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Research and Applications

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Application of persuasive systems design principles to design a self-management application user interface for Hispanic informal dementia caregivers: user preferences and perceptions

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ABSTRACT

Objective: We designed an mHealth application (app) user interface (UI) prototype informed by participatory design sessions, persuasive systems design (PSD) principles, and Lorig and Holman's self-management behavior framework to support self-management activities of Hispanic informal dementia caregivers and assessed their perceptions and preferences regarding features and functions of the app.

Materials and Methods: Our observational usability study design employed qualitative methods and forced choice preference assessments to identify: (1) the relationship between user preferences for UI features and functions and PSD principles and (2) user preferences for UI design features and functions and app functionality. We evaluated 16 pairs of mHealth app UI prototype designs. Eight paper-based paired designs were used to assess the relationship between PSD principles and caregiver preferences for UI features and functions to support self-management. An Apple iPad WIFI 32GB was used to display another 8 paired designs and assess caregiver preferences for UI functions to support the self-management process.

Results: Caregivers preferred an app UI with features and functions that incorporated a greater number of PSD principles and included an infographic to facilitate self-management. Moreover, caregivers preferred a design that did not depend on manual data entry, opting instead for functions such as drop-down list, drag-and-drop, and voice query to prioritize, choose, decide, and search when performing self-management activities.

Conclusion: Our assessment approaches allowed us to discern which UI features, functions, and designs caregivers preferred. The targeted application of PSD principles in UI designs holds promise for supporting personalized problem identification, goal setting, decision-making, and action planning as strategies for improving caregiver self-management confidence.

Key words: caregivers, dementia, mobile health, persuasive systems design, self-management

Lay Summary

Informed by a set of persuasive systems design principles, we designed an mHealth application (app) user interface prototype to support self-management activities of Hispanic informal dementia caregivers and assessed their perceptions and preferences regarding the app user interface and functionality. We asked 14 Hispanic informal dementia caregivers about their perceptions and preferences for 16 paired user interface designs; 8 using paper-based and 8 on an iPad. We also asked them about preferred app functionality. Caregivers preferred an app user interface with features and functions that included more persuasive systems design principles and an infographic to help with self-management. They also preferred functions like drop-down list, drag-and-drop, and voice query for data entry when documenting self-management activities. Caregiver's perceptions and preferences suggest that use of persuasive systems design principles in user interface designs holds promise for supporting personalized problem identification, goal setting, decision-making, and action planning as strategies for improving caregiver self-management confidence.

INTRODUCTION

Persuasive systems design (PSD), according to Oinas-Kukkonen and Harjumaa, focuses on reinforcing, changing, or shaping attitudes and/or behaviors by addressing 4 groups of principles: primary task support, dialogue support, system credibility support, and social support.[1] Primary task support enables users to complete an intended task. For example, tailoring to provide specific content programmed in a mobile health application (mHealth app) to different group's unique needs. Dialogue support motivates users to stay engaged with the intervention for accomplishing the intended behavior. For instance, reminders in an mHealth app to send daily text messages to reinforce self-monitoring behaviors. System credibility support enhances users' perception that information is dependable. A dependable system can be produced using principles of authority (eg quoting a government official), verifiability (eg claims supported by external information), and expertise (eg removing out-of-date evidence). Lastly, social support leverages group influence to motivate behavior change. For example, applying the principle of normative influence to connect individuals with a shared goal (eg text message to challenge group to quit smoking).

PSD principles have been used to design and evaluate existing physical activity, weight loss or weight loss maintenance, smoking and/or alcohol use, and chronic arthritis technology-based behavioral interventions.[2–6] Depending on the target of the intervention, different PSD principles may be applied to the system design, for example, motivation to lose weight versus adherence to maintain weight loss. Beyond characterization, in a meta-analysis of 48 studies on web-based mental health interventions, Wildeboer et al.[7] found that including more persuasive systems design principles overall resulted in a larger intervention effect size; however, this was not confirmed within each group of principles. Interventions that combine PSD with a behavior change theory may produce significant outcomes.

Fewer studies have applied PSD principles in the design of technology-enabled behavior interventions and assessed their influence on user perceptions and intervention effectiveness. In the application domain of metabolic syndrome, Karppinen et al.[8] mapped habit formation stages with the PSD model and examined user experiences ($n = 43$) with a lifestyle intervention. Habits related to information technology but not lifestyle was associated with use adherence. The findings suggest that habit formation stages provide a possible explanation for why users perceived self-monitoring, reminders, and tunneling as valuable PSD features. The Milky Way breastfeeding application integrated self-efficacy enhancing strategies and PSD principles (eg reduction, reminders, trustworthiness, social learning).[9] Also, 6 of 7 survey respondents reported that the application was useful, and they intended to continue using it.

The literature provides support for the integration of PSD and behavior theories in the design of technology-enabled interventions that enable self-management behaviors. Informal dementia caregivers are a population in critical need of such interventions given the high prevalence of dementia in the United States[10] and the burden, depression, and physical strain associated with dementia caregiving compared to nondementia caregivers.[11–14] These emotional and mental health challenges make informal dementia caregivers vulnerable to physical health complications, including elevated stress hormones, compromised immune system function, impaired wound healing and endothelial function, heart disease, and hypertension.[15–21] Hispanic and African-American families bear the largest within-group burden of coping with the care of a family member living with dementia compared to non-Hispanic White families.[22–24] Hispanics are one and one-half as likely to be living with dementia as non-Hispanic Whites.[25–27]

Interventions have been developed to relieve the stressful aspects of informal dementia caregiving including those focused on case management, psychoeducational, counseling, support groups, respite, and psychotherapeutics.[28] There has been less focus on the health and health care needs of informal dementia caregivers. A technology-based self-management intervention has the potential to improve caregiver knowledge and confidence as well as enable and promote their ability to manage day-to-day health and health care needs for themselves and the person living with dementia (PWD).[29]

OBJECTIVE

We assessed Hispanic informal caregivers' perceptions and preferences regarding features and functions of an mHealth app user interface (UI) prototype to support self-management activities of informal dementia caregivers informed by participatory design sessions with intended end-users, PSD principles, and Lorig and Holman's self-management behavior framework.[1,30–33]

METHODS

Design

We conducted formative participatory design sessions with Hispanic informal caregiver's focused on identifying their comprehension, experience, information and communication needs, and online tool needs related to self-management.[31–36] After we analyzed the participatory design sessions data, 2 research team members (RJL and SY) conducted an expert evaluation which resulted in mapping 12 of 28 PSD principles to self-management behavioral targets as shown in Table 1. Based on shared agreement between RJL and SY, the PSD principles that were identified contribute to the set of requirements

that support functional (ie system behavior) and nonfunctional (eg privacy protection) features.[1,37] PSD principles varied in number according to category: 5 of 7 primary task support principles, 3 of 7 dialogue support principles, 3 of 7 system credibility principles, and 1 of 7 social support principles.

We applied an iterative design approach to create pairs of mHealth app UI features and functions with input from 11 experts affiliated with the Visualization Design Studio at the Columbia University School of Nursing Precision in Symptom Self-Management Center. The experts, who were not considered human subjects, all had graduate education in nursing and informatics. During monthly group meetings, we sought their opinions to draft designs until agreement was reached through consensus.

This iterative process resulted in app UI prototypes related to 16 self-management tasks. A list of mHealth app development concepts and their associated definitions or descriptions can be found in Supplement 1. User Interface Design A was produced to provide a direct representation of Lorig's Chronic Disease Self-management Program activities.[38] The key difference in UI Design B was the use of additional cognitive support elements (eg automated calculation or infographic gallery) as compared to UI Design A. Cognitive support elements were used to operationalize PSD principles. For example, using an infographic gallery plus a button icon demonstrates dialogue support (see Table 2, task 2). While both UI designs were informed by PSD principles, Design B contained a greater number of principles (ie 46) across the 8 tasks compared to Design A (ie 35) (see Table 1). The app UIs were designed to elicit preferences of user interactions, including: (1) realistic image versus (vs) illustrative image; (2) button vs button *plus* infographic; (3) fill-in-the-blank vs the following: drop-down list, infographic gallery, infographic gallery *plus* swipe view, infographic gallery *plus* checkbox, infographic gallery *plus* structured format, and drag-and-drop; (4) slider vs slider *plus* infographic; (5) navigation tab vs hamburger button; (6) infographic gallery vs infographic carousel; (7) vertical layout vs horizontal layout; (8) manual vs auto calculation; and (9) voice query vs manual entry (see Tables 2 and 3).

User testing

Design

We conducted an observational usability study that employed forced choice preference (ie selection of one choice when presented with a pair of options) and qualitative assessments of the 2 separate mHealth app UI designs. We alternated the presentation of app UI designs (ie A then B or B then A) to address the threat of an order effect on user preference.

Participants

Individuals were eligible to participate in the study if they were a family caregiver of a PWD, Hispanic/Latino, 18 years or older, and spoke English or Spanish. They were recruited from the Northern Manhattan Caregiver Intervention Project research registry.[39] A member of our research team, a bilingual Certified Health Educator (NST), telephoned 28 family caregivers, and 17 agreed to be participants. Research procedures were explained verbally and provided in writing to potential participants. We consented 14 caregivers prior to study participation.

Data collection

Data were collected between November 13, 2017 and December 8, 2017 at the Columbia University School of Nursing. Two team members (NST, SY) conducted the usability evaluations. Data collection was monitored by the study Principal Investigator (SB) with scheduled reports from the data collectors. All procedures were approved by the Columbia University Medical Center Institutional Review Board (IRB no. AAL8701).

Table 1. Mapping of persuasive systems design principles and self-management behavioral targets or goals

	Behavioral target															
	Personalization		My problem		My goal		My solution								My confidence	
System task	Choose avatar		Identify problem		Identify goal		Identify action		Tailor action		Action period and frequency		Action duration			
Interface design	A	B[a]	A	B[a]	A	B[a]	A	B[a]	A	B[a]	A	B[a]	A	B[a]	A	B[a]
Primary task support																
1. Reduction			■	■	■	■	■	■	■	■	■	■	■	■		
2. Tunneling															■	■
3. Tailoring	■	■														
4. Personalization			■	■	■	■	■	■	■	■	■	■	■	■	■	■
5. Self-monitoring																
Dialogue support																
6. Suggestion			■	■		■		■		■		■		■		
7. Similarity	■	■														■
8. Liking																
System credibility support																
9. Expertise			■	■	■	■		■		■		■		■	■	
10. Surface-credibility	■	■														■
11. Real-world feel																
Social support																
12. Cooperation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

[a]A greater number of persuasive systems designs principles were used in the mHealth app interface design. Attributional definitions of the 12 persuasive systems design principles can be found in Supplement 1.

Table 2. Preferences of user interface (UI) design for mobile applications to support self-management tasks among Hispanic family caregivers of people living with dementia ($n = 14$)

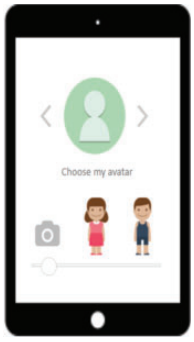
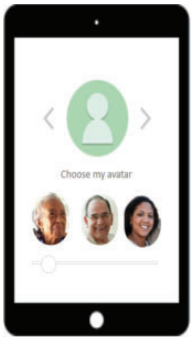
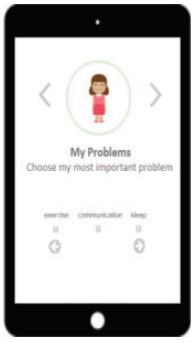
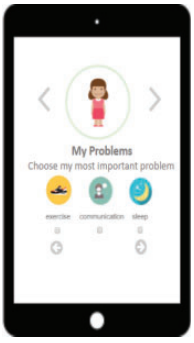
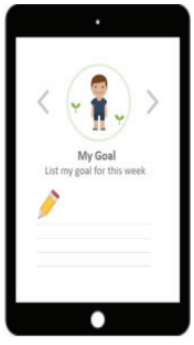
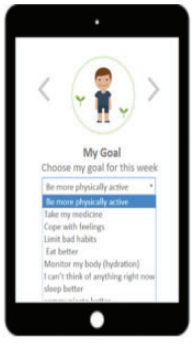
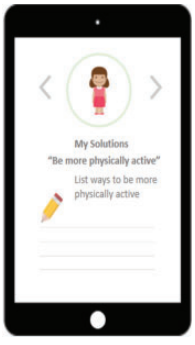
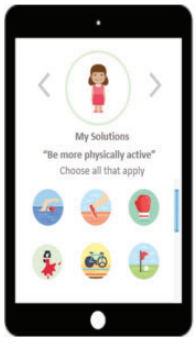
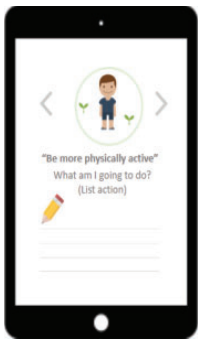
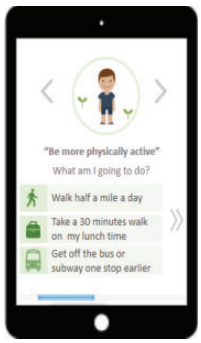
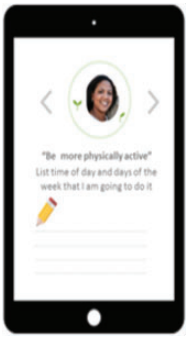
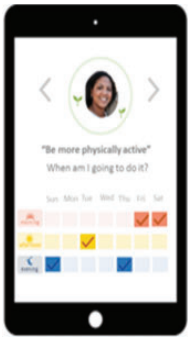
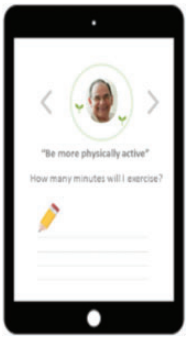
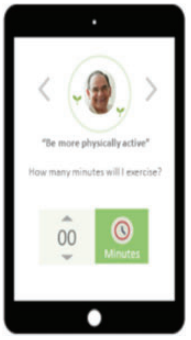
<table>
<tr><th>Self-management target</th><th>UI Design A</th><th>UI Design B</th></tr>
<tr><td>Task 1. Personalization
UI preferences
<table>
<tr><th></th><th>Design A</th><th>Design B</th></tr>
<tr><td>English</td><td>2</td><td>5</td></tr>
<tr><td>Spanish</td><td>3</td><td>4</td></tr>
<tr><td>Total</td><td>5</td><td>9</td></tr>
</table>
English
Illustrative image: “Cartoon takes your life; it’s a happy moment as a child. I like cartoon; it’s fascinating….I hate my picture there” **realistic image**: “I would love this one …someone is smiling and happy”
Spanish
Illustrative image: “not a cartoon, I want to take my own picture…”</td><td>Illustrative image
  </td><td>Realistic image
  </td></tr>
<tr><td>Task 2. My problem
UI preferences
<table>
<tr><th></th><th>Design A</th><th>Design B</th></tr>
<tr><td>English</td><td>0</td><td>7</td></tr>
<tr><td>Spanish</td><td>0</td><td>7</td></tr>
<tr><td>Total</td><td>0</td><td>14</td></tr>
</table>
English
Button + infographic: “Sneakers on the picture helps, very good! Icons help, more accessible. It liked to the reality (concept of exercise)”
Spanish
Button + infographic: “…are more interactive than photographs…”</td><td>Button
  </td><td>Button + infographic
  </td></tr>
<tr><td>Task 3. My goal
UI preferences
<table>
<tr><th></th><th>Design A</th><th>Design B</th></tr>
<tr><td>English</td><td>2</td><td>5</td></tr>
<tr><td>Spanish</td><td>3</td><td>4</td></tr>
<tr><td>Total</td><td>5</td><td>9</td></tr>
</table>
English
Fill in the blank: “when I woke up I know a lot in my head. I know what I want to do. I would rather do my own (write my own list)”
Spanish
Drop-down list: “What benefits everyone is a combination of the 2”</td><td>Fill-in-the-blank
  </td><td>Drop-down list
  </td></tr>
<tr><td>Task 4. My solution
UI preferences
<table>
<tr><th></th><th>Design A</th><th>Design B</th></tr>
<tr><td>English</td><td>0</td><td>7</td></tr>
<tr><td>Spanish</td><td>3</td><td>4</td></tr>
<tr><td>Total</td><td>3</td><td>11</td></tr>
</table>
English
Fill in the blank: “I prefer to write down. I know what I’m doing, what I want”
Infographic gallery: “I like to see icons. I am a visual kind of person. Maybe I am going to do (exercise). It gives little motivation…man I should be doing bicycling (when I watch icons). It reminds me what I should do. It gives me motivation”
Spanish
Infographic gallery: “I can see I can do...”</td><td>Fill-in-the-blank
  </td><td>Infographic gallery
  </td></tr>
</table>

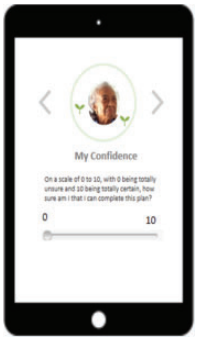
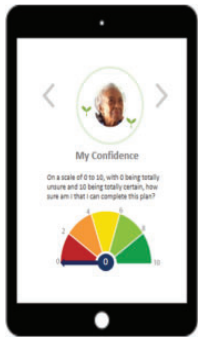
Table 2. continued

<table>
<tr><td>Task 5. My action: what

UI preferences
<table><tr><td></td><td>Design A</td><td>Design B</td></tr><tr><td>English</td><td>2</td><td>5</td></tr><tr><td>Spanish</td><td>1</td><td>6</td></tr><tr><td>Total</td><td>3</td><td>11</td></tr></table>English
Fill in the blank: “…I can only do this combined”
Infographic + slider: “Give you ideas…”
Spanish
Infographic + slider: “…prepares her mind to go do exercise…?”</td><td>Fill-in-the-blank
  </td><td>Infographic + slider
  </td></tr>
<tr><td>Task 6. My action: frequency

UI preferences
<table><tr><td></td><td>Design A</td><td>Design B</td></tr><tr><td>English</td><td>1</td><td>6</td></tr><tr><td>Spanish</td><td>1</td><td>6</td></tr><tr><td>Total</td><td>2</td><td>12</td></tr></table>Infographic + checkbox: “I like the check list…this is the goal to achieve…”
Spanish
Infographic + checkbox: “…I’m forgetful…perfect design for the people who have a memory problem”</td><td>Fill-in-the-blank
  </td><td>Infographic + check box
  </td></tr>
<tr><td>Task 7. My action: duration

UI preferences
<table><tr><td></td><td>Design A</td><td>Design B</td></tr><tr><td>English</td><td>1</td><td>6</td></tr><tr><td>Spanish</td><td>0</td><td>7</td></tr><tr><td>Total</td><td>1</td><td>13</td></tr></table>English
Infographic + structured format: “This one because it has a clock, it’s clear”
Spanish
Infographic + structured format: “It’s easier to mark on the clock”</td><td>Fill-in-the-blank
  </td><td>Infographic + structured format
  </td></tr>
<tr><td>Task 8. My confidence

UI preferences
<table><tr><td></td><td>Design A</td><td>Design B</td></tr><tr><td>English</td><td>3</td><td>4</td></tr><tr><td>Spanish</td><td>0</td><td>7</td></tr><tr><td>Total</td><td>3</td><td>11</td></tr></table>English
Slider: “…this one would be very simple…”
Infographic + slider: “…the other one will be confusing”
Spanish
Infographic + slider: “easier to move”</td><td>Slider
  </td><td>Infographic + slider
  </td></tr>
</table>

We asked informal caregivers to think aloud in their preferred language while participating in the usability evaluation. This approach invites participants to verbalize their thoughts while performing tasks on prototypes[40] and complements other strategies such as the forced choice preference assessment between Design A and Design B and open-ended questions. We observed directly and audio recorded caregiver interactions with the study materials. At the end of each evaluation, participants completed a Demographics & Technology Use Questionnaire, including personal characteristics, caregiver role information, and internet use items adapted from the Health Information National Trends Survey.[41]

Usability activity 1: features and functions. We used a physical activity self-management scenario to assess informal caregiver preferences in system features and functions. We showed each caregiver 8 pairs of paper-based "iPad" screenshots representing the mHealth app UI designs (see Table 2, tasks 1–8) and encouraged them to think aloud. Each caregiver was first asked to consider their preference for app personalization (*task 1*: Personalization). We simulated the process of self-management prescribed by Lorig and Holman[30] to assess caregiver preference for features and functions as well as the manner in which the caregivers completed the following: *task 2*: identify a health problem; *task 3*: identify a specific goal that addressed the health problem; *task 4*: create a list of solutions; *task 5*: create a plan to achieve a specific goal within their specified timeframe; *tasks 6 and 7*: prescribe the frequency and duration of task 5; and *task 8*: evaluate their ability or confidence to achieve task 5. For each task, we asked the following, "What is the system asking you to do?" "Which design do you prefer? and Why?" and "How would you improve this design?" At the conclusion of each task, we asked each caregiver if they preferred UI Design A or UI Design B.

Usability activity 2: functionality preferences. Usability Testing Activity 2 was comprised of 2 components assessing preferences for app functionality using an Apple iPad WI FI 32GB.

Component 1

To separate assessments of user preference for UI app functionality for problem-solving from self-management content, we used party planning as a scenario for interacting with the iPad. We guided each informal caregiver through a set of tasks (Table 3, iPad 1-6) associated with choosing and determining the elements of their party. The tasks in this scenario were intended to elicit caregiver's preferences related to the functionality of the system UI, for example, fill-in-the-blank vs drop-down list or using a hamburger button vs navigation tab. We repeated the questions asked in Usability Testing Activity 1 to capture further caregiver preferences for functional support of their problem-solving processes.

Component 2

The main task for caregivers in this generic scenario was to manage personal information and locate resources by using a voice query virtual assistant, namely Apple's Siri, or manually enter information (see Table 3, iPad 7 and 8). We included these tasks to meet the expressed needs identified in our participatory design sessions with caregivers.[31–33] When necessary, technical and verbal assistance was provided to all participants by the Certified Health Educator. We asked caregivers to schedule and cancel a future medical appointment using Siri. Then, using Siri and the Google Search Engine, we asked caregivers to find a nearby hospital. Next, we asked caregivers to manually create and delete in the Apple and Google calendars the same appointment they scheduled and cancelled using Siri. Lastly, we asked caregivers if they preferred voice command vs manual entry.

ANALYSIS

We used summary statistics to describe informal caregivers' personal characteristics, technology use, and mHealth app UI design preferences. We translated Spanish usability sessions into English prior to data analysis. We ensured the scientific adequacy of the qualitative procedures by: (1) involving multiple investigators in data collection and analysis, (2) conducting member checks with caregivers after each major usability activity, (3) producing verbatim transcripts for review prior to analysis, and (4) recording field notes of each usability evaluation peer debriefing.[42]

The 2 members of the research team (NST, SY), with master and doctoral degree preparation, respectively, and more than 10 years of experience each in qualitative methods, analyzed the transcripts using a descriptive content analysis approach to identify positive and negative feedback and caregiver's design preferences.[43] Field notes focused on user's preferences were taken by a member of the research team during each design session. After each design session, NST and SY debriefed over participant's reaction and preferences to the study material, and coded all transcripts. NST and SY met to discuss and come to agreement on coding differences. Using descriptive content analysis facilitates categorizing content into smaller groups or system requirements. We have used this approach to develop a web-based falls prevention self-management system for older adults and an mHealth app for caregivers of children with asthma and obesity.[36,44] Caregiver representative quotes related to ease of use are reported jointly with the preference results (see Table 3).

RESULTS

Family caregivers (7 English- and 7 Spanish-speaking) ranged in age from 53 to 86 years (mean 63.5 ± 8.7) and were predominantly high school graduates ($n = 8$), female ($n = 12$), and single ($n = 12$). Participants were or had been caring for a family member with dementia from 3 to 17 years (mean 8.4 ± 3.9). Nearly all study caregivers ($n = 12$) reported using the internet to look up health or medical information and belonged to a social media platform. Only 2 caregivers reported participating in an online support group for people with similar health issues and 4 said they used email or the internet to communicate with a doctor or doctor's office. Results of caregiver's design preferences are summarized in Tables 2 and 3. Because English- and Spanish-speaking participants may have culturally-specific information and/or communication needs, we report caregiver's design preferences by language.[45]

Features and functions preferences and PSD principles

Caregivers preferred mHealth app UI designs that were informed by a greater number of PSD principles, that is, Design B (see Tables 1 and 2). This was especially apparent for tasks 2, 5, 6, and 7 because nearly all English- and Spanish-speaking participants (ie 5–7 out of 7) preferred designs that were informed by more principles. However, with tasks 1, 3, 4, and 8, preference varied between English- and Spanish-speaking participants. In task 4, English-speakers had a clear preference for UI Design B (ie 7 vs none) while only 4 of the 7 Spanish-speakers preferred B over A. With task 8, there was an ab-

Table 3. User preferences for mobile application functions to support self-management tasks among Hispanic family caregivers of people living with dementia ($n = 14$)

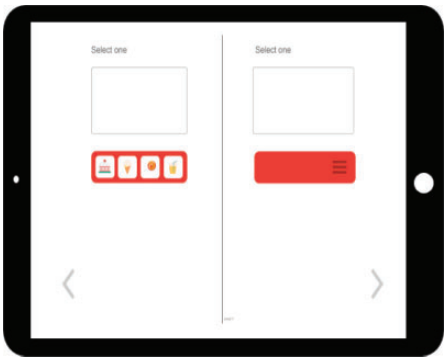
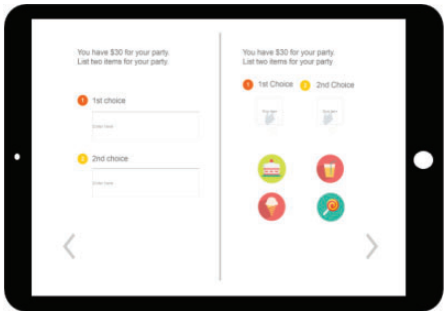
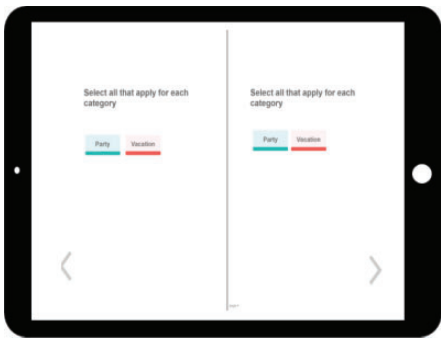
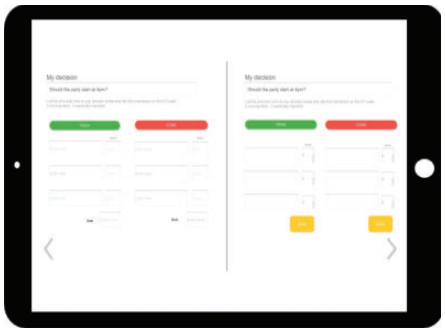
<table>
<tr><td colspan="3">iPad task 1: Listing</td><td>Drop-down list</td><td>Fill-in-the-blank</td></tr>
<tr><td></td><td>Function A</td><td>Function B</td><td colspan="2" rowspan="5">  </td></tr>
<tr><td>English</td><td>6</td><td>1</td></tr>
<tr><td>Spanish</td><td>6</td><td>1</td></tr>
<tr><td>Total</td><td>12</td><td>2</td></tr>
<tr><td colspan="3">English
Dropdown list: “More simple, it’s ready.”
Spanish
Type in: “it could be a very personal preference…I always write and plan.”</td></tr>
<tr><td colspan="3">iPad task 2: Choosing one</td><td>Navigation tab</td><td>Hamburger button</td></tr>
<tr><td></td><td>Function A</td><td>Function B</td><td colspan="2" rowspan="5">  </td></tr>
<tr><td>English</td><td>5</td><td>2</td></tr>
<tr><td>Spanish</td><td>2</td><td>5</td></tr>
<tr><td>Total</td><td>7</td><td>7</td></tr>
<tr><td colspan="3">English
Hamburger button: “I have little computer skills…but I usually use that [hamburger button].”
Spanish
Hamburger button: “nothing to select there…”</td></tr>
<tr><td colspan="3">iPad task 3: Choosing 2 and prioritizing</td><td>Fill-in-the-blank</td><td>Drag-and-drop</td></tr>
<tr><td></td><td>Function A</td><td>Function B</td><td colspan="2" rowspan="5">  </td></tr>
<tr><td>English</td><td>1</td><td>6</td></tr>
<tr><td>Spanish</td><td>2</td><td>5</td></tr>
<tr><td>Total</td><td>3</td><td>11</td></tr>
<tr><td colspan="3">English
Drag and drop: “So much easier to enter”
Spanish
Drag and drop: “why is not moving...needs more explanation”</td></tr>
<tr><td colspan="3">iPad task 4: Choosing multiples (a)</td><td>Infographic gallery</td><td>Infographic carousel</td></tr>
<tr><td></td><td>Function A</td><td>Function B</td><td colspan="2" rowspan="5">  </td></tr>
<tr><td>English</td><td>7</td><td>0</td></tr>
<tr><td>Spanish</td><td>6</td><td>1</td></tr>
<tr><td>Total</td><td>13</td><td>1</td></tr>
<tr><td colspan="3">English
Infographic gallery: “Because it’s all here…”
Spanish
Infographic gallery: “it’s more attractive to see all together”</td></tr>
</table>

Table 3. continued

<table>
<tr><td colspan="3">iPad task 5: Choosing multiples (b)</td><td>Vertical scrolling</td><td>Horizontal scrolling</td></tr>
<tr><td></td><td>Function A</td><td>Function B</td><td colspan="2" rowspan="4">  </td></tr>
<tr><td>English</td><td>3</td><td>4</td></tr>
<tr><td>Spanish</td><td>3</td><td>4</td></tr>
<tr><td>Total</td><td>6</td><td>8</td></tr>
<tr><td colspan="5">English
Vertical scrolling: “More professional…”
Horizontal scrolling: “Everything is there”
Spanish
Vertical scrolling: “like to see it go down, it’s easier to see”
Horizontal scrolling: “You don’t have to scroll down, everything is there”</td></tr>
<tr><td colspan="3">iPad task 6: Decision making</td><td>Manual calculation</td><td>Automatic calculation</td></tr>
<tr><td></td><td>Function A</td><td>Function B</td><td colspan="2" rowspan="4">  </td></tr>
<tr><td>English</td><td>0</td><td>7</td></tr>
<tr><td>Spanish</td><td>1</td><td>6</td></tr>
<tr><td>Total</td><td>1</td><td>13</td></tr>
<tr><td colspan="5">English
Manual calculation:“it depends on the individual capacity, professional level”
Auto calculation: “…Excel function…a little bit of help is a lot of help, I’ll use this”
Spanish
Auto calculation: “This is good…but this is confusing [yellow button]”</td></tr>
<tr><td colspan="5">iPad task 7: Make and delete an appointment</td></tr>
<tr><td colspan="3"></td><td>Apple calendar</td><td>Google calendar</td></tr>
<tr><td colspan="3">English</td><td>4</td><td>3</td></tr>
<tr><td colspan="3">Spanish</td><td>6</td><td>1</td></tr>
<tr><td colspan="3">Total</td><td>10</td><td>4</td></tr>
<tr><td colspan="5">English
Google calendar: “it looks like a lot it’s going on, like you know, things pop in, and having to you know that’s confusing if you’re not computer savvy”
Spanish
Apple calendar: “ …the second one was more comfortable…the information is more concentrated”</td></tr>
<tr><td colspan="5">iPad task 8: Locate nearby hospital and scheduling an appointment</td></tr>
<tr><td colspan="3"></td><td>Manual search</td><td>Voice query</td></tr>
<tr><td colspan="3">English</td><td>1</td><td>6</td></tr>
<tr><td colspan="3">Spanish</td><td>2</td><td>5</td></tr>
<tr><td colspan="3">Total</td><td>3</td><td>11</td></tr>
<tr><td colspan="5">English
Voice query: “I like this, I like this, this is better than typing it or writing it…”
Spanish
Manual search: “It's more practical than talking to a computer”</td></tr>
</table>

solute preference for UI B (ie 7 vs none) among Spanish speakers but not for English-speaking participants (ie 4 vs 3).

Design preferences

At least 3 out of 4 caregivers preferred a design that contained an infographic to support selecting an option(s) to identify a problem (task 2) and a solution to resolve the problem (task 4), and choosing specific actions and frequency and duration (tasks 5–7) in the self-management process. English- and Spanish-speaking caregivers remarked, respectively, “Sneakers on the picture helps, very good! Icons help, more accessible” and “Icons are more interactive than photographs.” Caregivers also preferred the use of an infographic design to evaluate confidence (task 8) suggesting that “the other one (ie slider feature without an infographic) will be confusing” [English-speaking] and the slider feature with an infographic is “easier to move” [Spanish-speaking]. When caregivers were presented with paired UI designs that did not contain an infographic option (tasks 1 and 3), the distribution of their preferences were not as clear.

Functionality preferences

When caregivers were presented with party planning problem-solving and generic scenarios (iPad tasks 1, 3, and 8) that included an option to type information on the iPad, both English- and

Spanish-speaking participants preferred the using a drop-down list, drag-and-drop, and voice query function (Table 3). English- and Spanish-speaking caregivers in general found the alternatives to fill-in-the-blank "more simple… (ie drop down)," "so much easier to enter (ie drag and drop)," "…this is better than typing it… (ie voice query)." When the only option was to manually input or delete information (iPad task 7), more Spanish-speaking caregivers preferred the Apple calendar. English- and Spanish-speaking caregivers had clear but opposite preferences with using a navigation tab vs hamburger button to choose one option from many (iPad task 2). Neither English- or Spanish-speaking participants had a clear preference for vertical or horizontal scrolling to make multiple choices among various options (iPad task 5). When presented with an infographic gallery and infographic carousel function and asked to make multiple choices (iPad task 4), nearly all participants preferred the gallery function. English- and Spanish-speaking participants provided similar reasons for their preference, respectively, "because it's all (ie the options) here" and "it's more attractive to see all together." Caregivers were almost in complete agreement on the use of some automation to support decision making (iPad task 6) suggesting, "a little bit of help is a lot of help."

DISCUSSION

In this evaluation of Hispanic informal caregivers' preferences and perceptions regarding an mHealth app, we tested paired app UIs that were informed by PSD principles and self-management concepts.[1,30,46,47] There is a compelling public health need for the design of technology-enabled interventions that support self-management behaviors of informal caregivers' health and health care needs considering they are the backbone of long-term care in people's homes.[48] Our evaluation provides the first results of using PSD principles to develop an mHealth app UI aimed at motivating and enabling Hispanic informal caregivers' self-management behaviors.

Features and functions preferences and PSD principles

Hispanic informal caregivers preferred an mHealth app UI that incorporated more PSD principles (Design B in our study). Design B included 5–8 principles per task in contrast to 4–6 for Design A. Participant's preferences could have be confounded by other factors, such as their experience with mHealth apps, as well as other individual experiences with technology use and self-management. Like other mHealth- and eHealth-based intervention tools, Primary Task Support was the most represented PSD category in our app UI.[5,49] Given the small number of participants, we could not assess whether a linear relationship existed between the number of principles and user preferences. While our findings are encouraging, it is still unclear how many PSD principles should be used to yield the best possible outcomes.[7] Moreover, the combination of PSD principles could also exert differential results on a targeted behavior.

mHealth app UI design features and functions for facilitating persuasive self-management in this study reflected each PSD category of principles.[1] This approach is congruent with studies that integrated behavioral theory and PSD principles in the development of web-based and mHealth systems.[8,9] Our research contributes to the evolving literature in this regard.[6] However, a recent systematic review of web-based and eHealth interventions for older adults with chronic conditions revealed that the use of at least one principle from Primary Task and Dialogue Support categories characterized interventions that positively affected self-care, daily functioning, blood pressure control, lifestyle behaviors, and disease knowledge.[50] Depending on the targeted self-management behavior, it may be possible to implement PSD principles within some but not all PSD categories and still achieve significant caregiver outcomes.[7] Additional research is needed to understand how best to apply a PSD approach that can be targeted to different behavior targets.

Design preferences

Few mobile technologies that target behavior change to manage problems, make decisions, plan actions, and create solutions have been developed based on understanding the requirements of informal caregivers. We found that English- and Spanish-speaking caregivers preferred automated functions rather than manual fill-in-the-blank features to prioritize, choose, make decisions, and search. This may reflect caregiver's need for time-saving, quick approaches to meet self-management goals which can be super-imposed on the caregiving role.[51,52] Orji et al.[53] found that manual recording can be tedious and time consuming for people with mental health conditions.

Caregiver's preferences including navigation tab vs hamburger button; vertical vs horizontal scrolling; and infographic gallery vs infographic carousel, varied between English- and Spanish-speaking participants even though overall they preferred one function to another in general. Heimgartner found significant differences with the use of a simulated automobile navigation system displayed on a personal computer between Chinese, German, and English-speakers.[54] It is possible, as Heimgartner suggests, that the variation in our findings is due to subconscious differences fixed by primary culture or language which can result in different human computer interactions independent of user's conscious cultural identity and/or attitudes. Moreover, identifying differences in "cultural interaction indicators" (eg number of movements on a screen, number of breaks in continuous movement, speed of movement, number of taps on a screen, number of interaction breaks, and number of accepting or refusing alerts) could provide evidence to inform the development of an adaptive mHealth system based on underlying cultural characteristics of caregivers.

English- and Spanish-speaking informal caregivers preferred a UI design that included a "real-world feel" and did not demand a lot of effort. A design that incorporates a real-world feel reinforces system credibility of content or functions.[1] Adding primary task and dialogue support principles to the design could reduce complexity and enable caregivers to generate self-management goals with minimal effort.[1,50] Users judged the app UI designs as easy to use. At least 11 of the 14 caregivers preferred a UI design that incorporates expertise and appears personally meaningful and attractive. Caregiver's assessment of an mHealth app UI can be enhanced by using system credibility and dialogue support principles to motivate curiosity and reinforce the caregiver role.[1,50] Future research should investigate whether the UI design that caregivers preferred would support adherence to self-management principles that result in positive outcomes.

Functionality preferences

There is limited evidence on preferences for app functions in the design process of mHealth self-management. This type of assessment focuses on how the system behaves when used by consumers. Caregivers preferred automated functions to other options, including drop-down lists, drag-and-drop, and infographic gallery but were in

less agreement about how to manage activities and vertical or horizontal scrolling to review content. In a qualitative study of healthy young adults, Dennison and colleagues found, as we did, that users preferred an app that was low effort and automated.[55] Our app functionality assessment allowed us to determine preferences for UI designs and app functions. Additional research is needed to determine if caregiver's preferences for automated functions that support an app and requires low effort can improve caregiving outcomes.

Limitations

Our study had multiple limitations. While we had a sufficient number of English- and Spanish-speaking caregivers in our study to detect major UI usability issues,[56] our sample was not representative of Hispanic informal dementia caregivers. We included 2 subgroups (ie Puerto Rican and Dominican) of the Hispanic diaspora. Because our purpose was not to establish generalizability of our UI design, we are not certain whether these findings could apply to non-Hispanic caregivers. We focused on evaluating perceptions and preferences regarding the features and functions of an mHealth app UI. As another limitation, the verbalizations of caregivers during the think aloud process may not reflect their actual thoughts but did provide useful information about perceptions and preferences. Even though participants judged the UIs as easy to use, their judgments should not be interpreted to mean the use of the UIs within a digital platform will be judged similarly by other informal dementia caregivers. While greater than 3 years has passed since we conducted this research, our results remain relevant as researchers continue to reveal that informal dementia caregivers face significant challenges with emotional and social well-being and physical health and chronic health conditions.[10]

CONCLUSION

Our use of PSD (including primary task, dialogue, system credibility, and social support principles) to create an mHealth app UI will be applied to the development of a fully functional tailored system that can motivate and enable informal caregivers' self-management behaviors. We found that English- and Spanish-speaking Hispanic informal dementia caregivers agreed mostly about their preferences for the design, features, and functions of a self-management mHealth app. This includes preferences for a system design that incorporates a "real-word feel" and expertise, appears personally meaningful and attractive, and supports app use with automated functions. The targeted use of PSD principles has the potential to support personalized self-management problem identification, goal setting, decision-making, and action planning.

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AUTHOR CONTRIBUTIONS

All authors have contributed sufficiently and meaningfully to the conception, design, and conduct of the study; data acquisition, analysis, and interpretation; and/or drafting, editing, and revising the manuscript.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *JAMIA Open* online.

CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY

The data underlying this article cannot be shared publicly due to the privacy of individuals who participated in the study. The data may be shared on reasonable request to the corresponding author.

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