fast forward, rewind, or stop the presentation by tapping on the personal digital assistant display.

Digital talking books are another form of text-based content that can be aurally navigated. The digital talking book gives access to the full text, and users can interact with it using keyboard (Morley, 1998). Likewise, the Mobile Rich Book Player prototype is a type of digital talking book that uses the Windows Mobile platform. Vast amounts of information cannot be displayed at once because the screen size is too small. To overcome this drawback, developers implemented tabs and different pages that can be navigated using the minimal set of physical buttons provided on most mobile devices (Duarte & Carriço, 2009). And Jain and Gupta (2007) presented a system called VoxBox, which generates automatic interactive talking books. This system converts digital books to audiobooks and makes them accessible to blind users using voice commands for navigation. For example, most recent services, such as audible.com, also offer audiobooks through an iPhone application, and users can download the audiobooks to listen to them on the go (audible.com).

Audiobooks follow linear architectures (table of contents, chapters, subchapters, sections, etc.), whereas existing web applications tend to be nonlinear. For example, on a news site, users can select from lists of topical categories (Local News, National News, Business, Sports, Entertainment, etc.), lists of stories within a category (via headline-based hyperlinks), related comments, multimedia content, and other related stories. None of the aforementioned studies addressed auralizing complex nonlinear structures like those found on news sites.

2.2. Other Applications of the Automated Browsing Concept

Automating repetitive browsing tasks (such as checking e-mail and paying bills) can reduce user interaction with an application. Some of the transactions might need the user's interaction and feedback, whereas others will happen automatically (Borodin, 2008). Because ANFORA is based on the notion that aural flow allows the user to automate browsing tasks, it is worth acknowledging some similar technologies that exist to implement automated browsing. For example, WebVCR allows users to record and replay their browsing steps (filling out a series of forms to access data in travel websites) in smart bookmarks as shortcuts to web content. This feature exists so users do not have to manually repeat all the steps to retrieve the web content each time they interact with the application. Pages involved in these browsing steps are hard to reach, so they are good candidates for this shortcut strategy (Anupam, Freire, Kumar, & Lieuwen, 2000). Similarly, Chickenfoot is a Mozilla Firefox extension, which allows users to automate and customize their web experiences without changing the source code. Chickenfoot provides a programming environment on the sidebar of a web browser, and users can write the scripts to manipulate and automate web pages. This automation helps reduce tedious repetition of tasks (Bolin, Webber, Rha, Wilson, & Miller, 2005).

These efforts show how linear tasks in website architectures can be automated to reduce continuous user interaction and repetition. Moreover, automated browsing applications allow users to record and replay browsing tasks later. However, automating nonlinear tasks in complex and nonlinear architectures (such as searching for particular information to read) is not addressed. Complex architectures are very common, and they are represented in the majority of existing web applications. Our research automates complex information architectures and allows users to select how they listen to the automated aural presentation of information to reduce the user interaction and distraction.

2.3. Mobile Browsing and Opportunities for Innovation in the News Industry

Innovations like ANFORA News are also important to a news industry in the midst of dramatic transition as it struggles to keep up with the rapidly evolving media landscape. A recent study shows that 24% of mobile news consumers said they use at least one app to access local news (Purcell et al., 2011). Because of these technological advances, 65% of American news consumers report it is easier today than 5 years ago to keep up with local news and information. Fifty-one percent of them use six or more different sources or platforms each month for accessing local news and information (Purcell et al., 2011).

"Media multitasking"—the use of TV, the web, radio, telephone, print, or any other media in conjunction with another (Papper, Holmes, Popovich, Biner, & Messineo, 2006)—has been intensified by the increase in platforms on which news can

be accessed. Multitasking occurs more frequently as the news consumption experience transitions to on-the-go when users leave the house and turn to mobile devices for content. A few of the most common media multitasking activities include listening to radio news while walking or jogging, watching video while waiting for the bus or in-between classes, and browsing the Internet while listening to podcasts.

At the same time, multitasking is accompanied by increased cognitive load, creating a more complex consumption experience for news audiences. Studies have found that traditional news home pages match the needs of the heaviest news consumers far better than those of light users (Lynch, Vahlberg, Oh, & Yun, 2009). Unfortunately, these strategies do not well lend themselves to the on-the-go nature of engaging with news on mobile devices. In fact, reading on a mobile device has been largely characterized as an exercise in information snacking, as readers tend to engage with content during the in-between moments of their lives. This creates an unmet need and an opportunity for news organizations to develop new products targeted specifically to the needs of mobile audiences. To date, there is no evidence that the news industry has attempted to move to the aural web in its digital offerings. However, users can and do apply TTS applications to existing news websites, such as FlameReader and Odiogo. Likewise, there has been no research on how applications like ANFORA News could affect news consumption. Thus, ANFORA News represents a potential paradigm shift in an industry that is struggling to reinvent itself and more effectively reach audiences.

3. ANFORA—AURAL NAVIGATION FLOWS ON RICH ARCHITECTURES

ANFORA is a conceptual framework built on top of existing content-rich information architectures (Ghahari & Bolchini, 2011) that provides a way to remodel existing websites into a set of aural flows to be listened to. An aural flow is a design-driven sequence of content pages that are concatenated with self-activating links; thus, an aural flow can be listened to with minimal interaction required. ANFORA provides a vocabulary and simple set of design principles to define flows of aural content on top of existing web navigation structures. Such vocabulary is extended from the tradition of hypermedia design models (Bolchini & Paolini, 2006), which aim at describing information and navigation structures at the conceptual level independently by the implementation mechanisms.

ANFORA could be applied to websites in a number of domains, such as museum sites, travel and tourism sites, and news sites, to name a few. By making use of an aural navigation system, ANFORA presents a number of design alternatives that have the potential to enhance quick scanning through content-rich pages when time, contextual, and physical constraints are at play.

ANFORA allows users to first choose content from only those categories of news in which they are most interested.

Then, users can choose how in-depth they want to delve into those categories based on how much time they have. Finally, ANFORA transforms text on information-rich web pages into a TTS presentation that users can listen to instead of read. These strategies are an evolution of the guided tour concept, which is a common pattern in media modeling. In guided tour navigation, users are "led around" by the application (e.g., selecting "next" or "previous" commands), according to the appropriate sequences of content conceived by the designers (Paolini, Garzotto, Bolchini, & Valenti, 1999). Through ANFORA, we investigate new ways different types of aural flow can be effectively applied to conventional web information architectures. In an effort to further describe the ANFORA experience, we have identified two main types of aural flow that are used to describe the interaction patterns outlined next.

3.1. "Full Flow" for Prolonged Aural Experiences

"Full Flow" is the concatenation of some or all of the categories of content (e.g., U.S. News, Local News, World News, etc.). This allows the user to experience the full set of main content that is available (Figure 2a). The length of the flow is determined by the number of items (e.g., news stories) in each group and by the number of groups. One advantage of Full Flow is that it caters to situations in which users have relatively long periods to listen to content while on the go. Some of the disadvantages, however, are that users might not perceive changes from one category to another and may have difficulty building mental models of the content structure being played. Moreover, some content types can get rather lengthy, and in these situations the computer-generated voice may cause users to lose interest or become bored.

3.2. Short Aural Explorations with "Group Flow"

"Group Flow" provides users with aural access to a selected category of content (e.g., U.S. News) and plays all the individual items (e.g., news stories) within the selected group (Figure 2b). The flow stops as all the items in the category have been read, and the user is led back to the home page. Some obvious advantages are that users can decide from the outset which category of content they would like to listen to, and they have this choice every time a category ends. They can also avoid categories of content in which they are not interested. A favorite group flow can also be "bookmarked." A disadvantage, however, is that users need to interact with the interface every time to select a new category.
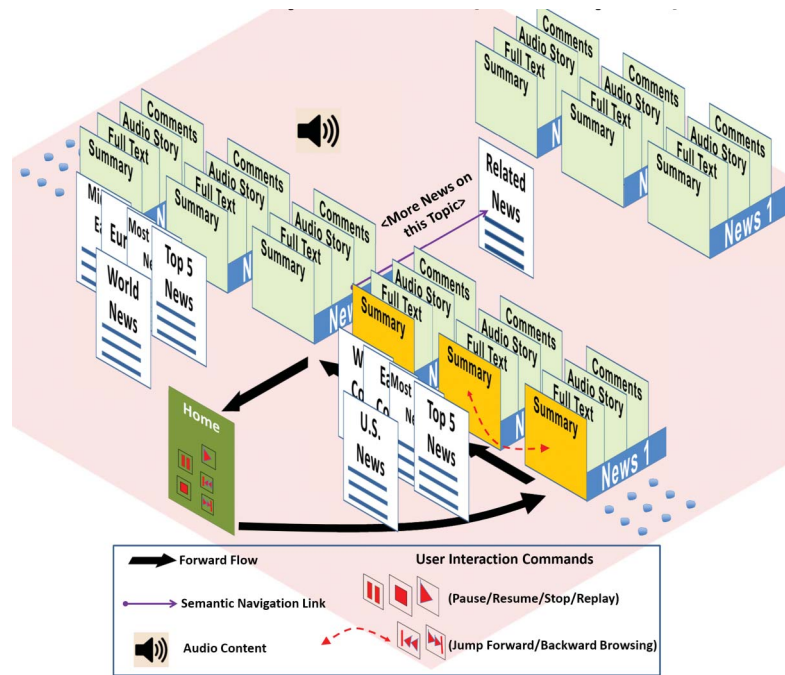
4. REIFYING ANFORA IN THE NEWS DOMAIN: ANFORA NEWS

To reify the ANFORA concept, we have applied it to the news domain because traditional news sites require active navigation and constant visual engagement.
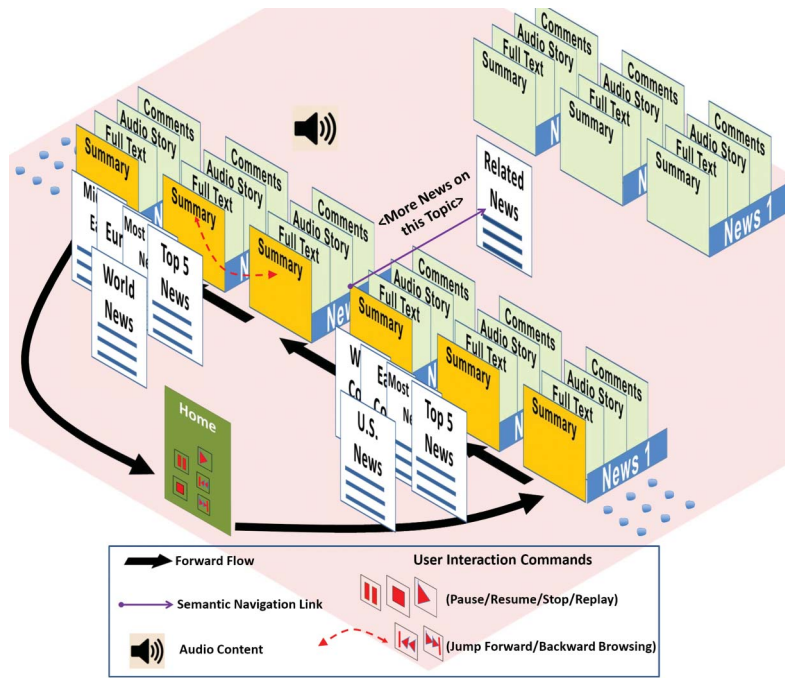
FIG. 2. Aural flows in a typical web architecture: (a) Full Flow through all categories; (b) Group Flow through one category at a time (color figure available online).

4.1. The Four Different News Consumption Experiences of ANFORA News

To give ANFORA News listeners a number of listening options that are based on how much time they have and how in-depth they want to "read" into a story, ANFORA News offers several different kinds of listening experiences, each based on the length of a story (Table 1). This design strategy is based on a number of well-defined news consumption experiences: scanning, sampling, and comprehensive reading/listening modeled in "Eyetracking the News," a widely cited study on print and online news consumption conducted by the Poynter Institute for Media Studies (Quinn, Stark, Edmonds, Moos, & Van Wagener, 2007).

Scanning is defined as the quick perusal of headlines, other display type, hyperlinks, and visual elements. Scanning readers rarely read full-text versions of stories, opting instead for a cursory glance at the news through top-level headlines and links.

Sampling occurs when news consumers go one step further than scanning by also engaging with brief summaries (one to five sentences) of text-based stories. If summaries aren't available, samplers sometimes read the first one or two paragraphs of a story but rarely go further.

Comprehensive reading/listening occurs when news consumers read full stories. Comprehensive readers/listeners tend to engage with news products (i.e., newspapers, magazines, and websites) more entirely than scanners and samplers.

Supplemental reading/listening is a fourth category that has been added to identify an interaction pattern that is more specific to the web information architecture that includes hyperlinks and the ability to comment on web content. Supplemental reading/listening occurs when news consumers choose read deeper into a topic with which they have acquired an interest. To do so, they may click on hyperlinks to related stories. They may also choose to comment on a story they have read as a means for interaction with the news source and/or other readers.

4.2. ANFORA News User Profiles

ANFORA News targets a broad audience of news consumers characterized largely by individual differences in news consumption habits. As previously mentioned, some news consumers are more likely to scan and sample stories of interest. Others tend to immerse completely, spending more time reading a wider range of news stories from several categories. Some news consumers engage in both types of activities, depending on how much time they have to devote to the news at any one time. Thus, we envision that ANFORA News users can be broken down into three key categories: the "light" user, the "heavy" user, and the "combination" user. These titles are based on the premise that different users exhibit varying levels of information motivation, technical savvy, and expectations regarding the time commitment related to news consumption at a given time. "Light" users most often choose to scan headlines or sample story summaries rather than listen to full stories. They do so because they are motivated by both time constraints and a less intense desire to spend time listening to news. "Major" news stories—regardless of category—are generally of interest. These may include stories on the death of Osama bin Laden; presidential elections; or breaking news stories like the tornadoes in Joplin, Missouri, to name a few. Light users are also often motivated to engage with only the stories in which they are personally interested. Heavy users are generally more likely to regularly spend more time with news than light users. They are more likely to listen to stories on a variety of topics, regardless of personal interest, and are more willing to listen to full stories than light users. Finally, combination users may exhibit behaviors common of both light and heavy users based on how much time they have and/or how motivated they are at a given time to engage with the news.

TABLE 1
Aural Flow Navigation Patterns

Flow	Advantages	Disadvantages	Listening Experiences			
			Scanning	Sampling	Comprehensive Reading/Listening	Supplemental Reading/Listening
Group	Decide the category from the outset	Interact every time to select a different category	Headline	Headline + Summary	Headline + Full Story	Headline + Full Story + Related story + Readers' Comments
Full	Less interaction	Difficulty in building mental model				

These user profiles were used to inform the design of the ANFORA News user experience. By providing users with a number of levels of listening—scan headlines, sample news stories, listen to full stories, and supplement with related headlines and/or reader comments—ANFORA News allows them to listen to the news in whatever format fits their current time constraints, interests in the day's news, and desired levels of detail when it comes to story length.

5. THE ANFORA NEWS PROTOTYPE

The ANFORA News design capitalizes on common news consumption habits by allowing users to choose which level of listening (i.e., scanning, sampling, comprehensive listening, supplemental listening) in which they wish to engage (Figure 3). Thus, we have designed a mobile version of this audio-based news website that looks like an application and implements different aural flow types in one prototype.[1] After users access the website, an introductory page is displayed for few seconds before they are redirected to the home page, where they can decide how deeply they want to listen to the news. Users can select "scan headlines," "sample story summaries," or "listen to full stories." They can also add "related stories" or "readers' comments." Next, users are redirected to a page where they can select the main categories of news; then subcategories are decided based on main category choices. Once all of these choices are made, the news is automatically read via TTS. Users can also follow along if they wish by looking at the screen.

ANFORA News is designed to minimize visual and physical interaction with the screen using self-activating links that concatenate pages in the flow (Figure 3). However, if they want to, users can interact by using either tap button commands and/or touch-based gesture commands. These commands allow users to *pause, resume, replay,* and *stop* the flow. Commands also allow users to *fast forward* to go to the next segment of a single news story (related stories or readers' comments) or *fast backward* to go to the previous segment of a single news story. Finally, users can skip to the next news story or go back to the previous one at any time using *Jump forward/backward* commands. Figure 4 shows the gesture commands that correspond with these interaction patterns. Figure 5 shows the appearance of the button commands.

Consider, for example, a scenario in which a user decides to listen to ANFORA News during his 30-min walk to work (as shown in Figure 6). He chooses to listen to the summaries for the Top 5 and Most Recent stories in the World News category as well as the Most Recent story summaries in the National News category and Indiana stories in the Local News category. Between stories and categories, the user hears sound effects (earcons) to indicate when a new story or category begins. Earcons are "non-verbal audio messages that are used in computer/user interface to provide information to the user

about some computer object, operation or interaction" (Blattner, Sumikawa, & Greenberg, 1989, p. 13; Lucas, 1994). In this scenario, the user employs gesture commands to skip to the next story summary or replay a summary.

5.1. Content, Styles, and Formats

The ANFORA News prototype contains news stories pulled from the National Public Radio (NPR) news website (www.npr.com). NPR was chosen for its comprehensive coverage of U.S. and World News as well as its regional focus on several local markets, including the market in which this study was conducted. Some of the stories used for the ANFORA News prototype were downloaded audio files from NPR programs. Others were text-based stories converted to TTS. ANFORA News could allow news organizations to offer a mix of broadcast quality reports along with TTS news stories.

News stories were divided into three main categories: Local, National, or World. Stories that would remain interesting to a general audience for several months were chosen so that the prototype wouldn't have to be updated every day with new stories. Stories were then assigned to four subcategories within each main news category (e.g., Top 5 Stories, Most Recent Stories, etc.). The number of stories in each main category varied, just as it would on a news website. Some stories could fall into multiple news categories or subcategories. ANFORA News stories are tagged in such a way that when such redundancies occur, they appear in only one group/category, namely, the first one encountered according to the order of groups and categories selected by the user.

5.2. Design Challenges for the Aural Experience

Blending together two distinct modalities like TTS technology and news is not without challenges. In fact, there are a number of characteristics rather unique to the way news organizations operate and present content that pose notable roadblocks to the implementation of ANFORA News. These challenges are certainly not insurmountable. However, they are worth noting here, along with some of the ways in which the current iteration of ANFORA News responds to them.

A few key issues rose to the surface early in ANFORA development: time, orientation, and TTS voice quality. Time refers to the time it takes users to complete a full news listening experience. Of course, different users will intend to spend varying amounts of time with the ANFORA News application, depending on the time of day and how much time they have. Therefore, ANFORA News was designed to accommodate a number of different interaction lengths, from 5 to 10 min up to 45 to 60 min. Because ANFORA News was built with a number of time and engagement options, users can quickly become disoriented when they are engaging with multiple news stories from several different groups of news (e.g., Local News, National News, or World News). Thus, a number of strategies for maintaining user orientation were designed.

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[1]The ANFORA News prototype is available at http://discern.uits.iu.edu:8670/ANFORA/. Full Source code and database are available at http://discern.uits.iu.edu:8670/downloads/ANFORA(Feb15_2012).zip

Selecting the Flow (Sample stories, Indiana Local News)

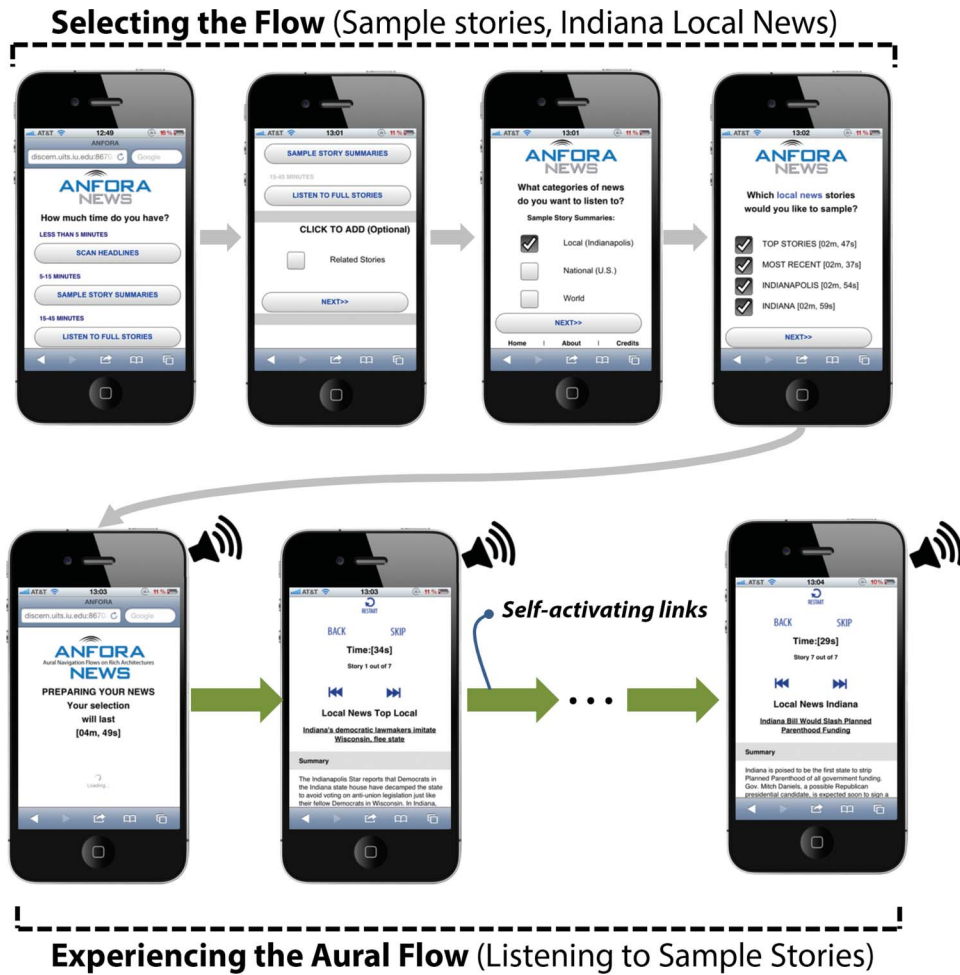**Experiencing the Aural Flow** (Listening to Sample Stories)

FIG. 3. ANFORA lets users choose how much time they want to spend with the application; then a custom aural flow of news stories starts (color figure available online).

| Pause/Resume | Fast Backward Browsing | Fast Forward Browsing | Jump Backward Browsing | Jump Forward Browsing |
| One Finger Single Tap | One Finger Flick Right | One Finger Flick Left | Two Finger Flick Right | Two Finger Flick Left |

FIG. 4. Applicable touch-based gesture commands can be used at any time during the flow experience.

| Restart | Fast Backward Browsing | Fast Forward Browsing | Jump Backward Browsing | Jump Forward Browsing |

FIG. 5. Button commands can be used at any time during the flow experience (color figure available online).

Ensuring User Awareness of Time Commitment

News stories vary in length, depending on the importance of a story and the amount of space and resources available for its coverage. For example online, many news organizations repurpose stories originally written for print—a medium that is very space dependent. Likewise, significant stories are often given greater depth and length than stories deemed less newsworthy. This concept is significant for a TTS application because it results in variation in the time it takes each story to play. Because ANFORA News is used primarily when news consumers are engaged in other tasks and because news consumption itself has been defined as a "snacking" activity when
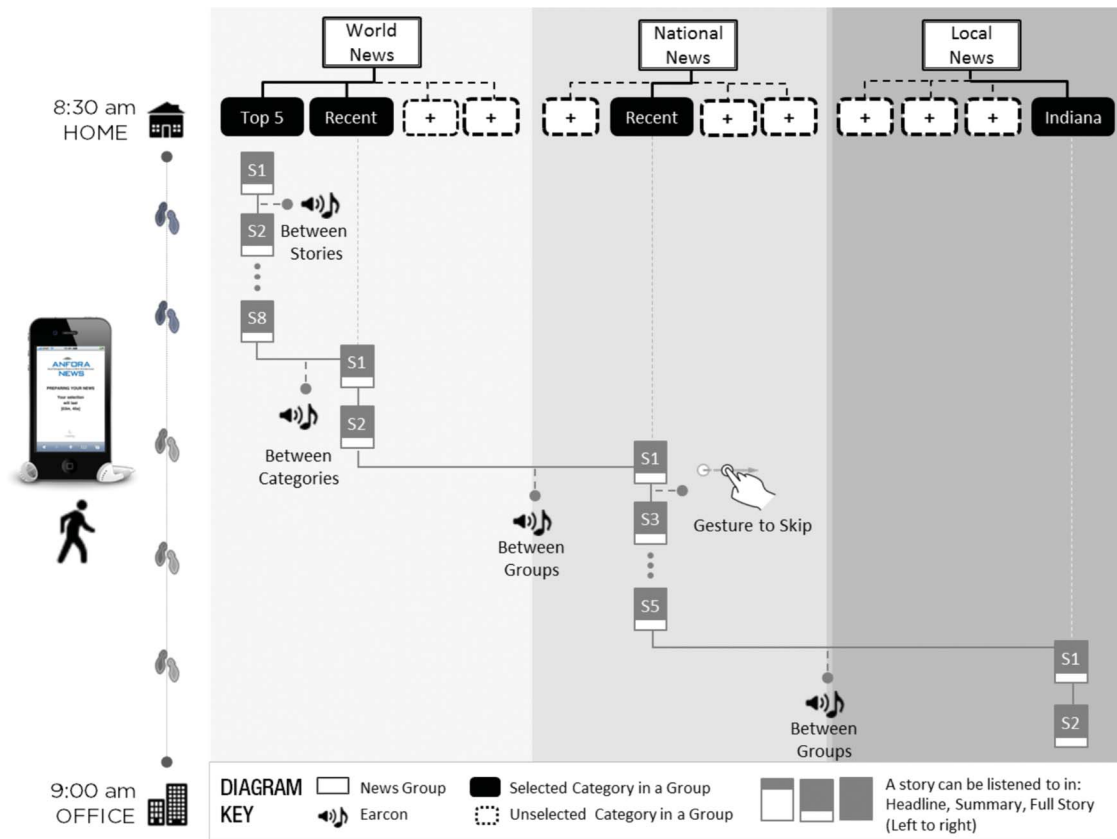
FIG. 6. Visualization of ANFORA News experience scenario (color figure available online).

executed on a mobile device, it is imperative that users are always aware of how much time they are investing in ANFORA News.

ANFORA News employs a couple of key strategies to address the issue of time. First, each news subcategory (e.g., within the local news group, users may choose to listen to Top Stories, Most Recent news stories, or stories focused on "Indiana" or "Indianapolis") is labeled with the amount of time it will take to listen to it in its entirety. Second, each news story is displayed on the device screen as it is being read and users can scroll through it to see how long it is. Third, each story segment (i.e., summary, full story, related stories, reader comments) is labeled with its length in minutes and seconds. Finally, as each segment plays, a label indicates how much is left to play. Together, these strategies ensure that the users are always aware of how much time their choices will take and how much longer a particular listening experience will last.

Ensuring User Orientation

ANFORA News can provide news headlines, summaries, full stories of varying lengths, reader comments, and related summaries in a TTS format. Users may also choose to listen to several stories from a number of different categories of news (i.e., Local, National, World, etc.). As ANFORA News transitions from a story in one category to another story in the

same category, it is necessary to include clear labeling to ensure that users can quickly assess which category of news they are listening to at any point in time. Finally, because users' attention is often divided between ANFORA News and other tasks (such as cooking, walking, or jogging), it is easy for users to quickly become disoriented. For this reason, it is important that users can easily reorient.

There are two different levels of orientation as shown in Figure 7. *Flow-level orientation* gives users an indication of how many news stories they have listened to or how many news stories are left to listen to across the whole flow. For example, in the ANFORA News, you might be listening to the first of 12 news stories across Top Local News, Most Recent Local News, and Indianapolis News. This enables users to plan ahead and gives them a sense of how long the whole experience will be. *Group-level orientation* gives users an indication of how many news stories exist in each category. For example, you might be listening to the first of five news stories in the Top Local News category and then you might be listening to the second of four news stories in the Most Recent Local News category. In this case, users do not know how long the whole experience will take, and they cannot plan ahead.

The challenge that exists for designers relates to which of these experiences—flow-level or group-level orientation—to
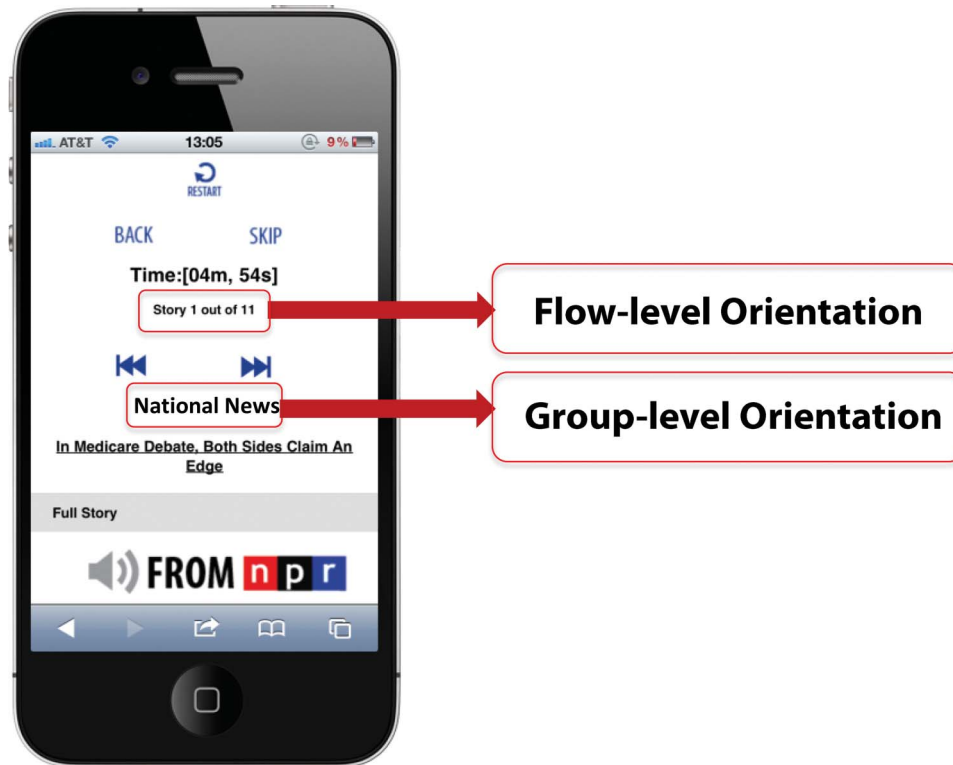
FIG. 7.   We combine group- and flow-level orientation by allowing users to *see and hear* which category of news they are listening to and *hear* which story they are listening to (color figure available online).

offer. If designers show orientation at both levels, there will likely be too much information for users to process aurally, increasing cognitive load. For example, imagine you are listening to the first of 12 news stories in a flow made up of more than one category. For example, the first five stories might be Top Local News stories, the next four stories might be under the Most Recent Local News category, and the remaining three might be from the Indianapolis News category. In a strictly visual interface, such as common or popular news website, it is easy to illustrate these categorizations while still allowing the user to view all 12 stories in a row. These divisions can be distinguished through the use of navigation labels, hierarchical menus, and other visual cues. However, these strategies are not available in the aural experience. Users would have to listen to a large amount of orientation information (e.g., "reading story one of 12 total stories; story one of five in the Top Local News category"), which would disrupt the flow experience. Listening to large chunks of sequential information can be improved by having sounds that mark the breaks or movements between one story and the next, one category and the next. To achieve this goal, we decided that it is more important for the user to know how many stories (12) make up the complete listening experience, so we opted for flow-level orientation to give the user a sense of overall flow. At any point during the flow, however, a user could glance at the screen to see a label that tells to which category of news (Top Local, Most Recent, Indianapolis, etc.)

the story they are listening to belongs. This strategy enables the user to regain the sense of group-level orientation.

Thus, although the primary function of ANFORA News is to provide a hand- and eyes-free TTS news experience, a visual interface exists to ensure that users clearly understand their time commitments and orientation at any given moment.

6. EVALUATION STUDY

This exploratory study commenced with four aims in mind:

1. To explore how well initial ANFORA News designs support an eyes-free browsing experience.
2. To learn how well ANFORA can coexist with the physical and cognitive tasks inherent to the mobile experience (e.g., physical = walking = paying attention to surroundings).
3. To explore the ecological validity of the ANFORA concept by testing usability, enjoyment and information value of the aural flow types, and the semiaural experience.
4. To explore the strengths and weaknesses of ANFORA in regard to the user experience of listening to news.

6.1. Study Design
Physical Setup

The evaluation study was conducted in a controlled environment that consisted of a predetermined path that users had to

walk while listening to ANFORA News. The path was established through the hallways in a highly populated building and included six sharp turns to simulate a real-world scenario in which people are required to avoid other people or objects in their way. Users' interaction with ANFORA News was video recorded to capture walking behavior along the path. Participants were encouraged to walk on the path as naturally as possible and listen to ANFORA News.

Participants

Twenty participants (ten male and ten female; all graduate students at a large Midwestern university) were recruited for this study. All participants spoke English fluently and had no hearing or walking impairments. Participants were all daily users of a touchscreen mobile phone and regular news consumers. Participants received a $15 Amazon gift certificate for approximately 60 min of participation.

Procedure and Tasks

Five tasks were identified to ensure that participants would engage all of the interaction patterns available in the ANFORA News prototype. Because each task yielded a listening experience that ranged from 3 to 15 min, the tasks were divided into two groups. This division of participants ensured that each research session would last no more than 1 hr to minimize participants' fatigue. Group one contained three tasks and group two contained two tasks. Participants were assigned to one of two task groups. Although the tasks were slightly different, depending on which type of listening interaction pattern (i.e., scanning, sampling, or comprehensive listening) users were asked to perform, the nature of the tasks was the same. Thus, although the stories users made different initial selections, their general experience was the same. Once a listening session began, the only difference was in the length and subject matter of stories. Thus, we can consider the two groups a single sample consisting of 20 participants because the aspects of the interaction and listening experience central to this study were the same. Prior to commencing the study, participants were given a brief explanation of ANFORA News. Researchers gave each participant a short demo of the interface and allowed each to practice using it to get a feel for how ANFORA works. The first task group was asked to complete a series of three tasks focused on the *scanning, sampling*, and *comprehensive listening* interaction patterns. In the comprehensive listening task, participants also engaged in the *supplementing* interaction pattern by adding reader comments and related stories to the initial selection. The second task group was asked to complete two tasks focused on the *sampling* and *comprehensive listening* interaction patterns. Participants were told they were not required to interact with the screen after making an initial news playlist. However, they were also told that if they wanted to, they could use either/both control buttons on the screen and gesture commands to do so. The length of each task depended on the interaction pattern. Tasks ranged in length from 4 min (scan headlines) to 15 min

(listen to full stories) each, depending on the type of interaction patterns.

Researchers accompanied participants during the walking aural experience and video recorded their sessions. Three main observations were made during this portion of the study:

1. Researchers recorded whether participants completed each task with or without assistance, or whether they chose to stop the aural flow before the end of the flow. These data are referred to as the aural flow completion rate.
2. Researchers recorded and the number of errors that occurred during each task and then categorized those errors according to their main cause. These data are referred to as the percentage occurrence of error during total number of listening sessions.
3. Researchers recorded the amount of time users visually or physically engaged with the screen. These data are referred to as percentage of time spent engaged with the screen.

Participants were asked to report whether they became distracted by their surroundings and whether distractions prohibited them from paying attention to the news. Likewise, they were asked to report whether listening to the news or any interaction with ANFORA News interfered with their ability to effectively navigate their surroundings.

After completing the tasks, participants completed a brief 5-point Likert item survey immediately following their task sessions. Both task groups engaged in a Sample Story Summaries task, whereas Task Group 1 also engaged in a Scan Headlines and a Listen to Full Stories task. Thus, Task Group 1 responded to 16 questions, whereas Task Group 2 responded to 14 questions. After completing surveys, participants engaged in a 15-min interview with researchers. (See Appendix B for full task lists, surveys, and interview questions.)

6.2. Analysis

For the task performance data analysis, the aural flow completion rate, the rate occurrence for different types of errors during the tasks, and the amount of time users engaged with the screen during task performance were recorded. These measures help form an understanding of how easy or difficult it was for users to use the ANFORA News interface while walking and to what extent they engaged in an eyes-free aural news consumption experience. The surveys were used to measure ease of use, willingness to use ANFORA News again, quality of TTS, perceptions of orientation and opinions about the value of the specific levels of reading (i.e., scanning, sampling, listening in full, and supplementing) in which they engaged. Results for survey were averaged across participants across tasks. For the qualitative analysis of the posttest interviews, recurrent themes were extracted and comments were grouped by theme. The emerging issues highlight user satisfaction with the ANFORA News listening experience, reflection on levels of distraction encountered during the listening experience, and positive and negative opinions about the interface.

6.3. Results

Task Performance Data Analysis

Aural flow completion rate. Ninety percent of participants (18) completed the flow from start to finish with or without assistance (Figure 8). Only 10% of participants (two) stopped the flow early (one during Task 4 and one during Task 5). Tasks varied in length, depending on the reading level (i.e., scan headlines, sample story summaries, listen to full stories) and the number of stories in a particular selection. In cases in which the session was very long (sometimes as long as 60 min) due to a large number of long stories, participants were asked to stop after 15 min to reduce fatigue. Aural flow completion rate was defined by whether a user stopped the task before all stories in a selection were read or before 15 min expired.

Eighty percent of participants completed Task 1 without assistance. This percentage is greater than that for participants who completed the other tasks. Because Task 1 includes scanning headlines, the task is much shorter than other tasks. The longer the task, the more likely it was that users needed assistance due to technical errors (explained in the next section) and not the design or orientation. Also, users were more likely to become disinterested during longer browsing tasks that had them listening to full stories.

Percentage occurrence of error during total number of listening sessions. The frequency of errors compared occurrences to the total number of sessions ($n = 50$). Figure 9 shows different types of errors that occurred during the total number of task sessions ($n = 50$). These errors often caused participants

to engage with the screen either by looking at it or physically interacting with it through button or gesture commands. Overall, the reason that users engage with the screen can be summarized as "confused by long pauses," "encountered technical problems," "poor recall of gesture commands," "misunderstood button labeling," and "misunderstood TTS."

Confused by long pauses: Confusion caused by long pauses between stories occurred in 50% of the total sessions and was the most frequent type of error participants encountered. Although pauses between stories were designed to be about half a second, a slow network connection sometimes caused them to be as much as 3 s. These long pauses often caused participants to look at the screen because they thought something was wrong.

Encountered technical problem: Technical problems accounted for 36% of the occurrence of error over the total number of listening sessions. Sometimes, the application timed out due to network malfunctions. This often caused users to look at the screen in an attempt to determine why the flow had suddenly stopped.

Poor recall of gesture commands: Twenty-eight percent of error occurrences were due to poor recall of gesture commands. If the participant touched a button while trying to swipe, for example, the button would be triggered before the gesture had a chance to work. Participants also had trouble remembering the different gesture commands. Therefore, they sometimes incorrectly used one- or two-finger swipe commands.

Misunderstood button labeling: Ten percent of the error occurrences during the total number of listening sessions was
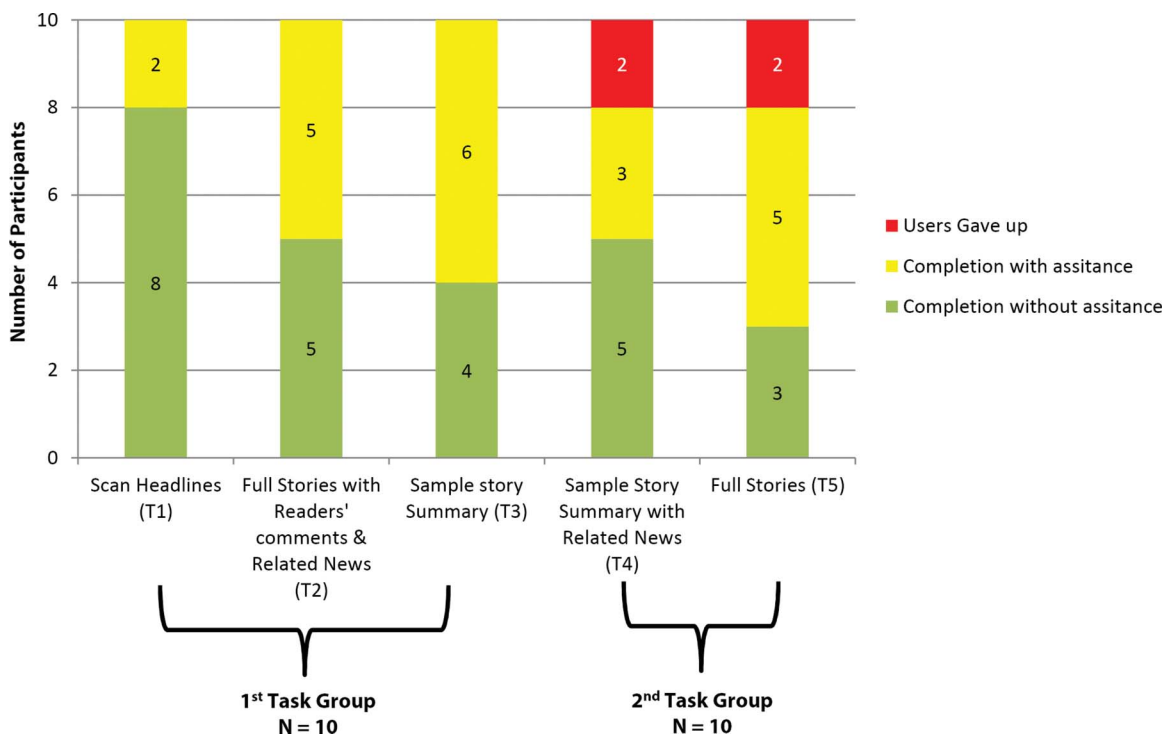

FIG. 8. Aural flow completion rate across all five tasks (color figure available online).
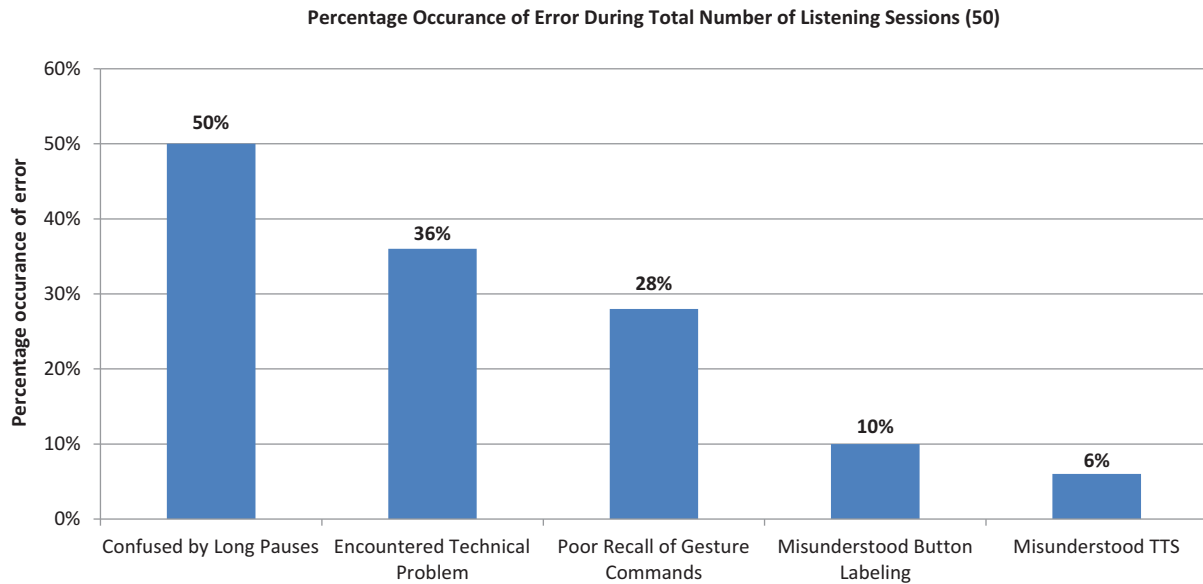
Percentage Occurance of Error During Total Number of Listening Sessions (50)

FIG. 9.   The frequency of errors compared occurrences to the total number of sessions ($n = 50$) (color figure available online).

caused when users didn't fully understand the function of a particular button. Although they understood that "next" and "back" would take them to next or previous stories, they did not always know what the double arrow/line button (jump forward/jump backward) meant.

Misunderstood TTS: Across all error occurrences, misunderstood TTS accounted for 6% of the errors encountered. Participants often looked at the screen when they had trouble understanding the TTS. Because the written stories appear on the screen as they are being read, users have the opportunity to clarify what they are hearing by visually following along with what they see on screen.

Percentage of time engaged in aural flow.   Overall, users spent more than two thirds of the time on task engaged in aural flow. The amount of time spent listening to news without engaging with the screen increased from Task 1 to Task 3 for the first group of participants and from Task 4 to Task 5 for the second group of participants (Figure 10).

Posttask survey.   The overall response to ANFORA News was positive. On average, users found ANFORA News to be easy to use (average response = 4/5), enjoyable (average response = 3.95/5), and easy to navigate (average response = 3.7/5). Most users also reported they would use ANFORA News again (average response = 3.85/5) and that the TTS voice was easy to understand (3.9/5). Figure 11 shows the average responses across all 20 participants to each of the 14 questions asked of all participants. As previously noted, although there were two groups that completed slightly different tasks, the nature of the tasks was the same, making the overall user experience the same among all 20 participants.

It is worth noting that for six survey items, the deviation from the mean dropped below 3. Responses to Items 5, 6, 11, 12,

13 and 14 were more widely distributed. Items 6 (The TTS voice was difficult to understand) and 11 (ANFORA News was easy to navigate) can be directly correlated with results of the error occurrences just summarized.

Finally, to detect relationships between questions, we examined the factorability of the 14 survey questions. Nine of 14 questions correlated with each other, suggesting reasonable factorability (Table 2). The Keiser-Meyer-Olkin test of sampling adequacy was .54, and Bartlett's test of sphericity was significant, $\chi^2(36) = 51.80$, $p < .05$. The Cronbach's alpha is .751.

Three factors were extracted (see Table 3 for the questions loading on each factor). The first factor is enjoyability of ANFORA News, which explained 34.71% of the total variation. The second factor is the content of ANFORA News, which explained 19.59% of total variation. The third factor measured is the navigation and structure (orientation) of ANFORA News, which explained 14.21% of total variation.

Posttask interviews.   Semistructured interviews, which included 15 questions, focused on three main themes: user satisfaction with the ANFORA News listening experience, reflection on levels of distraction encountered during the listening experience, and positive and negative opinions about the interface. We discuss these three themes in the remainder of this section.

User satisfaction with the ANFORA News listening experience.   Interviews confirmed users' general satisfaction with ANFORA news, as all 20 participants reported it was easy to use and convenient. Interviews allowed them to elaborate; they cited ease of use and convenience as the most appealing aspects of the application. In particular, six users said that liked that they have
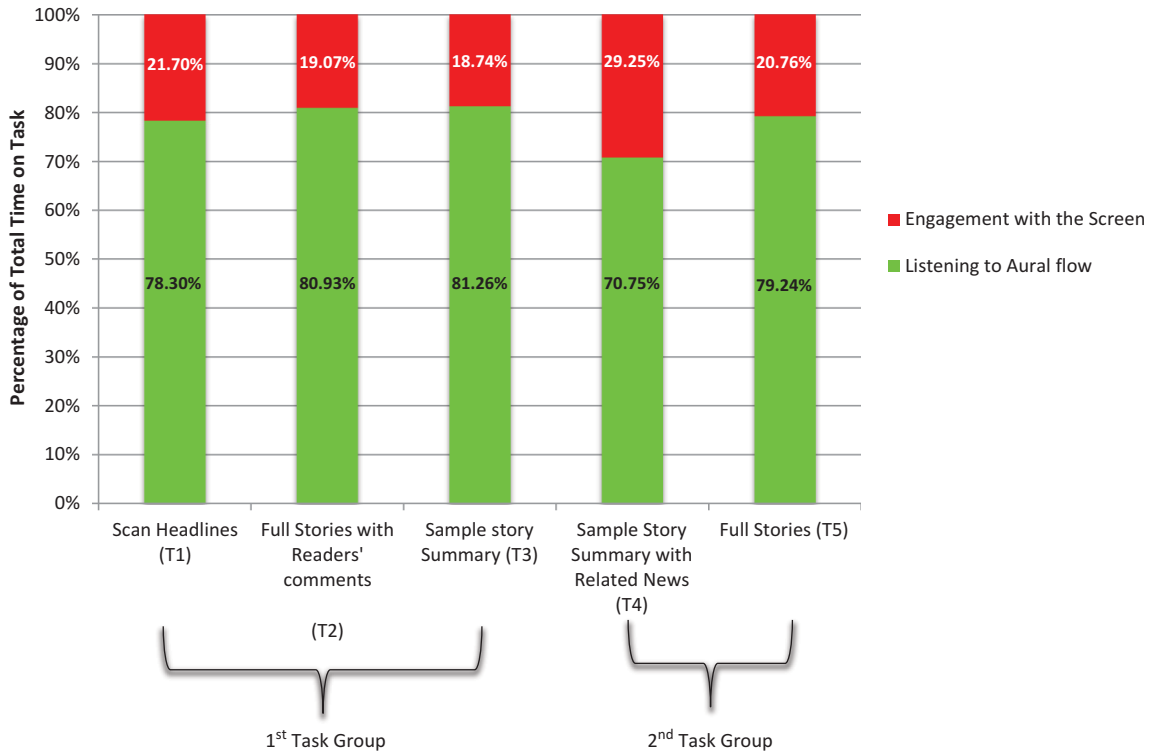
FIG. 10.   Aural flow accounted for two thirds of the overall listening experience (color figure available online).

to listen to only the categories of news in which they are interested. One likened the experience to only reading one section of a newspaper. Nineteen users reported they would use ANFORA News if it were available today and noted that there are other contexts (besides walking) in which they would find it useful, such as while cooking or driving. One user said, "It's quick and easy to use and you spend a lot of your time in motion, in commute to somewhere; you don't have a lot of time to sit still and focus on a reading, or news articles or news online." Five users also noted that ANFORA is a good alternative to other news consumption activities, such as listening to the radio or podcasts or surfing the web. For the most part, users were satisfied with the quality of TTS. Three even suggested that it should be faster in order to keep their attention. However, one user reported that TTS was not pleasing, and two said that at first the TTS voice was confusing and hard to understand.

Reflection on levels of distraction encountered during the listening experience. When participants were asked about whether they became distracted during their listening sessions, it became clear that distraction is a relative term when it comes to aurally navigating the web while engaged in another task. In fact, distraction seemed to be measured in two ends of a continuum. On one end, participants sometimes stopped carefully listening to the news in order to adequately monitor their surroundings. When they did, they often failed to fully process some of the content. On the other end, participants were sometimes so engrossed in a story that they lost a

sense of their surroundings. In these cases, listening still may be dangerous. One participant noted that situational awareness fluctuated between the news story he was listening to and his surroundings.

Positive and negative opinions about the interface. Participants were basically split when it came to preferences regarding button or gesture commands for interacting with the screen. Ten users preferred gesture commands, whereas eight preferred button commands. Among those who preferred gesture commands, the primary concern was efficiency. Several noted that gesture commands allow users to quickly skip to the next story without having to look at the screen. On the other hand, those who liked buttons better noted that buttons were more intuitive. Several participants said the buttons made more sense because they were easier to understand than gesture commands.

Although users were generally happy with the ANFORA News experience, there were a couple of key recommendations that surfaced repeatedly. Half of our users noted that they want even more choice when it comes to selecting news in which they are most interested. Ten participants specifically recommended that we give a list of headlines in each category so that users can choose individual stories for the playlist. Likewise, nine users reported they would like more content options, such as sports, business, technology, and entertainment. There were only two complaints that consistently surfaced about the ANFORA News interface. One
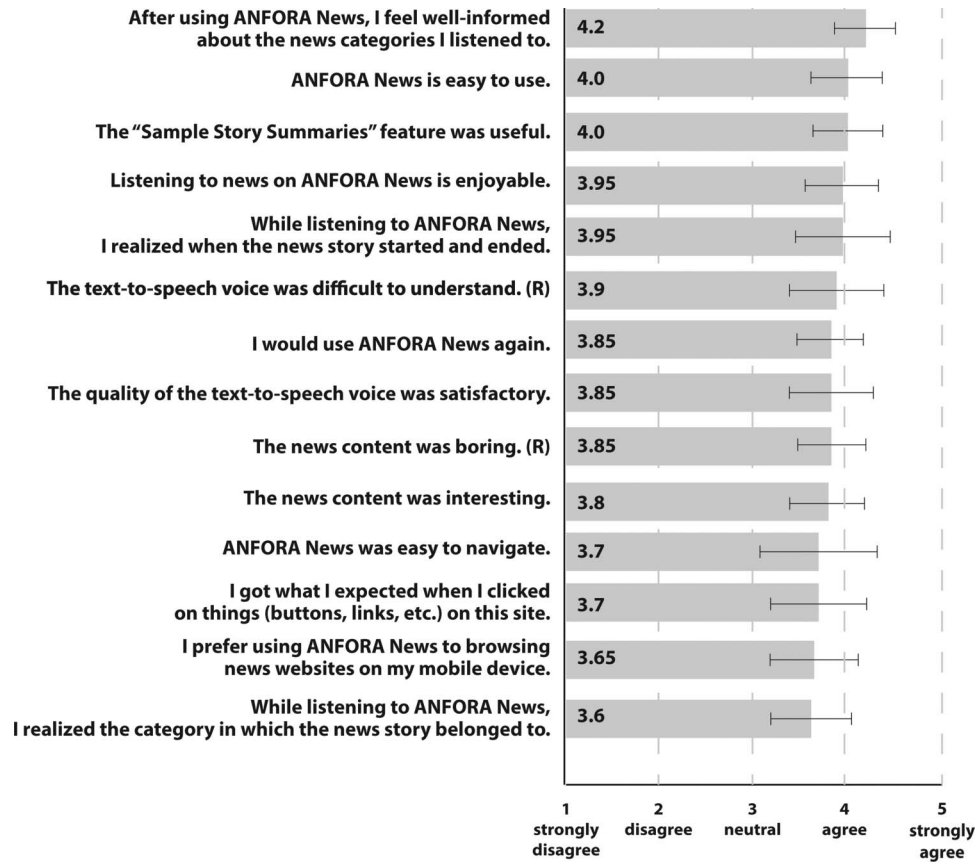
FIG. 11.   Average responses to survey questions ($N = 20$).

TABLE 2
Extracted Factors From Posttest Survey Questions

Factor	Questions
Factor 1. Enjoyability of ANFORA News	**Q11.** After using ANFORA News, I feel well-informed about the news categories I listened to. **Q3.** I would use ANFORA News again. **Q15.** The "Sample Story Summaries" feature was useful. **Q2.** Listening to news on ANFORA News is enjoyable.
Factor 2. Content of ANFORA News	**Q10.** The news content was boring. (R) **Q8.** The news content was interesting. **Q9.** The quality of the text-to-speech voice was satisfactory.
Factor 3. Navigation Structure and Orientation	**Q13.** While listening to ANFORA News, I realized the category in which the news story belonged to. **Q12.** While listening to ANFORA News, I realized when the news story started and ended.

related to button and gesture command functionality, and the other related to the length of pauses between news stories. Five users said button commands were confusing, and eight said gesture commands were confusing. Seven users said pauses between stories were too long, and several noted that long pauses between stories often caused participants to look at the screen because they thought something was wrong.

TABLE 3
Questions Loading for Each Factor

Rotated Component Matrix[a]

Questions	Component		
	1	2	3
Q11. After using ANFORA News, I feel well-informed about the news categories I listened to.	.783		
Q3. I would use ANFORA News again.	.769		
Q15. The "Sample Story Summaries" feature was useful.	.758		
Q2. Listening to news on ANFORA News is enjoyable.	.637		
Q10. The news content was boring. (R)		.879	
Q8. The news content was interesting.		.799	
Q9. The quality of the text-to-speech voice was satisfactory.		.768	
Q13. While listening to ANFORA News, I realized the category in which the news story belonged to.			.900
Q12. While listening to ANFORA News, I realized when the news story started and ended.			.827
Extraction Method: Principal Component Analysis.			
Rotation Method: Varimax with Kaiser Normalization.			

[a]Rotation converged in four iterations.

7. DISCUSSION AND FUTURE WORK

Through this study, we unearthed initial evidence that suggests that aural flows represent a promising paradigm to support eyes-free browsing of mobile devices while on the go. We acknowledge a number of limitations that still need to be addressed. For example, a few participants required initial assistance to make sense of the mechanics of ANFORA News. Also, because this was a preliminary study, the number of participants ($n = 20$) is relatively small, making it difficult to generalize the results. In spite of these limitations, however, this study provided some key insights into the benefits of using aural flows to minimize the amount of visual attention that is necessary for users who wish to browse content-rich websites while on the go. Specifically, this study helped us address our research aims in the following ways:

Regarding the first aim—to explore how well initial ANFORA News designs help support an eyes-free browsing experience—the fact that participants spent more than two thirds of the time on task engaged in aural flow suggests that ANFORA News achieves what it was designed to do: minimize visual interaction with the mobile device screen. Moreover, with an aural flow completion rate of 90%, it is clear that for these participants, ANFORA News was easy to use while on the go. These results also lead us to believe that there is promise regarding basis for the second aim, which was to explore how well ANFORA can coexist with the physical and cognitive tasks inherent to the mobile experience. Because ANFORA News minimizes the amount of time users must engage with the screen during a rich news consumption experience, users are better able

to monitor their surroundings while walking or engaged in other primary tasks. Unlike the experience of browsing news websites on a mobile device, ANFORA News promotes consumption of large amounts of information by listening to rather than looking at content.

ANFORA News also differs from other methods of listening to news, such as radio broadcasts and news podcasts, as shown in Figure 12. These differences are based on a few key principles, including flexibility of access and broader content selection at a high level of abstraction, a multimodal experience that provides different output and input modalities, and various levels of reading/listening (i.e., scan headlines, sample story summaries, listen to full stories, etc.). A radio news broadcast, on the other hand, is synchronous in that users tune in to a complete newscast edited linearly by a producer for a predetermined time slot and a mass audience. Thus, listening to a particular program that contains multiple news stories requires that users do so at a predetermined time for stories presented in a preedited format. The news podcast provides a more asynchronous experience by allowing users to download programs and listen to them wherever and whenever they want. However, these are the same programs edited by producers with a mass audience in mind. Thus, neither the radio newscast nor podcast can take into consideration any single individual's time constraints and/or personal interests. ANFORA News, however, lets users decide the length of time they will spend with the news and how in-depth they will delve into individual stories (i.e., scan headlines, sample story summaries, or listen to full stories) and then allows them to make choices about the categories of news
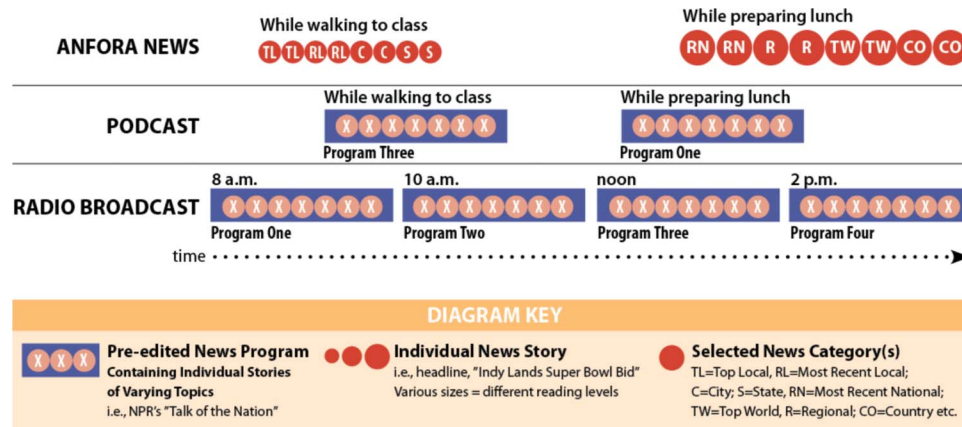
FIG. 12. Comparing ANFORA News to podcasts and radio broadcasts. Aural flows provide different reading levels and flexible access by content categories (color figure available online).

they listen to. Admittedly, the cost for this flexibility lies in the fact that users must initially take time to select the category of news and the amount of time they want to spend listening to news. However, by spending just a few minutes making initial selections, users can create an automated playlist, avoiding the need to visually engage with a complex news website to browse and read stories of interest one at a time. Most users spent about one minute making initial selections. Once those selections were made, subsequent visual interaction with the screen was minimal, as users spent the rest of the time listening to stories they selected. On the other hand, visual interaction with the mobile device is exponentially higher when a user must visually browse a news website and then reading stories while on the go. Thus, the cost of initial interaction is mitigated by the fact that all subsequent interaction is eyes free. Finally, like a podcast, ANFORA News offers an asynchronous experience by allowing users to listen whenever they want to a concatenated linear broadcast entirely based on their individual choices. In this sense, users become producers/editors by creating their own, personalized news listening experiences.

The fact that most users found ANFORA News to be easy to use and preferred it to browsing news websites on their mobile devices lends additional promise to the third aim: to explore the ecological validity of the ANFORA concept by testing usability, enjoyment, and information value of the aural flow types and the semiaural experience. This positive response was encouraging, and even the more critical users provided great feedback for how to improve ANFORA News for the future. This feedback helped address the forth research aim: to explore the strengths and weaknesses of ANFORA in regard to the user experience of listening to news. Results of both the posttask survey and the semiformal interviews yielded a few narrowly focused recommendations for improvement.

According to these recommendations, the next iteration of ANFORA News will include more categories of content (i.e., sports, business, entertainment, etc.), a list of headlines in each section that users can choose from for their master playlist, redesigned button and gesture commands that are more intuitive, and shorter pauses between stories. Thus, future research will focus on improving the modes of interaction through the addition of vocal commands for infrequent interaction as a means for navigating the flow. Results from a 2005 study of the use of vocal commands showed that participants evaluated the speech modality more satisfying, entertaining, and natural to use than using mobile keypad to interact with mobile (Lee & Lai, 2005). Because our participants were not fully satisfied with gesture and control commands, we will implement vocal commands to determine whether this control modality is preferred. We are currently exploring a logical vocabulary for that a vocal library, as well as planning additional user studies to inform that process.

An important evolution of ANFORA is also the seamless and automatic extraction of fresh content for existing websites. For example, we are working on building a software engine that connects to the NPR Application Program Interfaces to automatically extract daily news to populate the ANFORA News database. This would enable people to use ANFORA News as a stand-alone service.

7.1. Validity of the Study

Internal Validity

Several strategies were used to maximize internal validity. First, a consistent training (demo of the interface and practice using the interface) was conducted with participants before the experiment commenced so that participants could reach a common threshold of experience with ANFORA News. Second, to reduce fatigue, tasks were divided into two groups, and each participant walked for no more than 30 min. Based on our observations, it was clear that although the walking tasks were potentially tiresome, users were not overworked in these tasks. Third, only those who reported they are regular news consumers

were chosen to participate in the study. This was important because those who have little to no interest in news to begin with would likely not find ANFORA News to be relevant to their lives. At a minimum, participants must have a general interest in news and propensity to regularly browse news websites for their feedback about ANFORA News to be useful. Fourth, the survey and interview questionnaires were brief and questions provided information needed to accomplish the research aims.

External Validity

As previously noted, to maximize internal validity, two groups were established. We acknowledge, however, that this poses a threat to external validity (or the generalizability of these results) because the sample sizes are low. However, given that the nature of the tasks is the same as explained in section 6.1.3., we can view the total sample size as 20, which is a suitable sample size given the preliminary nature of this study.

As further indication of the ongoing work on ANFORA News, we filed the U.S. provisional patent application (No.: 61/699,748 on September 11, 2012) titled "aural navigation of information-rich visual interfaces." It is our hope that after additional research and revision ANFORA News will be ready for public use.

Additional limitations include the fact that, the study was conducted in the hallways of a busy academic building, not on a city street. This was due to inclement weather and a desire to avoid fatigue and discomfort for participants. And there may have been an experimenter effect on users' general opinions about ANFORA News, in that they may have been more inclined to respond favorably in order to please the researchers who conducted the experiment.

8. CONCLUSION

Through this preliminary exploratory study, we learned that aural flows can support eyes-free browsing. Although participants needed some support to initially make sense of new/novel framework, they were able to quickly grasp the ANFORA News concept and begin listening to news stories while walking with minimal interaction with the screen. Aural flows allowed them to engage with web-based news content without having to visually browse the screen. Likewise, participants reported that they generally enjoyed the experience and found the ANFORA News concept to be easy to use. Granted, this was not a comparative study with a controlled condition. However, when participants were asked to consider ANFORA News in relation to its alternative—visually navigating news websites while on the go—they reported that they believed ANFORA News would be safer and easier to use. These results provide initial evidence that aural flows supports an eyes-free browsing and can therefore mitigate the physical and cognitive tasks inherent to the mobile experience.

Admittedly, the ANFORA News needs additional improvement and development. Thus, our future work will include enhanced prototypes that address the less intuitive aspects of the existing ANFORA News design. Specifically, we will improve upon the selection and navigation controls and introduce voice commands to further minimize the amount of visual interaction required of users.

In addition, a future study will compare ANFORA News to an equivalent experience that involves traditional mobile browsing, which requires eyes on the screen. This will provide an opportunity to make a direct comparison between ANFORA News and other, more widely used, methods of browsing.

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APPENDIX A

Detailed Screenshots of ANFORA News Prototype

The ANFORA News prototype is available at http://discern.uits.iu.edu:8670/ANFORA/
Full Source code and database are available at http://discern.uits.iu.edu:8670/downloads/ANFORA(Feb15_2012).zip

Scan Headlines Scenario
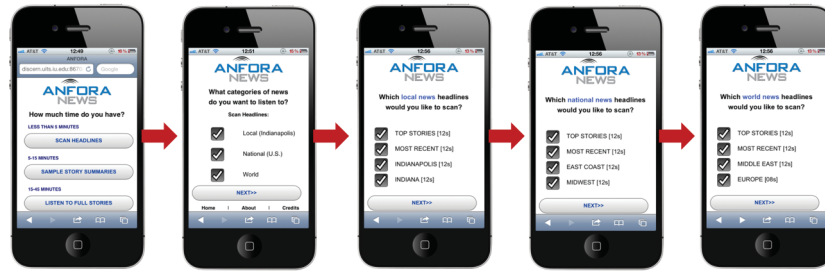
Selecting the Flow
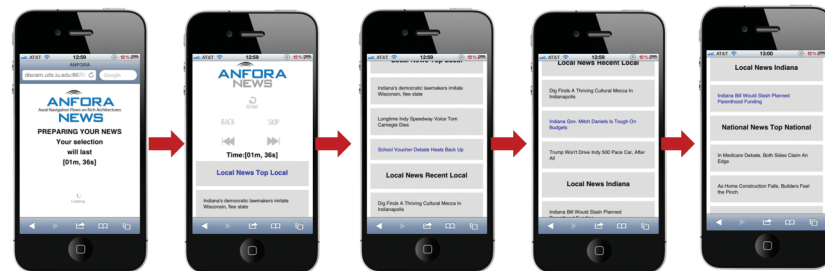
Experiencing the Flow (Listening to Headlines)

Sample Story Summary with Related News

Selecting the Flow

Experiencing the Flow (Listening to Sample Stories)

Listen to full stories with related stories and readers' comments
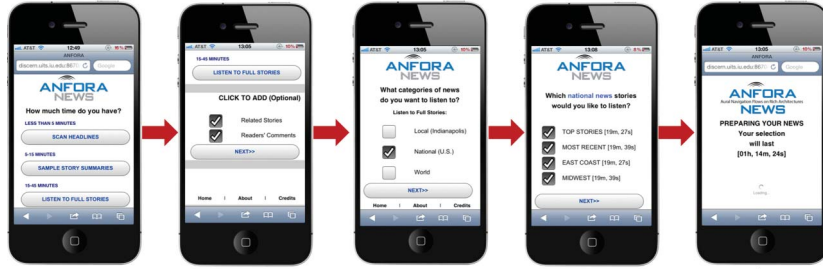
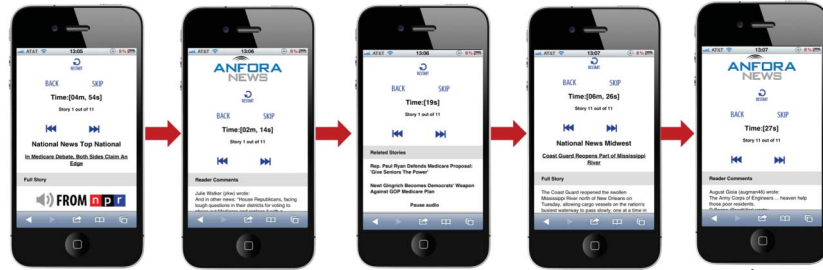Selecting the Flow

Experiencing the Flow (Listening to Full Stories)

Quick hits "Indiana in 15 min"

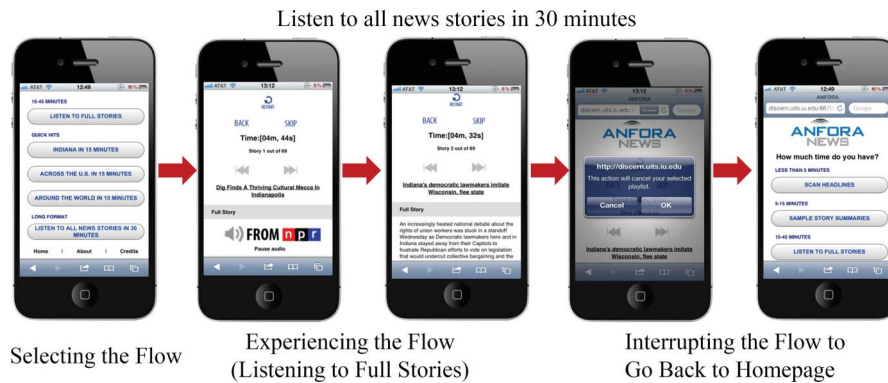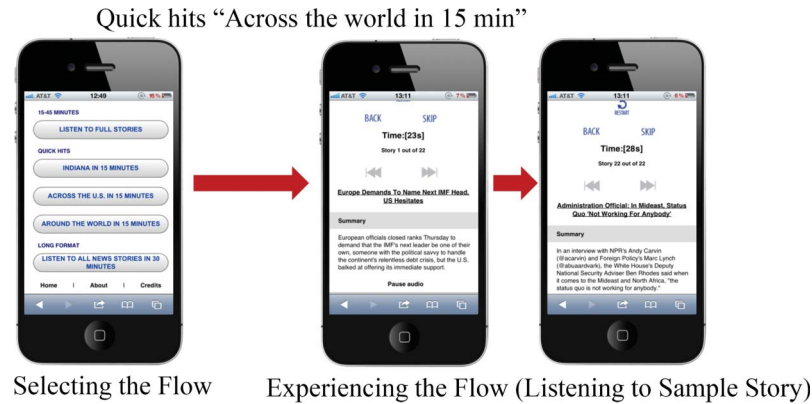Selecting the Flow   Experiencing the Flow (Listening to Sample Story)

Quick hits "Across the U.S. in 15 min"

Selecting the Flow   Experiencing the Flow (Listening to Sample Story)

Quick hits "Across the world in 15 min"

Selecting the Flow   Experiencing the Flow (Listening to Sample Story)

Listen to all news stories in 30 minutes

Selecting the Flow   Experiencing the Flow   Interrupting the Flow to
                            (Listening to Full Stories)   Go Back to Homepage

APPENDIX B

Evaluation Study Instruments and Scripts

Introductory Script

Thank you for agreeing to participate in our research project. For this project, we have developed a mobile news application called ANFORA News that will allow you to listen to news stories in the form of text-to-speech while on-the-go. ANFORA News is designed to allow you to customize your news experience, by first choosing the types of news stories you would like to listen to based on how much time you have.

Imagine that you want to browse a news website using your mobile phone. But you also must walk to work or class, which may make it difficult to visually browse a news site and read stories while you walk. ANFORA News allows you to select the categories of news you want to listen to before beginning your walk. Once your selections have been made, ANFORA News creates a playlist of those stories and allows you to listen to them, one after another, without further visual interaction with the screen. In other words, ANFORA News provides a customized, eye-free news listening experience.

In general, we aim to test ANFORA News' usability, collect your opinions regarding its strengths and weaknesses and determine whether you find the ANFORA News experience to be enjoyable. Therefore, you will be asked to complete up to three simple tasks focused on interaction with the ANFORA News interface while walking through a busy hallway. I will join you on your walk to observe your interactions with the interface, video record your session and help you if any technical problems should arise. During this experience, please let me know if you become distracted by your surroundings and/or obstacles encountered while walking. When we return to the lab, I will ask you a series of questions regarding your experience. The entire session should last about one hour.

You do not have to interact with the screen after making an initial news playlist. However, if you want to, there are both control buttons on the screen and gesture commands you can use to do so. The buttons should be self-explanatory. Gesture commands are as

follows: One-finger swipe left allows you to go to the next section within a story; one-finger swipe right allows you to go to the previous section within a news story; two-finger swipe left allows you to go to the next news story; and two-finger swipe right allows you to go to the previous news story. You can also scroll to the top of the page and use the button control commands if you like.

You can skip to the next story or stop the flow at any time. However, ANFORA News is designed to minimize interaction.

First Task Set

1. From the home screen, select "Scan Headlines." Then, select all three categories "local, national and world." For each category, select at least two sub-categories. ANFORA News is designed to minimize interaction and allow you to listen to a playlist of news stories on-the-go. However, you can skip to the next story or stop the flow any time you like by using gesture or control commands.

2. From the home screen, select "Listen to Full Stories" and add "Related Stories" and "Comments." Then, select one category, "local, national or world." Finally, select all four sub-categories. Remember that you can skip to the next story or stop the flow any time you like by using gesture or control commands. However, you are not required to interact with the screen after making these initial selections.

3. From the home screen, select one of the three "Quick Hits" options. Remember that ANFORA News is designed to minimize interaction. But you can skip to the next story or stop the flow any time you like.

Second Task Set

1. From the home screen, select "Sample Story Summaries" and add "Related Stories." Then, select two of three categories, "local, national and world." For each of the two categories you selected, choose at least two sub-categories. Remember that you can skip to the next story or stop the flow any time you like. ANFORA News is designed to minimize interaction and allow you to listen to a playlist of news stories on-the-go. However, you can skip to the next story or stop the flow any time you like by using gesture or control commands.

2. From the home screen, select "Listen to All News Stories" under the "Long Format" option. Remember that you can skip to the next story or stop the flow any time you like by using gesture or control commands. However, you are not required to interact with the screen after making these initial selections.

Survey for First Task Set

On a scale of 1 to 5 (1 = strongly disagree, 5 = strongly agree) rate your level of agreement with the following statements:

1. ANFORA News is easy to use.
2. Listening to news on ANFORA News is enjoyable.
3. I would use ANFORA News again.
4. I prefer using ANFORA News to browsing news websites on my mobile device.
5. ANFORA News was easy to navigate.
6. The text-to-speech voice was difficult to understand.
7. I got what I expected when I clicked on things (buttons, links, etc.) on this site.
8. The news content was interesting.
9. The quality of the text-to-speech voice was satisfactory.
10. The news content was boring.
11. After using ANFORA News, I feel well informed about the news categories I listened to.
12. While listening to ANFORA News, I realized when the news story started and ended.
13. While listening to ANFORA News, I realized the category in which the news story belonged to.
14. The "Scan Headlines" feature was useful.
15. The "Sample Story Summaries" feature was useful.
16. The "Listen to Full Stories" feature was useful.

Survey for Second Task Set

1. ANFORA News is easy to use.
2. Listening to news on ANFORA News is enjoyable.
3. I would use ANFORA News again.
4. I prefer using ANFORA News to browsing news websites on my mobile device.
5. ANFORA News was easy to navigate.
6. The text-to-speech voice was difficult to understand.
7. I got what I expected when I clicked on things (buttons, links, etc.) on this site.

8. The news content was interesting.
9. The quality of the text-to-speech voice was satisfactory.
10. The news content was boring.
11. After using ANFORA News, I feel well informed about the news categories I listened to.
12. While listening to ANFORA News, I realized when the news story started and ended.
13. While listening to ANFORA News, I realized the category in which the news story belonged to.
14. The "Sample Story Summaries" feature was useful.

Interview Questions
1. Overall, how would you describe your experience with ANFORA News?
2. How convenient was it for you to set up your news playlist? In other words, how easy was it for you to choose the categories of news you wanted to listen to?
3. Were you able to adequately monitor your surroundings while walking? If no, why not?
4. Was it clear when a new news story started/ended?
5. At any point, did you feel confused by the interface? If so, can you recall when?
6. At any point, did you feel lost in the while listening to the news? If so, can you recall when?
7. Did you notice any sound effects such as music or bells in between stories? If yes, what did they mean to you?
8. At any point, did you stop ANFORA News before your playlist ended? If yes, why?
9. Did you use gesture commands? Control commands? Both? Why or why not?
10. How did you feel about the way ANFORA allowed you to make initial choices about what types of stories you wanted to listen to and then automatically played stories in order after those choices were made?
11. If ANFORA News were available today, when would you use it? How? Why or why not?
12. What did you like best about ANFORA News?
13. What did you like least about ANFORA News?
14. How many news stories did you listen to today?
15. Briefly tell me about a news story that you remember.

APPENDIX C

Tabulated Data

Task Performance

Aural Flow Completion Rate	Scan Headlines (T1)	Full Stories with Readers' comments & Related News (T2)	Sample story Summary (T3)	Sample Story Summary with Related News (T4)	Full Stories (T5)
Completion without assitance	8	5	4	5	3
Completion with assitance	2	5	6	3	5
Users Gave up	0	0	0	2	2

	Confused by Long Pauses	Encountered Technical Problem	Poor Recall of Gesture Commands	Misunderstood Button Labeling	Misunderstood TTS
Percentage Occurrence of Error During Total Number of Listening Sessions (50)	50%	36%	28%	10%	6%

	Scan Headlines (T1)	Full Stories with Readers' comments & Related News (T2)	Sample story Summary (T3)	Sample Story Summary with Related News (T4)	Full Stories (T5)
Engagement with the Screen	21.70	19.07	18.74	29.25	20.76
Listening to Aural flow	78.30	80.93	81.26	70.75	79.24

Survey Questionnaire

	Age	Gender	Kind of Phone	News Web	Mobile News	Radio News	TV News
P1	30	M	iPhone	6+ hrs	5-30 min	no time	no time
P2	27	F	Epic 4G	5-30 min	5-30 min	no time	5-30 min
P3	27	M	iPhone	3-6 hrs	30-60 min	5-30 min	6+ hrs
P4	26	F	Samsung	5-30 min	5-30 min	5-30 min	1-3 hrs
P5	23	F	iPhone 4S	1-3 hrs	5-30 min	no time	no time
P6	24	F	Basic Model	1-3 hrs	no time	no time	no time
P7	25	M	Blackberry Torch	30-60 min	5-30 min	3-6 hrs	3-6 hrs
P8	24	F	iPhone	5-30 min	1-3 hrs	no time	no time
P9	27	M	Nokia- M73	6+ hrs	no time	1-3 hrs	1-3 hrs
P10	55	F	LG Optimus	30-60 min	30-60 min	1-3 hrs	6+ hrs
P11	26	M	Android	5-30 min	no time	5-30 min	no time
P12	50	M	Blackberry	5-30 min	5-30 min	6+ hrs	no time
P13	29	F	iPhone 4	1-3 hrs	5-30 min	no time	1-3 hrs
P14	37	F	Android Samsung Fascinate	1-3 hrs	5-30 min	no time	1-3 hrs
P15	23	F		30-60 min	5-30 min	5-30 min	5-30 min
P16	27	M	LG CU500 (java)	3-6 hrs	no time	5-30 min	5-30 min
P17	37	M	iPhone 4	1-3 hrs	1-3 hrs	1-3 hrs	no time
P18	30	F	iPhone	30-60 min	5-30 min	3-6 hrs	3-6 hrs
P19	24	M	Android-SGH T959	1-3 hrs	30-60 min	5-30 min	5-30 min
P20	34	M	Regular P.O.S	30-60 min	no time	1-3 hrs	no time

	Q1. ANFORA News is easy to use.	Q2. Listening to news on ANFORA News is enjoyable.	Q3. I would use ANFORA News again.	Q4. I prefer using ANFORA News to browsing news website on my mobile device.	Q5. ANFORA News was easy to navigate.	Q6. The next-to-speech voice was difficult to understand.	Q7. I got what I expected when I clicked on things (buttons, links, etc.) on this site.	Q8. The news content was interesting.	Q9. The quality of the text-to-speech voice was satisfactory.	Q10. The news content was boring.	Q11. After using ANFORA News, I feel well-informed about the news categories I listend to.	Q12. While listening to ANFORA News, I realized when the news story started and ended.	Q13. While listening to ANFORA News, I realized the category in which the news story belonged to.	Q14. "Scan Headlines" feature was useful./ The "Sample Story Summaries" feature was useful.	Q15. The "Sample Story Summaries" feature was useful.	Q16. The "Listen to Full Stories" feature was useful.
P1	2	4	3	2	1	1	2	4	5	2	4	4	4	3	3	4
P2	4	4	3	3	4	2	3	4	4	2	4	3	3	4		
P3	4	5	5	5	4	3	2	3	3	3	5	5	5	4	4	3
P4	5	4	4	5	5	1	3	3	4	2	4	4	4	5		
P5	5	5	4	5	1	5	4	5	3	3	5	5	5	5	5	5
P6	3	3	4	3	4	2	3	5	5	2	4	3	4	4	5	3
P7	4	4	4	3	4	2	4	4	4	2	5	5	4	3		
P8	3	3	2	2	4	1	4	4	4	2	4	4	2	3		
P9	3	2	3	3	3	4	4	4	4	2	4	3	3	4	4	4
P10	4	5	5	3	5	1	4	5	5	1	5	4	4	4	4	4
P11	5	5	4	5	4	1	4	4	4	2	3	4	3	4		
P12	5	3	4	4	5	2	4	3	2	3	4	5	4	4	4	4
P13	4	4	4	4	5	1	5	4	5	1	5	5	3	5		
P14	4	4	4	3	5	2	5	4	4	2	4	3	4	4	4	4
P15	4	3	3	3	4	2	4	3	4	3	3	4	4	3	3	3
P16	4	4	4	4	4	2	4	4	4	2	3	5	4	3		
P17	4	4	4	4	2	2	1	3	3	2	4	1	2	2	3	4
P18	4	5	5	5	2	3	5	5	5	1	5	5	4	5		
P19	4	4	4	3	3	2	4	2	4	4	5	3	2	5		
P20	5	4	4	4	5	3	5	3	3	2	4	4	4	4		