INDYCAR Mobile Timing and Scoring Application

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ABSTRACT
Sports fans want to keep up-to-date information regarding their favorite teams, personalities, and the like. Mobile devices have become a primary source for this information, including smart phone devices. INDYCAR and open-wheel racing fans are no different. While business-to-business partnerships currently provide mobile applications specific for INDYCAR fans, specific smart phone demographics were omitted. This paper discusses a proposed initial INDYCAR mobile application prototype and usability testing results, specific for Apple's iPhone. Test results indicate the mobile application could be considered a proper baseline application for further design, and suggests select design and prototype improvements may provide developers a well-received mobile application upon release to consumers.

Keywords
INDYCAR, Prototyping, Smart Phone Prototyping, iPhone, Usability Testing, HCI Project, System Usability Scale

INTRODUCTION
Problem Space
In March 2010, the Indianapolis Motor Speedway Corporation, INDYCAR (a sanctioning organization for North American open-wheel racing), and RacerSites.com introduced a significant redesign of the IndyCar.com website. As part of the redesign, both organizations understood the need for a mobile version of the IndyCar.com (http://m.indycar.com) website, for access via standard and "smart phone" technologies. Mobile content is presented in a condensed version, including a basic HTML-based Live Timing & Scoring mechanism for track activity. While this mechanism appears accurate, there are perceived shortcomings, such as:

- Not enough data being displayed to users
- Requires manual refresh of the mobile webpage
- Availability and accuracy concerns outside of race-mode data (i.e., qualification sessions)
- Underutilized for development series track activity (i.e., Firestone Indy Lights)
- No video playback or social media connectivity

In September 2010, capitalizing on expanding business-to-business partnerships, Verizon Wireless was introduced as the official cellular provider of INDYCAR, and, according to the Indianapolis Business Journal [6], the carrier announced plans to develop an INDYCAR mobile application, available for BlackBerry & Android devices, providing "live timing and scoring from events; driver and team information; highlights, streaming audio and video of races; and social networking links." While the next directions for INDYCAR mobile phone development appear moving away from Apple products, consumers should still be provided an enhanced sports information mechanism for their INDYCAR experiences. In February 2011, Verizon announced an agreement to start carrying the Apple iPhone as part of their available smart phones, but was unclear whether the created Timing & Scoring application would be converted for Verizon iPhone users, and whether the current AT&T iPhone users would be allowed to download the application.

Product Purpose
The proposed INDYCAR Mobile Timing & Scoring application would be a mobile utility designed to provide INDYCAR fans detailed information regarding current track activity for a given event. The product should provide both a schedule of events and a detailed activity itinerary for an individual event. Upon accessing the "live" session, a clear representation of current track activity, whether the session is during a practice, qualifications, or the race itself, should be concise, as to not inundate users with too much statistical data. Users should be allowed to examine session results by investigating driver-specific data not shown on overall session screens. Track condition changes, such as cautions or restarts, should be provided to users, and include enough information to give users a brief understanding of details leading to the track condition change.

The proposed application should give users the ability for use in numerous contexts without adjusting application settings. The three primary contexts to be considered are:

- In attendance at a race event
- Watching the race event on television or streaming online
- Monitoring track activity without ability to watch video from TV or online sources

Other contextual events should be considered as they are discovered in pre-project survey and interview sessions, though initial target context must include these areas.

LITERATURE REVIEW SYNOPSIS

Prototype Purpose Considerations

In general, designers must consider different areas a prototype will be used for. If a product is creating new functionality, design teams may want to create a prototype to test the overall role it will play in users' lives [5]. Prototypes themselves should focus on what should really be tested, filtering out aspects not under consideration, and presenting those filters in the most appropriate and simplest manifestation, without impacting overall levels of understanding [7]. Design teams should not necessarily worry about what tools or media used to create prototypes, but more how they are used to explore or demonstrate some aspect of the future product [5]. Additionally, user context in which a prototype will be introduced must be considered. Defining the context of where and how the prototype will be used will give test subjects an overall "experience" in using the prototype, including sensory and cognition perspective [2]. It is crucial the overarching experience is still concentrated upon physically, viscerally, and cognitively, thus by understanding the target audience to which a prototype is presented, including perceived expectations toward the product, design teams should have understanding towards determining a proper fidelity and resolution to the prototype.

Examining Mid-Fidelity Prototyping

Engelberg & Seffah [3] write prototypes of "low and high fidelity are loosely defined and each covers a broad range of fidelity levels, leading to confusion in comparing different tools." In their discussion, they presented characteristics of prototypes of specific fidelity (low, medium, and high), in conjunction with perceived advantages and disadvantages of each style. Their research concludes stating Microsoft PowerPoint as an ideal tool for producing mid-fidelity prototypes, as it can be quickly learned and requires no coding-specific skills for creating a testable interactive prototype. Other prototyping tools, such as Microsoft FrontPage and Adobe PageMill (now Adobe Dreamweaver), were designated high-fidelity prototyping tools and not appropriate for mid-fidelity prototyping. However, since their research, the aforementioned tools appear to have evolved from coding-specific tools to design-specific tools, which in turn may lessen designer demands of understanding coding principles, allowing for rapid web site designs that reflect a mid-fidelity prototype style for usability testing purposes.

It is also important to also evaluate the definition of "fidelity" itself. Fidelity can be described as how close to the eventual design a prototype reflects [5]. However, defining the term can be rather broad, as researchers have started emphasizing resistance to assigning a fidelity level to describe the <u>entire</u> prototype. Does the fidelity level refer to the level of functionality, level of interactivity, or other dimensions? [8,13,14]. Prototype characterization dimensions should be investigated individually, rather than in whole. For example, a prototype's "look and feel" may be hand-drawn sketches and digitized for testing on a computer (low- to mid-fidelity), but the "interaction" created between the digital sketches may give a test subject a fully functional application (high-fidelity).

User-Centered Mobile Design Principles

Don Norman [11] specified four principles of design for understanding and usability: (1) providing a good conceptual model, (2) making things visible, (3) the principle of mapping, and (4) the principle of feedback. In Apple Computer's iPhone Human Interface Guidelines manuscript [1], six guiding principles are suggested for designing user interfaces for mobile Apple products, comparable to Norman's principles from 22 years earlier:

- Metaphors: A user should instantly process information, due to the mental model each displayed icon provides. A quality metaphor should be an image, an action, or an object that can be transferred to a different environment, yet still retain an easily-associative meaning [15].
- Direct Manipulation: Users want to work with real artifacts, whether physical in form (i.e., opening a novel) or mentally tangible (i.e., clicking on a book icon to open an electronic version of the novel). With today's mobile technology, users can manipulate objects using fingers as gesture instruments to interact with the application, rather than physical objects (i.e., mouse).
- See and Point: Applications should provide users with pre-arranged choices, and let the users choose their own selections. Users do not wish to take time learning a device or application, yet want to be quickly competent for immediate use regarding their own tasks.
- Feedback: Always provide clear and immediate feedback to users, whether audible, visual, or even physical. Otherwise, the user may not understand their progress in accomplishing their task. The received feedback must be substantial and easily understood [4], or it will only cause additional confusion.
- User Control: Users should feel in complete control of application functionality, rather than feeling the application is controlling their actions and usage. All applications, including those for use in mobile devices, should afford users with messages and functionality if performing a task that could end in catastrophic results.

- Aesthetic Integrity: Applications assisting in productivity or utility tasks (i.e., calendar) need to perform the task immediately, whereas entertainment applications (i.e., games) should encourage application exploration with a visually-stimulating experience, yet still be responsible for the user to accomplish a task or goal. Designing aesthetic qualities should be carefully weighed as to their usefulness towards accomplishing the task.

Highlighted Personal Sports Information Devices

Three different personal sports information devices were studied. The first device was a patented "Electronic Sports Information Retrieval Device" [12], which would provide potential users either baseball or football statistics for individual players. The device was structurally based on a scientific calculator, though physical buttons were alphabetic, directional, and category abbreviations for the sport itself. Essentially, the device would have the same effect as carrying around individual player baseball cards to reference career statistics. It is unclear whether this device was ever created, and the patent has been allowed to expire.

In 1996, Motorola unveiled the "SportsTrax" pager, which relayed "in-game" information to customers, based on data supplied by volunteers monitoring events via media outlets and updating data on compilation servers, which in turn transmitted regular pager updates. The device kept users engaged in an event, including if the user was attending the game itself. The National Basketball Association (NBA) successfully sued Motorola, STATS, Inc., and America On-Line (AOL) for copyright infringement against the broadcast of their in-game data [9], as neither Motorola nor STATS, Inc. wanted to pay for using raw, in-game information. The Second Circuit Court of Appeals overturned the original ruling [10], stating sporting event data itself were not copyrightable, since no predefined script controls the event outcome. The reproduction of the factual event data (i.e., raw statistics) does not include the event expression or description, which in turn, constitutes the event's "broadcast," which is copyrightable. Motorola immediately reactivated pager use, though other competitors began their own live in-game data devices, including Disney's "ESPN To Go" pager. Eventually, Motorola converted pagers to use the ESPN To Go data, and the SportsTrax pager was retired in late 2000.

Lastly, the North American Stock Car Auto Racing (NASCAR) series and Sprint/Nextel (now Sprint) introduced their personalized sports information device in late 2005. The NASCAR "FanView" device was designed for fans attending a specific race to not only listen into radio transmissions between drivers and crew members, but also provide live in-car video, current standings, among other information, all by alleviating the aggravation of programming radio scanner devices with a specific frequencies (such as 460.2575 MHz) for a single driver, let alone the entire participant list. Along with providing driver-specific information, FanView also has capabilities of connecting fans to the actual radio race broadcast and the local track's public address system. Sprint made the devices both available for rent at a specific race weekend or for purchase if a fan were to choose so (with a nominal per-race activation fee).

METHODOLOGY

Type of Research

A mixed-methods research approach was used for this project. Quantitative measurements would be used to determine overall success rates for individual tasks. An additional task of calculating the time test subjects interact with the mobile application during a television broadcast. Qualitative information gained through post-task and post-test interview questions will assist the next directions of experimentation, design, and prototyping ideas prior to any application being developed, as an iPhone/iPod Touch mobile application for IndyCar Live Timing & Scoring does not currently exist.

Prototype Creation

The usability test prototype was created using HTML, cascading style sheets (CSS), and basic graphical skills, utilizing Microsoft FrontPage 2003 and Adobe Fireworks CS4. A special "viewport" HTML tag allowed each page to properly fit on the iPhone screen. A free mobile web browser, SwiftBrowser SE, was used, rather than the iPhone default Safari web browser, allowing for full screen application simulation. All displayed data was acquired using 2010 season statistical information available from the IndyCar website (www.indycar.com). Usability tasks were individually designed to reflect different race events and activities throughout the 2010 season. Two individual pilot tests for all tasks were conducted to confirm both prototype functionality and overall test methodology.

Recruitment and Sampling

The author became adept in Twitter, a social networking and microblogging service, allowing users to communicate with other Twitter members in short messages, or "tweets", of 140 characters or less. Links to pictures, web sites, and documents can be provided within these messages. An online questionnaire was created via Google Documents and "tweeted" to the authors' Twitter followers with a link to the questionnaire. Potential test subject recruits were asked a series of four total questions on the questionnaire in order to confirm participation viability: (1) age, (2) current residence, (3) knowledge of Apple iPhone/iPod Touch devices, and (4) knowledge of motorsports. All participants whom were over 18 years of age, resided in the Indianapolis, Indiana metropolitan area, stated a basic knowledge of iPhone/iPod Touch device functionality, and stated a basic knowledge of motorsports were allowed to submit their first name and e-mail address as a test recruit. After ten days, seventeen (17) questionnaire submissions had qualified to become potential test recruits. The author contacted each recruit through his university e-mail account to schedule a test session with each test subject, to which the first eight (8) responders to schedule a time would become the test population. Subsequent responders placed on a waiting list for potential cancellations and informed accordingly.

Data Collection Methods

Each test subject was presented with an informed consent document explaining his/her rights towards participation. A brief pre-test introduction was given to each test subject, including project purpose, proposed activities, introducing recording mechanisms to be used, and a brief charger on INDYCAR and prototypes. All talk-aloud comments would be recorded via AudioNote, a free Apple iPad recording application. Test subjects were informed they would not be timed during testing, but informed the test session would be forcibly ended once a one-hour time limit was reached, with no fault to the test subject.

For the first testing portion, each test subject was given four scenario-based tasks to attempt full completion. The perceived task complexity was mixed, and the order of tasks was randomized. Test subjects were encouraged to talk-aloud regarding what they were thinking when performing the given task, and provide the evaluator with the requested information, indicating usability task completion. After completing each task, two Likert scale-style questions were asked, and the test subject was allowed to freely comment on the completed task.

After completing the scenario-based tasks, each test subject was asked to watch a segment of a recorded INDYCAR race television broadcast while interacting with the prototype. The pre-recorded race segment was from the 2010 IZOD IndyCar Series season, and was 400 seconds in length between two noted points in the broadcast. The race broadcast was presented on a large-screen laptop computer (appx. 17” diagonal). Test subjects were video-recorded during the broadcast using TechSmith Camtasia software, recording the subject’s activities during the broadcast. After the video concluded, the evaluator asked test subjects three open-ended interview questions based on perceptions during the in-situ of watching the race on television.

A System Usability Scale (SUS) questionnaire was presented to each user after all usability tasks were completed, and two final open-ended interview questions were asked for users to comment on the best and worst aspects regarding their overall use of the prototype. Once the final interview questions were answered, each test subject was presented with a $10 gift card of choice.

Data Analysis Methods

A binary success score (success vs. failure) will provide the evaluator with the most basic information of whether the user was able to successfully complete the task. A distributed success score will inform the evaluator whether the user’s success required evaluator assistance at any point during the usability test task. Average scores for each task would indicate potential issues within the instructed task(s), if any. While distributed score success could be averaged properly, it was believed more appropriate to report the frequency of each score through all tests. Verbal talk-aloud and interview responses for each task provided constructive supplementary information regarding scores.

For the in-situ task, the evaluator reviewed recorded video of test subjects, monitoring the amount of time subjects were no longer watching the pre-recorded video, but either reviewing the mobile device or “staring off into space & listening” (neither watching the pre-recorded video nor operating the mobile device). Average calculations were made to determine how much time users are operating the device during the broadcast. The post-task interview questioning discussed the engagement felt regarding the event in whole (watching the broadcast in conjunction with reviewing the race standings in “live time” on the mobile device), versus perceived engagement without the use of the supplementary mobile device information.

The SUS questionnaire responses were averaged, providing a baseline score for future prototype versions to be compared against. Associatively, a traditional school grade would be provided on the average SUS score, providing an accepted means to relay the average SUS score to not only the evaluator, but also to any member receiving project results.

Auditory comments recorded during all five tasks were transcribed to remove voice identification, and then deleted from the recording device. Comments were analyzed for repeated issues, thus providing higher priority on issues to be investigated further in future designs and opportunities for growth not discovered during initial cognitive walkthroughs and pilot tests performed prior to formal usability tests. All video recordings were reviewed for engagement time recordings, and deleted from the recording device once raw data calculations were completed.

RESULTS

Scenario-Based Tasks

For Task #1, users were asked to proceed to a live practice session, provide the name of the fastest driver in the session, and the best speed of a given driver. Four test subjects (50%) were not able to provide the correct information to the evaluator, even though those that failed believed they had accomplished the task. Even with half of the test subjects officially failing the task, 7 test subjects (87.5%) felt the task was either Easy or Very Easy to accomplish, and all 8 test subjects were satisfied with the amount of time it took to complete the task.

For Task #2, users were asked to proceed to a live qualification session at a street course event, provide the current qualification session underway, and provide the current qualification status of a given driver. All 8 test subjects were able to successfully complete this task, with a single subject requiring evaluator assistance. Only 5 test subjects (62.5%) felt the task was either Easy or Very Easy to accomplish, 2 subjects were neutral, and 1 felt the task was difficult to complete. Six test subjects (75%) were satisfied with the amount of time needed to complete the task, whereas 1 subject (12.5%) thought the task took too much time.

For Task #3, users were asked to proceed to a live qualification session for the Indianapolis 500, which uses a different qualification format than used in Task #2. Users were asked whom was current making a qualification attempt, what position he/she provisionally qualified in, and to state the next three drivers scheduled to make qualification attempts. Seven test subjects (87.5%) were able to successfully complete this task without assistance. The eighth test subject did fail the task, and was recorded as such; however, the user did notice the correct answer and stated such during the post-task interview. All 8 subjects (100%) felt the task was either Easy or Very Easy to accomplish, with 7 test subjects (87.5%) were satisfied with the amount of time needed to complete the task.

Finally, for Task #4, users were asked to review information from an associated racing series (Firestone Indy Lights) for a previous event, providing the evaluator with the 1st, 2nd, and 3rd place finishers from the requested race, the qualification position and best practice lap speed from that race's winner. This task, just as in Task #1, proved more difficult, with only 3 test subjects (37.5%) able to successfully complete the task without evaluator assistance. Two subjects were successful, but required evaluator assistance, and 3 test subjects (37.5%) failed the task. Correspondingly, 5 subjects (62.5%) thought the task was either Easy or Very Easy to accomplish, with one subject stating the task was difficult. Seven test subjects (87.5%) stated they were satisfied with the amount of time needed to complete the task, with the 8th subject stating dissatisfaction.

Charts #1, #2, & #3 display the results of the four scenario-based tasks.

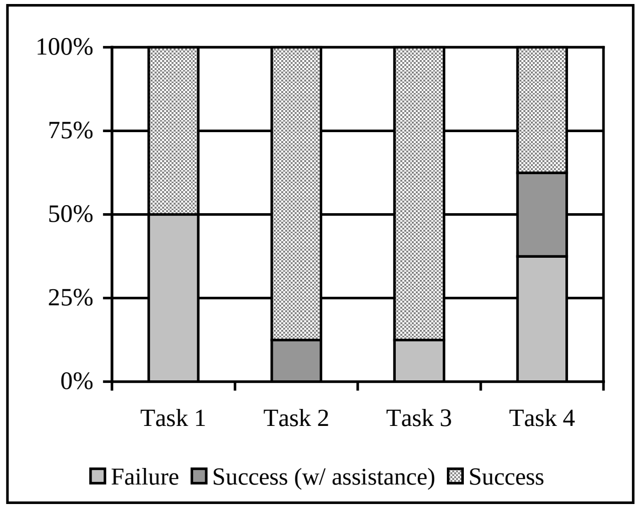

Chart 1: Scenario-Based Tasks – Success Rate

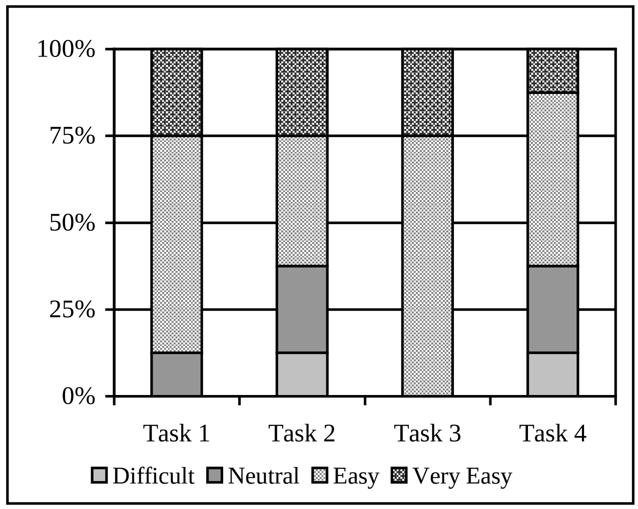

Chart 2: Scenario-Based Tasks – Overall Satisfaction

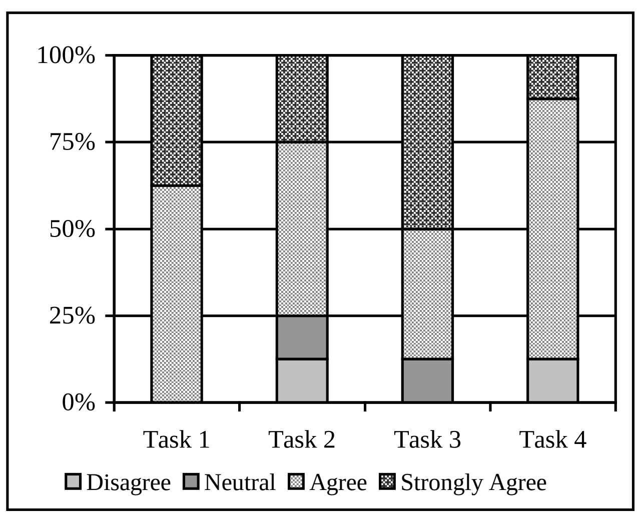

Chart 3: Scenario-Based Tasks – Time-on-Task Satisfaction

Scenario-Based Tasks

All test subjects were asked to participate in a final usability task, whereby test subjects were asked to watch a segment of a pre-recorded television broadcast while using the application prototype, as they saw fit. Both the broadcast and prototype were cued to a given point, and upon instruction by the evaluator, users started the prototype simulation as the race was restarted after a caution period.

All users were videotaped for the purpose of discovering the amount of time the test subject was interacting with the device itself during the television broadcast. The evaluator reviewed each video on three separate occasions, recording the total number of seconds the subject was interacting with the application prototype, and averaged for each participant. Participant averages ranged from 130 seconds (32.5% of the 400-second video length) to 283 seconds (70.8% of the video), with an overall average of 227.2 seconds (56.8% of the video).

Chart #4 displays the results and average time of the in-situ task.

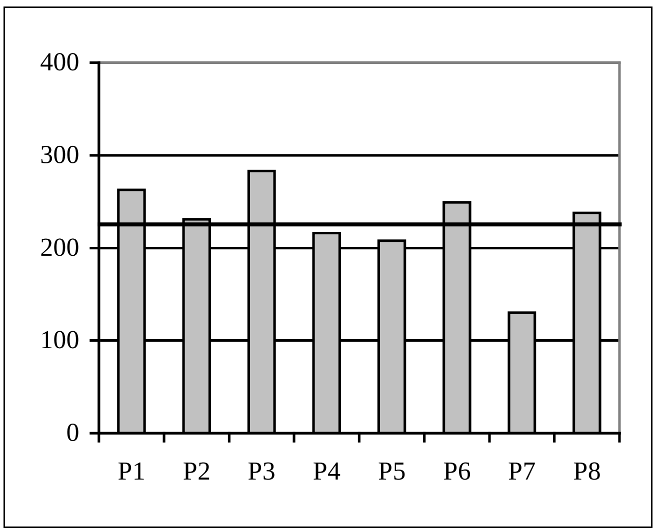

Chart 4: In-Situ Task Results (avg. 227.2 seconds)

System Usability Scale (SUS) Questionnaire

All test subjects were given a System Usability Scale (SUS) questionnaire upon completing all usability tasks during the test session. Users were instructed to answer each question without too much thought, and if no answer could be given, the middle "neutral" selection should be chosen. The SUS question verbiage was slightly modified to reflect "mobile application" rather than "product", to assist responses specific to the application prototype itself. By design, calculated SUS scores can range from 0 to 100. Additional to the ten standard questions asked in the SUS questionnaire, an eleventh "adjective-based", seven-point question on overall perceived usability was asked, ranging from "Worst Imaginable" to "Best Imaginable".

For this project, SUS calculated scores ranged from 70 to 92.5, with an average of 81.9. Using an adopted university-grade analogy (90-100 = A, 80-90 = B, etc.), the overall score would be graded as a "B-". The adjective-based question average was 5.375, which placed the overall prototype perception between the adjectives "Good" (value = 5) and "Excellent" (value = 6).

Chart #5 displays the results and average score of the SUS questionnaire.

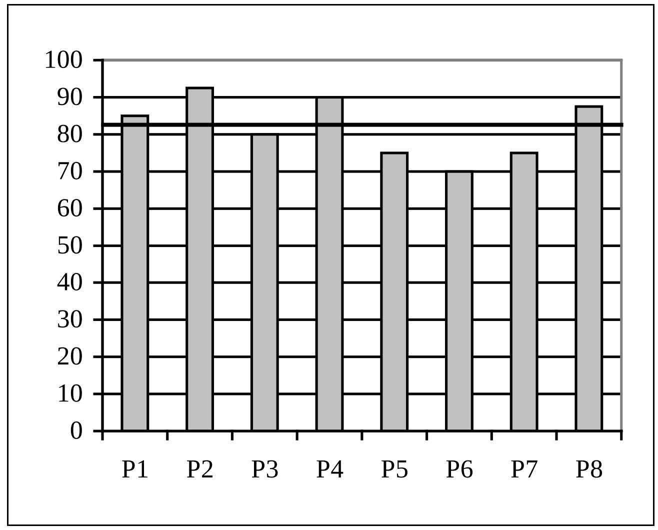

Chart #5: System Usability Scale Results (avg: 81.9)

DISCUSSION

There were mixed results in the four scenario-based tasks from a success/failure perspective. Two tasks (Tasks #1 and #4) saw much higher failure ratios. Specific to Task 1, all recorded failures were users providing perceived correct information from the first practice session, highlighted in black, rather than the second practice session, highlighted in red indicating the "live" event. During follow-up questioning, several test subjects mentioned thinking the red highlighted event was perhaps the live event, but were unsure. Worth noting was each event activity icon displayed an activity time range when the activity was taking place, yet the clock bar at the top of the screen, default to the Apple iOS operating system and displayed universally across all applications and homepages, presented the correct time of day, which may have contributed to misleading users as to event was, in fact, live. For Task #4, all users identified the requested winner of the race, as well as the 2^{nd} and 3^{rd} place finishers. Afterwards, many people attempted to access the driver-specific information on the race results screen, in the attempts of retrieving event-specific information for that driver. Users were provided the ability to return to the previous screen to begin navigation to the next pieces of requested information. Only three users recognized this functionality, and two users questioned the return functionality and had to be instructed accordingly. Of the three failures, one test subject "gave up," while the other two test subjects provided incorrect data, believing the qualification best lap times & speeds were, in fact, the best practice lap times & speeds, which were located in a separate past event activity. As for Tasks #2 & #3, Task #2's only Success with Assistance was in response to proceeding down a wrong path and questioning how to return to the previous screen, and Task #3's failure was from responding with incorrect information, but did notice the correct answer and stated such during the post-task interview. Thus, both tasks achieved close to perfect success scores with very minor issues.

It is appropriate to discuss the two Likert-scale questions together, as both task difficulty and perceived time-on-task may be related. Task #1, even with a 50% user failure rate, seven of eight test subjects stated the task was either easy or very easy to accomplish, and all eight test subjects agreed or strongly agreed with the perceived time-on-task assessment. This may indicate the failures were not due to the prototype architecture, as subjects were able to acquire data within five (5) application screens, but rather more regarding a lack of visual cues to the correct information itself. For Task #2, test subjects were presented a list of color-coded driver details, and had to interpret the data in order to make a proper response. Only five test subjects (62.5%) rated the task easy or very easy, and the overall perceived time-on-task was between neutral and agree. While the number of accessed prototype screens was identical to Task #1, the amount of information interpretation required by test subjects may have inhibited their overall satisfaction with the display. Task #3 is believed to be the top scenario-based task, as all eight test subjects felt completing the task was easy or very easy, and seven of eight agreed or strongly agreed with the perceived amount of time required to complete the task. However, these results may demonstrate location bias, as the task design was based on information for the Indianapolis 500 race, to which all test subjects resided in the Indianapolis metropolitan area. Finally, Task #4, test subjects were able to interpret the podium positions (1^{st}, 2^{nd}, & 3^{rd} place) with minimal task complications, but users became dissatisfied with requirement of proceeding to a page, and then having to go "back" in the application. Only one test subject thought the task was very easy, and three subjects were either neutral or believed the task was difficult. Similarly, six test subjects (75%) felt the perceived time-on-task was only agreeable, with one disagreeing, providing a lower-than-expected average result.

The in-situ task results interpretation could be perceived both positively and negatively. As stated, users were interacting with the application just under 57% of the video length. This could cause for questioning whether users were really fascinated by the novelty of the application itself, or was there something else keeping their attention on the application, rather than the video. It is the author's opinion this high percentage was not from the novelty, but rather due to the user's personal desire for supplemental information not being provided by the television broadcast itself, such as the race action, the race information displayed digitally on the screen, and from the broadcast personalities. From the positive perspective, INDYCAR business-to-business partners may find this percentage intriguing to inquire about potential in-application advertisement opportunities. However, from the negative perspective, this percentage result could detract from potential television sponsors to purchase advertisement air time if viewers whom are also using the mobile application are not fully-engaged during the television broadcast. Without proper consultation from INDYCAR, an adequate target percentage of application use during a television broadcast segment is currently unknown, but the average percentage found could be considered a proper starting figure to use for future testing and prototyping.

SUS Scores, by design, are to be taken in whole to determine a proper usability grade for a given prototype. An average of 81.9 across ten SUS questionnaires indicates test subjects interpreted the prototype as a good-to-excellent prototype, and would be given an above-average grade using a standard university grading scale. All eight test subjects strongly disagreed to the question "I think that I would need the support of a technical person to be able to use this mobile application," indicating comfort with the technology mechanism the application provided. The two SUS questions that scored the lowest overall were Question 2 ("I found the mobile application unnecessarily complex.") and Question 3 ("I thought the mobile application was easy to use."), though both questions averaged as favorable from test subject perspectives. Overall, the author believes the initial prototype, while containing noted flaws, would be an excellent baseline for future revisions to use moving forward in application design and development.

CONCLUSIONS AND AREAS FOR IMPROVEMENT

Prototype Improvements

Four primary areas for prototype-specific improvements have been determined. An inclusion of an icon, indicating the highlighted event is currently "live," should be added to the events, in conjunction with the highlighting of events and track activities. Users demonstrated confusion as to which event or activity was currently "live," even with the use of high-contrasting colors used for highlighting event schedules and activities. The additional icon would not only assist normally-sighted people finding the live event, but also assist those with visual impairments, whom may not be able to distinguish colors being used by the application in whole.

Second, a revisit to the information architecture should be investigated, primarily for the purposes of attempting to keep the user moving forward in the application. Users were negative with their remarks regarding the back-and-forth navigation they were required to perform during Task #4. Interestingly specific with the task, most users attempted to access driver-specific information from that page, rather than proceeding backwards. While this functionality was not developed into the initial prototype, users responded with hopes of finding event-specific information for the chosen driver, which would include their practice and qualification information, among other data, and not looking for biographical information of the driver himself/herself, to which users mentioned they could access the IndyCar.com or the driver's personal web site for that type of data. Redesigning steps and screens for Task #4 to incorporate the event-specific information for a selected driver should be considered necessary, and should produce better success and satisfaction rates.

Third, the amount of scrolling required to perform for several tasks, including the in-situ task, must be improved. At any one moment, a maximum of three (3) events, event activities, or driver-specific details could be displayed on the iPhone screen. In regards to the driver-specific icons, while users were generally favorable with the driver picture incorporated into the driver-specific details, it might be a primary cause for the overall large icons. One test subject suggested a one- or two-line "collapsed" description, to which upon a first tap would expand to the current icon information design, and upon a second click, would expand to the driver-specific details. Regarding the event and activity icons, collapsing this information could be beneficial, as it could provide an opportunity to combine both event and event activities into a single screen, while still providing the same functionality and information as the current prototype. Events could still be listed in chronological order, as they are in the prototype, but a single click on the event expands the event to show all individual abbreviated activity information, and a single click moves the user to the activity-specific detail with driver data.

Fourth, a prototype shortcoming from the in-situ task should be investigated. After each lap was completed, the prototype would appear to refresh the screen with up-to-the-minute information. The prototype was designed to automatically move the user from one HTML page to the next HTML page using basic HTML "redirect" functionality. However, if the user was reviewing information towards the page end, the refresh would force the user back to the page top, rather than keeping the user in the same location on the grid as they were previously viewing. For example, if the user is reviewing information for the drivers in 12th and 13th place, upon refreshing to the next page, the user was forced back to the top of the screen for 1st and 2nd place. If, however, the prototype refreshed with new data, but kept the user reviewing 12th and 13th places, user satisfaction during the in-situ should improve.

Finally, the prototype and environment artificiality should be mentioned for future research opportunities. All prototype data was from a previous season statistics, and was not truly "live" data. All tests were conducted in an artificial environment whereby users would not normally watch an INDYCAR event, and were conducted using a high-speed WiFi network connection. Users were also provided an iPhone device (original release), rather than using their own iPhone device. Due to the overall positive opinions and experiences with this prototype, it may be worth discussing opportunities with INDYCAR about performing further tests at a live event, such as on site at the Indianapolis Motor Speedway during the Indianapolis 500. It is believed having live data at a live event would greatly enhance a user's overall event race engagement. However, a prototype investigation using this testing method could come at a significant, but necessary, cost, as event attendees may not have readily-available high-speed wireless connectivity during the event itself, reducing their connectivity speed to that provided by cellular services. At several event locations, cellular services can be significantly limited in nature, and with rising attendances throughout the INDYCAR series and use of smart phone technology, connectivity and service in whole may be greatly hindered due to cellular service overload. Subsequent questioning regarding perceived satisfaction on time-on-task and their overall success rates should be recalculated, as they could be very different than reported in this paper.

Project Improvements

Potential bias in two interview questions were not discovered until after six (6) of the eight usability tests were conducted. Neither pilot tests nor previous usability tests detected the bias beforehand. While the author did keep the interview questions consistent for the remainder of the project, the author recognizes continued need for championing proper pilot tests, as well as the need for outside peer participation (i.e., class members, other test evaluators), whom might have discovered or questioned the bias prior to starting the usability tests.

Within the constructed prototype, the author used a color-based scheme to identify past, current, and future events, which, upon testing, users were not clear as to the color specifics. As web and mobile technologies have advanced over the last decade, so, too, has the growing need for proper accessibility design. A number of test subjects noted while the used colors were very contrasting to them, other users whom may have slight to moderate visual impairment, including color blindness, may not be able to properly differentiate between the colors. The author's past education and experiences had not properly taken this into account, and would like to improve upon his overall design skills, including those for accessibility concerns. The author also cordially suggests Indiana University School of Informatics to consider an accessibility-specific elective course offering, which could provide a necessary foundation in accessibility design for students whom do not have the experience or whom their future employment opportunities may have them focus attention to.

Finally, the author originally performed the in-situ task more out of a curiosity, rather than having a question or questions the task was to assist answering, which is extremely bad form for performing usability tests. Questions must be properly defined prior to any project, as the questions will help usability analysts define prototype fidelity and construction, choosing an appropriate testing methodology, and construction of adequate usability tasks, among other activities. After performing the in-situ tasks and generating results, it should be noted the author began more questions about the results than evaluating the data, which should not have been the case. While the information gathered from this task for this project was suitably evaluated once a question was derived, the author has become much more conscious of his error, and that future projects must have these questions clearly defined.

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