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Web-based, mobile-device friendly, self-report survey system incorporating avatars and gaming console techniques

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Abstract

We describe building an avatar-based self-report data collection tool to be used for a specific HIV prevention research project that is evaluating the feasibility and acceptability of this novel approach to collect self-reported data among youth. We discuss the gathering of requirements, the process of building a prototype of the envisioned system, and the lessons learned during the development of the solution. Specific knowledge is shared regarding technical experience with software development technologies and possible avenues for changes that could be considered if such a self-report survey system is used again. Examples of other gaming and avatar technology systems are included to provide further background.

Keywords: Self-report survey data collection; ACASI; CAPI; CASI; Avatar; Interactive questionnaire; PHP; HTML5; HIV Prevention

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Introduction

Researchers who are involved in self-report data collection continue to look for ways to collect better survey result data with electronic data capture systems. Survey tool strategies such as ACASI (audio computer-assisted self-interviewing), CASI (computer-assisted self-interviewing), CAPI (computer-assisted personal-interviewing), and IVRS (interactive voice response system), to name a few, do currently exist, but finding other novel methods continues to be something considered by social science and epidemiology researchers. The use of avatars and gaming systems is popular with adolescent youth. These electronic technology entertainment systems tend to keep adolescents engaged. This article describes the situational need for a customized avatar-based research data collection system and takes the reader through the expected and unexpected challenges experienced.

Background

Several promising HIV preventative medications are under study and offer great potential to alter the course of HIV incidence trends. However, the collection of accurate adherence records by participants has been a persistent challenge across a diversity of studies and populations [1,2]. Frequently participants over-report the consistency with which they've adhered to a medication regimen making it difficult for researchers to assess the acceptability of promising preventive methods in real-time. Methods of survey administration such as ACASI (audio computer-assisted self-interviewing) data collection have resulted in minimal improvements in the accuracy of participant adherence reports in clinical trials, and they have greater effects when other sensitive behaviors are probed such as sexual practices [3]. New methods of electronic survey administration are critically needed, particularly approaches that are appealing to young men who have sex with men, as the incidence of HIV has remained highest among this group in the U.S [4].

To address this challenge, our research and technology team developed an innovative web-based data collection system that uses a participant-designed avatar to deliver the survey. Research indicates that gaming systems and avatar-based programs may be especially attractive to youth. Programs that allow participants to customize their own avatar may prompt greater engagement [5-7]. Self-report surveys can be lengthy, and may include detailed calendar recall type questions. Through the use of a self-created avatar, participants may remain engaged and complete longer, more detailed on-line surveys. Through our study, we aimed to test and assess if our avatar-centered survey method might improve the accuracy of self-reported adherence to biomedical HIV prevention methods. The system needed to be accessible from multiple computer, tablet, and smartphone platforms as well as through a variety of browsers. The customized avatars would appear on each question screen, but would move to different locations on the screen and present the questions within a text bubble.

The web-based self-report questionnaire system with avatars that we developed provides another potential survey tool for health researchers to utilize, particularly where there is a concern about the honesty or validity of responses. Although the system was created for a specific HIV prevention project, it could also have applications in other research efforts including electronic data collection with a younger population. For example, an additional application might include health behavior research studies with efforts to solicit accurate information about cigarette smoking, illegal drug use and alcohol consumption, and perhaps even dental hygiene. In this article we will share with you our process for the design and building of such a data collection system. We will then share issues we had foreseen as well as those we did not, and finally discuss potential future uses of avatars in electronic data collection systems.

Methods

In approaching the software development of the data collection tool, the more traditional software development life cycle (SDLC) methodology was utilized. This includes the phases of requirements specifications, software design, implementation and integration, testing, deployment and maintenance. The overarching research project included the use of a protocol document for HIV prevention. This planning document was instrumental in outlining the detailed requirements that help in the very important first step of SDLC which emphasizes planning.

During the design phase, in the spirit of Scrum framework, several iterations of the user interface pages were created and shared with the investigative and protocol team leadership. Utilizing this additional complement to the overall SDLC approach proved to be extremely important since expectations of the design were adjusted frequently before fully entering the programming phase of the effort.

Discussion

How the requirements were established

The research investigators were interested in an engaging electronic data collection system that could be used by participants located in the United States in a self-administered manner. The system needed to be available both onsite at clinics and more often, remotely from outside the clinic with connectivity to the Internet via smartphones, tablets, laptops or desktop computers. Participants needed to be able to create their own avatars by selecting from a variety of personal qualities and attributes. When resuming a questionnaire via subsequent login, the self-created avatars would re-appear, connected to the user's unique profile/login. In addition, the project included a follow-up questionnaire and upon login to the second questionnaire at a different time, the self-created avatar would again be presented. Site administrator staff needed to be able to technically enable surveys for participants; monitors survey completion status, and provide automated emails when surveys were completed. The ability to resume an already-started survey was necessary, but within a certain a time limit. When resuming an already- started survey, the customized avatars would be available and present to the participant. Security was needed for assigned user accounts, the Internet or browser communication traffic and finally, storage of the resulting data. Prototypes were built and demonstrated to both the research investigator teams as well as the clinic staff responsible for enabling the surveys. Comprehensive staff training and on-going technical support were critical to the successful launch and implementation of the system.

The majority of the previous data collection projects our technology team has been involved in required us to provide a system that could be used in less-developed areas of the world where interrupted internet and power were frequently experienced. In this case the customized data collection system with integrated avatars would be used domestically in the United States, and these challenges were not anticipated.

Previous experience in building self-report data collection systems that provided foundation, and experience

The Population Council's Information Technology group has assisted with the creation of customized ACASI and CAPI/CASI (Computer Assisted Personal/Self Interviewing) solutions for over ten years in a variety of research projects. These solutions involved the development of a full customized ACASI module, in which respondents listen to prerecorded audio questions through headphones connected to a handheld computer and record their responses using a touchscreen [8]. Our development experience includes research efforts designing data collection interfaces for semi-literate populations and implementing them in resource-poor areas. At the time of this publication, our team has overseen the technical implementation of approximately 19 distinct research projects in 10 countries and in 21 different languages.

This depth of experience was one of the reasons our team was called on to assist with the creation of a web-based self-report questionnaire system that integrated participant generated customized avatars. When embarking on software development of any system, our development team generally tries to first determine if any products are already available for purchase, rather than building a new system from scratch. After collecting the requirements and doing online research for existing solutions, we determined that a custom built solution was required, especially to integrate the more complex tracking and monitoring portal.

Building the prototype

Lots of trial and error and brainstorming took place during the building of the initial prototype of the avatar web-based self-report data collection system. At first the design included building separate applications that could run on traditional computers, tablets and smartphones with the variety of operating systems, such as iOS, Android, Windows, Linux and Blackberry. Our experience at the time indicated that users had the best user flow experience when specific programs were written for these different platforms. However, this was quickly dismissed since maintaining and building these individual programs would be time and cost prohibitive as well as creating the need to manage change and version control for each platform. Ultimately we decided to create an HTML5 compliant website utilizing Responsive Web Design (RWD) principles that could run on the required variety of user interface devices. The use of Cascading Style Sheets in combination with JavaScript allowed for employing a RWD. The idea behind RWD is that the website would adjust automatically to the dimensions and form factor of whatever screen was being used. The site was also only reachable via SSL encryption. It should be noted that while the avatars employed were customized, they were not in the format of ECA (Embodied Conversational Agent), where the avatar can see and hear the respondent through a webcam and react to body posture and spoken language [9].

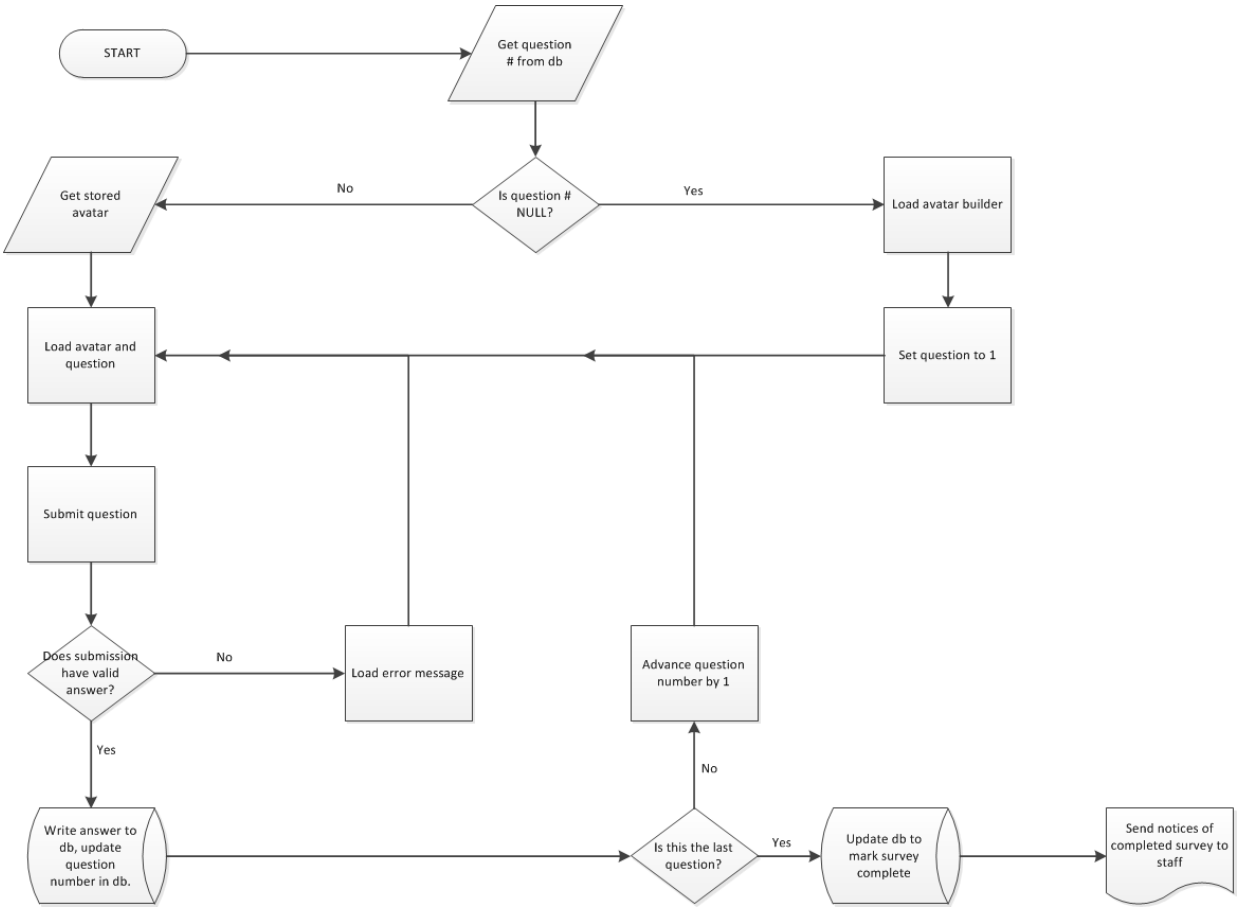

Figure 1: Data Flow diagram

The core of the application was built using the programming language PHP, with jQuery version 9, and the Bootstrap framework. The back end database is Microsoft SQL Server 2008, which makes exporting of the resulting data possible into a variety of formats, including Excel, and the website site is running on IIS 7.5. It was felt that these were the most proven technologies and had the best chance of performing as expected on the broadest range of devices. The data flow design including database updates are demonstrated in Figure 1. We considered using HTML5 local storage, but that meant that there was a possibility that sensitive data would be stored on participants' devices, such as their smartphones.

Challenges that were expected

Building websites that will be thoroughly supported on all web browsers is not something to be taken lightly, especially given the gamut of devices that can access the web. Smartphone browsers change over time, as do most other browsers, and this can create problems. In our case the surveys were being completed on a variety of smartphones and we did see several instances where we had to make small adjustments because of an upgraded browser. When creating sites that provide data from a back-end database it is important to make sure the screen and interface response are almost instantaneous, otherwise there is a risk of delays when a user attempts to move from one screen to the next, as is the case in responding to questionnaires. We anticipated

that there may be cases where a particular browser on a particular machine may not work, so we were prepared to suggest that participants try another device if they were having a problem with the site functionality.

Additionally, virtual worlds that include 3D avatars such as Second Life are very sophisticated in the level of imagery they use. We realized this at the onset of building the website questionnaire system, but resource and time restrictions hindered our efforts. As technology advances and programming costs shift, we would aim to make improvements to the visual appearance of future avatars and their environments to heighten their life-like qualities and capabilities. Although we do not envision a system similar to Second Life in use, we would consider some of the future visual qualities could include the ability for greater movement and flexibility of the avatars.

Challenges that were unexpected and what we would do differently

When you think of avatars you may imagine Second Life – a very rich and high-end multi-user 3D-like virtual web site that provides a surreal lifelike feel. While we knew that we would not be able to build on the same scale or on par with the graphical complexity of Second Life, we did not expect it would be as difficult as it was to create even the simple screens that permitted the user to create their own custom avatar. For this we may consider using a design service specialist or firm in the future if we are to create another custom avatar function. Because of time constraints and development complexity, we did not incorporate some higher-end more personal and/or specific qualities such as tattoos, hair type, and ear/nose rings, although we did receive requests for users to be able to add more of those types of details. A subset and sample avatar building screen is demonstrated in Figure 2. Audio sound was played during the customizing section and the users had the ability to turn it off.

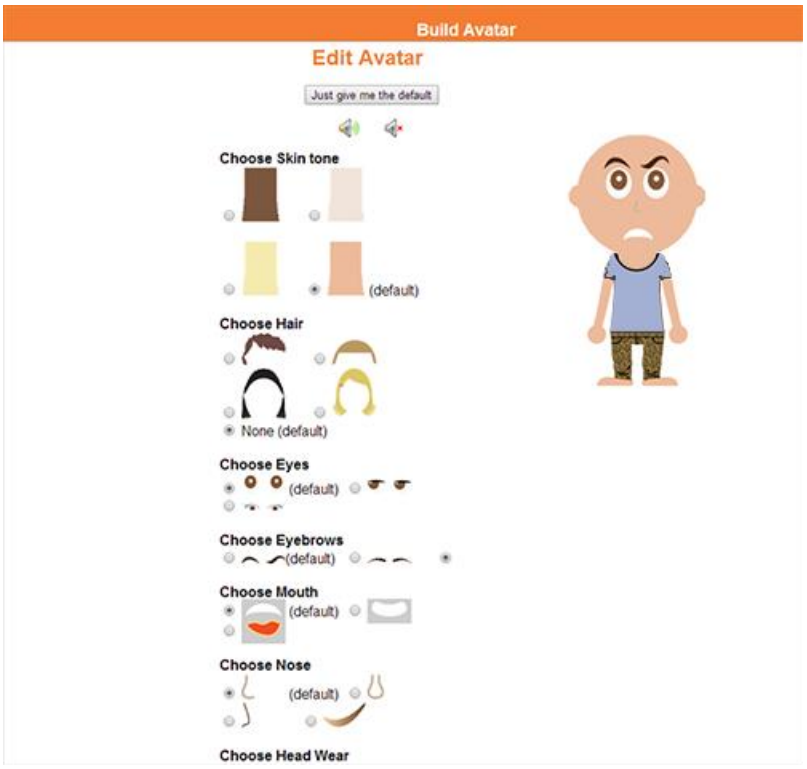

Figure 2: Avatar builder screen

We originally envisioned that our avatars would be able to move their arms and legs and walk around the screen. Initial attempts to enable the avatars to move were successful. The movement included jumping, spinning and even walking. However, when these movements were tested on a mobile device browser in 3G the performance or speed and fluidity of the avatar movement was inconsistent and displayed intermittent movement or jerkiness. In addition, the Javascript libraries that made use of HTML5's Canvas element were not consistent across browsers during development, meaning much code duplication. Because of this it was decided to adjust the avatars for less movement, in order to ensure that the core focus of the questionnaire, which is to allow self-reporting, would be done.

The site used for the web-based questionnaire system was built top-down, meaning first for a general computer web-browser and then retrofitted to work on mobile or tablet computers. After having gone through that approach, we think there are advantages to building bottom-up, meaning starting from the mobile device version and scaling up to the computer web-browser.

The Bootstrap framework software utilized certainly has its advantages, especially since it is probably the most known and tested responsive framework. Before the beginning of February of 2014 we would probably have said that we would use a framework other than Bootstrap, since the version of Bootstrap we used had high overhead and was not really designed mobile first. A quick Google search turns up many responsive frameworks to choose from. Bootstrap 3, however, is getting very good press, and seems to have major advantages to Bootstrap 2. Of course we would still look around for the toolkit that was right for us.

One of the biggest issues is that this survey was designed to take advantage of the new technologies of HTML5. We thought that most participants would be using their smartphones, or perhaps their tablets or Apple laptops. So far the reality has proven to be that more users than anticipated chose to take surveys at the clinic – which usually meant Windows desktops which do not have full HTML5 functionality. While the current version of Internet Explorer (IE) is great, HTML5 compatibility is only guaranteed for IE10 and above. IE9 has some partial support. Many HTML5 elements, such as the Canvas element do not degrade gracefully in older versions of Internet Explorer. Even though we promised a working survey for HTML5 compatible browsers only, it is still necessary, even for an audience of young "hip" persons, to have a fallback. Unfortunately, in some cases, especially for presentation and validation, that would mean writing and maintaining two versions of the survey. Admittedly we didn't expect so many users using Internet Explorer on Windows desktops.

We also found out that some types of questions simply don't lend themselves to handheld devices, no matter what framework or design is used. For example, long grids of yes/no survey data and calendars often didn't display correctly on some handhelds.

We do believe that HTML5 local storage has a bright future. It's easy to work with and provides the ability to store data offline and then send to the main server when on-line. Given the nature of this survey, it was not a fit, but perhaps in future surveys we will use it and thus reduce round trips to the server. Of course we must keep in mind that HTML5 local storage are like web site cookies, very insecure, and client side encryption (typically using JavaScript) will deter few people from exploiting this security weakness to obtain this potentially sensitive information.

Vision for future use

Will the use of avatars continue to expand within the area of electronic data collection? The authors consider that this may occur and there appears to be movement in some areas surrounding eHealth where this is being demonstrated. In one case, the EU-funded MyHealthAvatar project is trying out a digital representation of a user's health status, designed as a lifetime companion (Avatar). Your Health Avatar will facilitate the collection of, and access to, long-term health-status information. This would empower patients, would be valuable for healthcare decision and promising for health research [10].

Electronic gaming systems such as the Wii, Xbox and others involve the creation of avatars that are presented to you as you start playing a digital game. These digital representations are popular and fun to create, and also add a level of customization created by the end-user to the canned games. The use of exergames is being studied for aiding in rehabilitation. These are electronic games such as the Wii Fit that allow for in some cases home rehabilitation [11].

Second Life continues to be popular, although at not the same level of social networking sites such as Twitter and Facebook. The authors wonder what it will take to make more people aware of Second Life.

Some initial research has indicated that eSMART-MH (Electronic Self-Management Resource Training for Mental Health) has shown promise with avatar-based depression self-management among young adults (18-25 years of age). Participants who received eSMART-MH had a significant reduction in depressive symptoms over 3 months, while individuals in the attention-control group condition had no change in symptoms [12].

The uses of games are further being assessed and evaluated by researchers to see if there are ways to help people in a variety of health-related areas. A randomized trial involving adolescents receiving cancer treatments showed that participation in a video-game intervention, increased adherence to select treatments for the intervention group [13]. Those participating in the video-game intervention group played *Re-Mission* at least 1 hour per week for a 3-month period. The game was designed to highlight the importance of continuing treatment during remission despite uncomfortable side-effects. The research team also measured a statistically significant increase in cancer-related knowledge by the intervention group and an increase in self-efficacy that they could successfully complete treatment [13]. In a separate study, a team at Iowa State tested how memory and brain enhancement could be facilitated through video games. They found surgeons who played video games were 27 percent faster and made 37 percent few mistakes during laparoscopic surgeries than did non-gamers [14].

One of the authors has adolescent children and has been guilty of telling them to stop playing electronic video games that include customized avatars. However, after building this novel data collection system and learning more about the potential gaming and avatar-centered technologies hold for promoting healthy behaviors, maybe it is time to say "go ahead and use these consoles!"

Limitations

Although the effort to design, develop and support the web-based self-report data collection system with avatars did further expand our experience and knowledge in this area, there are some limitations that could be addressed in further research and system development efforts.

Future development of the system would include a more comprehensive administrative portal for allowing researchers to construct their own surveys without the need of an information technology programmer. Including pre-tests with survey respondents would allow for further feedback which may result in system design or user-interface changes. In addition, a greater variety of innovative question types could be created to provide alternatives for researchers and in turn the participants taking the web-based surveys.

When considering electronic self-report data collection in research projects our information technology group has often been asked about the price feasibility for performing them. This paper did not address the cost savings or efficiency that can be obtained when automating the survey process. Future efforts or research to address the costs associated when comparing manual (paper-based) versus web-based avatar questionnaires could help to address this scrutiny.

Conclusion

Researchers and information technologists continue to explore and look for innovative ways to collect self-report data via electronic surveys. Introducing customized avatars and gaming techniques is one new approach that has been discussed in this paper and has demonstrated it is possible to create such a web-based solution. We envision that a future generation of the tool built and discussed above would include much more life-like graphics with the introduction of more movement; this was not attempted in this version as it created technical hurdles that would have made the system unreliable and unusable in the context of the participant survey flow.

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