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Home safety hero: testing reaction time differences among teen mothers for single versus multiple game play

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Abstract

The purpose of this pilot study was to examine *Home Safety Hero* an innovative serious game simulation designed to train parents on home safety risks and how to resolve those risks. The aim of this research was to compare whether the reaction times for multiple plays of *Home Safety Hero* would improve identification, with or without distraction, and resolution of hazards would improve when compared to single play. Participants were 19 parenting teens (M_{age} = 17.66 years, SD_{age} = 0.80 years; 100% female) who completed questionnaires on their demographics, frequency of game use, and their engagement with the game simulation and content. Teens were divided into two groups, one (n = 8) that played the game once and the second (n = 11) that played the game four times over a one-week period. Engagement data indicated no differences between the group of teens, suggesting that they found the game engaging even if they played it multiple times. Teens were faster at spotting risks in the home and were quicker at acting when encountering risks after playing the game four times when compared to teens in the single play group. *Home Safety Hero* shows promise for promoting home safety knowledge and resolution.

Keywords Serious games · Simulation · Home injury · Injury prevention · Teens · Teen parenting

Falls, cuts, burns, poisoning, near suffocations, and near drownings account for most unintentional home injuries treated in emergency rooms in the United States and they cost $211 billion in 2013 to treat (Safe Kids Worldwide, 2013; Zonfrillo et al., 2018). Preventing childhood injuries is important because such injuries are linked to long-term physical, cognitive, and emotional impairments (Rhodes & Iwashyna, 2007). Injury rates are increased in single parent families, when parents are young (i.e., teens), reside in disadvantaged neighborhoods, and lack supervision (Azar & Weinzierl, 2005; Kendrick et al., 2005; Landen et al., 2003; Morrongiello & Schell, 2010; Strobino et al., 1992). Consequently, prevention research targeting inadequate supervision are vital for helping to reduce the incidence of childhood injuries. Many childhood injuries occur in the household and adults play an essential role for preventing these injuries.

Because adults play an essential role in preventing injuries, parental training aimed at promoting home safety is important, as well as training that promotes autonomy and improves engagement with the intervention. Utilizing a game-based approach to injury prevention might better provide parenting skills for reducing children's injuries. The purpose of the present study was to examine the potential of an injury prevention serious game simulation (*Home Safety Hero*) to promote learning about and resolving household hazards. In this pilot study, we examined teen parents' reaction times to identify and resolve hazards in *Home Safety Hero*; we were particularly interested in whether playing the game multiple times might improve reaction times for identifying and resolving hazards when compared to playing the

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game one time only. To this end, we conducted a small randomized control trial to compare reaction times of a single game play group to a multiple game play group. Engagement with *Home Safety Hero* was also examined and compared across the groups.

Teen parents and home injuries

Research indicates that the children of teen parents are at greater risk of home injury when compared with parents in other age groups (Barczyk et al., 2015; Jordan et al., 1993; Taylor et al., 1983). Young children of teen parents are particularly at risk of home injury and hospitalization because they are often raised in families with greater social isolation, fewer resources and social support, and more family disorganization and conflict (Agran et al., 2004; Kendrick et al., 2005; Rhodes & Iwashyna, 2007; Strobino et al., 1992). Furthermore, limited supervision, lack of safety protection devices, and failure to remove safety hazards further increase the risk of injury among young children of teen parents (Robertson et al., 2014).

Ultimately, teen parents could use parenting skills, particularly about home safety. Many teen parents learn about such skills from their own mothers (Bennett Murphy, 2001; Yuma-Guerrero et al., 2013). Although grandparents might be more than willing to provide home safety knowledge to their parenting teens, the quality and nature of the advice concerning child safety practices are often outdated (e.g., placing babies to sleep on their stomachs) and do not provide safe injury prevention recommendations (e.g., placing babies to sleep with soft bedding in the crib; Yuma-Guerrero et al., 2013). Such well-meaning but dangerous advice from grandmothers is even more concerning when considering that one study found that none of the teenaged mothers in the study reported that they received injury prevention information from primary care physicians or pediatricians (Bennett Murphy, 2001). Therefore, it is crucial to provide parenting teens with the best child safety practices.

Parental injury prevention interventions

Traditionally, parental injury prevention interventions rely on instructional materials presented in pamphlets, consultations, and internet instruction (Kendrick et al., 2007; Nansel et al., 2008; van Beelen et al., 2014). Oftentimes home injury interventions are part of a broader program designed to promote child well-being (e.g., Olds et al., 2007); embedding home injury prevention programs within a larger program make it difficult to determine whether the specific child safety information decreased child injuries. Some behavioral interventions delivered in the home have high attrition, limited engagement, and utilize a lot of human resources (Duggan et al., 2000). Furthermore, home visiting programs have greater attrition in contexts that might increase injury rates, such as parenting teens' homes. Negative biases among providers concerning specific parent populations, such as parenting teens, also negatively impact the reach and influence of parenting programs.

Technology might help to remedy some of these issues, although incorporation of technology into injury prevention interventions has been slow. Technology has the potential to enhance service delivery, ensure fidelity, improve engagement, and extend the reach of the program at a lower cost. Previous studies using computer software or web-based methods to tailor injury prevention and child safety information to parents have been effective for increasing knowledge (van Beelen et al., 2014). These programs typically assess only one or a few hazard types (e.g., burns). Serious games also have the potential to overcome processes that might hinder learning and retention, including the ability to tailor instruction to parents' needs and characteristics (Kim et al., 2012). Defined as a game designed for something other than entertainment, serious games involve empirically derived principles to promote learning through rewarding progress, storylines, repetition, and realistic simulation (Cook et al., 2013; de Freitas & Liarokapis, 2011; Knowles et al., 2014; Mozelius, 2014; Whyte et al., 2015). Furthermore, research has shown that serious games have the potential to improve adults' real-world behaviors in the context of learning skills in healthcare settings (e.g., see Ricciardi & De Paolis, 2014 for review), sports (Wiemery, 2010), resiliency among older adults (Yoon, 2014), and fire evacuation (Sacfung et al., 2014). Thus, serious games have the potential to cut costs over time and in the long run, reduce caseload burden, diminish biases associated with needing help and services, and improve engagement (Azar et al., 2019).

Serious games might be particularly helpful for parenting teens. They might have difficulty with or a lack of access to traditional in-person parent training; these teens might benefit from serious games for parent training. Furthermore, because many teens utilize technology, serious games might help deliver child safety practices through a relatable mechanism. Parenting teens are also often stigmatized, which might increase their reluctance to seek help from medical personnel who have the most up-to-date child safety practices. Serious games are effective for educational purposes, and it might be an effective medium for parenting teens to learn about injury prevention (Zhonggen, 2019).

Home Safety Hero

The pilot research examined the serious game, *Home Safety Hero*, as a promising tool to promote parenting

teens' understanding of home safety risks and how to resolve those risks. *Home Safety Hero* is designed to help parents learn parenting skills in a safe environment without placing children at risk (Azar et al., 2018). It was also designed to promote parental autonomy and agency in their own learning. The game was designed to compensate for low literacy by including voiceovers and making learning contextualized (i.e., storyline) to improve engagement (Azar et al., 2019).

There are four main pillars of cognitive science used as a framework for learning, including attention, active learning, feedback, and consolidation (Dehaene, 2013). These pillars were used when designing the storyline, levels, and features of *Home Safety Hero*.

Attention is defined as being alert while learning is occurring, with some level of arousal (Baldi & Bucherelli, 2005). Arousal is necessary to aid in the acquisition of knowledge. In serious games, attention is maintained through graphics (i.e., in the rooms, hazards) and sounds (i.e., music, sound effects for hazards). While playing *Home Safety Hero,* animations (e.g., steam of a kettle, moving water in the bathtub) are provided to also maintain attention. Human-voice voiceovers provide encouragement to train players on why risks are dangerous and maintains players' engagement and alertness; the background music and unique sounds for hazards also serve this purpose. Fostering engagement in *Home Safety Hero* is an important element of the game because of its positive effects on learning (Hamari et al., 2016).

Active learning was the second aspect of *Home Safety Hero's* design. Active learning engages learners in the process of learning through activities (Freeman et al., 2014). To this end, *Home Safety Hero* was designed to be interactive and to increase learning effectiveness (Sitzmann, 2011). This is accomplished by allowing players to navigate the game with interactive content, such as having hazards disappear, and sounds and animations when hazards are clicked. Players are further immersed in the content through an engaging storyline that places them as a "hero" trying to save children from hazards in the household. The game also allows players to interact with answer selections by deciding what "solution" they would perform to remove hazards.

Feedback is an important element of serious games (Pritchard et al., 1988). *Home Safety Hero* incorporates tailored feedback based on the specific hazard and solutions chosen. Incorrect responses or identification of a hazard trigger feedback that is tailored to players' specific responses; players can also select another resolution option if their first response was not correct, and if that response is still not correct, they receive tailored feedback about why their choice was not correct and what the correct choice was. *Home Safety Hero* includes a progress bar, scoring, and achievements (i.e., stars) that provide additional feedback to players (Lameras, 2015).

Multiple training sessions through serious games are critical for memory consolidation (Wouters et al., 2013). "Spaced training" involves "spacing out" learning so that there is time for learning to "sink in". Serious games allow for such spaced learning to enhance memory consolidation (Vlach et al., 2008). Furthermore, memory consolidation is further enhanced through the possibility for serious games to include repetition and reinforcement (Goverover et al., 2009). *Home Safety Hero* includes multiple trails (i.e., various levels and phases) and learning materials in different formats to promote repetition.

The present study

The first aim of this pilot study was to conduct a small-scale randomized control trial with *Home Safety Hero* to determine if the game promotes learning through identification of hazards, with or without distraction, and the resolution of hazards. Teens' reaction times to identify and resolve hazards were recorded by the game; teens were randomly assigned to either a single play group or a multiple play group (four times total). The single play groups' reaction times were compared to the reaction times for the first, second, third, and fourth play of the multiple play group. Home safety injury prevention programs focus on improving hazard identification and resolution of those hazards (e.g., Senthilkumaran et al., 2019; Warda et al., 1999), and reaction time can be used to provide an assessment of how effective learning was (e.g., quicker reaction time is seen as translating into better learning).

Another second aim was to examine teens' engagement with *Home Safety Hero.* Engagement is important and thus we assessed engagement by asking for ratings of teen's engagement with the game which will be used for future improvements of the game. In addition, we will compare engagement across the two groups to examine whether multiple plays might reduce engagement with the game. Because they play the game multiple times, they might become bored with the content and disengage.

Method

Participants were 19 parenting teens ($M_{age} = 17.66$ years, $SD_{age} = 0.80$ years; all female) from an urban city in Central Pennsylvania. Approximately 85% of teens self-identified as white and non-Hispanic, 5% as white and Hispanic, 5% as Black and non-Hispanic, and 5% as mixed. Most teens' income or family income was $35,001 to $40,000 / year. Seventy-five percent of teens were single, 20% lived with a partner, and 5% had another arrangement. All teens had one child, with an average age of 0.64 years (SD = .77) and ages ranging from 2 months through 2.05 years. Teens were

enrolled in a parenting teens program affiliated with a local school district. The parenting program provides teens with parenting education classes, and it helps students who are parents or about to become parents complete their high school education.

Procedure

The authors' university's Institutional Review Board approved the study and APA standards were followed throughout the study. The study was also approved by the school district. Research personnel and program staff held a meeting to discuss the study's purpose, what teens would be expected to do, and the consenting and assenting procedures. Consent documents were distributed to teens who were 18 years of age or older ($n = 11$) and parental permission slips were distributed to teens under the age of 18 ($n = 8$) who indicated to program staff that they were interested in the study. Parental permission slips and consent documents were returned to the school. After all documents were collected, teens were randomly assigned to one of two conditions (single play group versus multiple play group). During data collection, research personnel visited teens three times on separate days within two weeks. We held three separate meetings with teens to space their participation in the study to reduce participant fatigue.

First visit At the first visit, teens under the age of 18 provided their assent and teens 18 years of age or older confirmed their consent. None of the teens declined. They were also informed of their rights as participants. During the first visit, teens completed the demographics information and the *Technology and Game Use* questionnaire.

Second visit The second visit occurred within three days of the first visit. For the second visit, teens played the *Home Safety Hero* game for the first time on a laptop supplied by the researchers. Teens in the "single play group" did not play the game again. At end of this visit, "multiple play group" teens were given information on how to access the game on the laptop provided to them and practiced this step. In addition, a tentative schedule was developed for these teens to play the game an additional three times over the next seven days. Laptops were left in a locked cabinet in the offices of the teen parenting program for this group. Teens asked program staff for the key. Contact information for research personnel was provided if there were any issues with the operation of the laptops or game. No issues came up.

Third visit The third visit took place approximately one week after the second visit. For the third visit, both groups of teens completed the *User Engagement Survey* questionnaire. They were also given payment for completing the study. Teens' data were downloaded from the laptops directly.

Materials

Demographics Teens were asked questions about their age, sex/gender, ethnicity, personal and/or family income, the age of their child, and whom they lived with. This questionnaire was administered during the first visit.

History of game play Teens completed the *Technology and Game Use* questionnaire; four open-ended items about how many hours per week they played games on a computer, smartphone, tablet, and gaming console were included on this questionnaire. Teens wrote in the number of hours they played games on each of these devices. These items were averaged to form a score on the frequency of game play, with a Cronbach's alpha of .88. This questionnaire was administered during the first visit.

Engagement One subscale ("Perceived Usability") was used from the *User Engagement Survey* to assess teens' engagement with the game (O'Brien & Toms, 2009). All teens, regardless of condition, completed this questionnaire during the third visit. Teens rated the eight items (e.g., Playing the game was mentally taxing) on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*) regarding how much they were engaged with the game. The items were averaged to form a final score on engagement. Cronbach's alpha was .83.

Home safety hero

Design Unity 3D was used to program *Home Safety Hero*. The game was designed to target common fatal and non-fatal injuries among young children, including burns, falls, suffocation, drowning, cuts, firearms, and poison (CDC, 2018). During game play, teens navigate virtual rooms in first-person to identify risks, with and without distraction, and resolutions (see Fig. 1 for game play visuals in the three phases). There are six virtual rooms: kitchen, bedroom (two different versions), living room, hallways, and bathroom (see Fig. 2 for illustrations of rooms). To reduce clutter and make identification easier for learning purposes and to reduce frustration, rooms were designed with minimal furniture and other items. Images of hazards were similar across all levels and phases, with randomization in different locations within the rooms. Hazards are not repeated within a level. To complete a level, teens must find all hazards or resolve hazards in the level before time runs out. Each level is approximately two minutes long and for each correct identification or resolution 15 seconds are added to the timer. Progression to the next level is only possible when all hazards are found in the

Fig. 1 Images of game play for identification, resolution, and distraction phases. **A**. Image of game play from identification phase showing the yellow triangle hint for the burning cigarette hazard. The time-bar is on the right. **B**. Image of game play from resolution phase after selecting the detergent soap hazard. Icons for what should be done to resolve the hazard are listed on the right. **C**. Image of game play from distraction phase showing hazards surrounding an image of a child. Hazards surrounding the child must be selected first

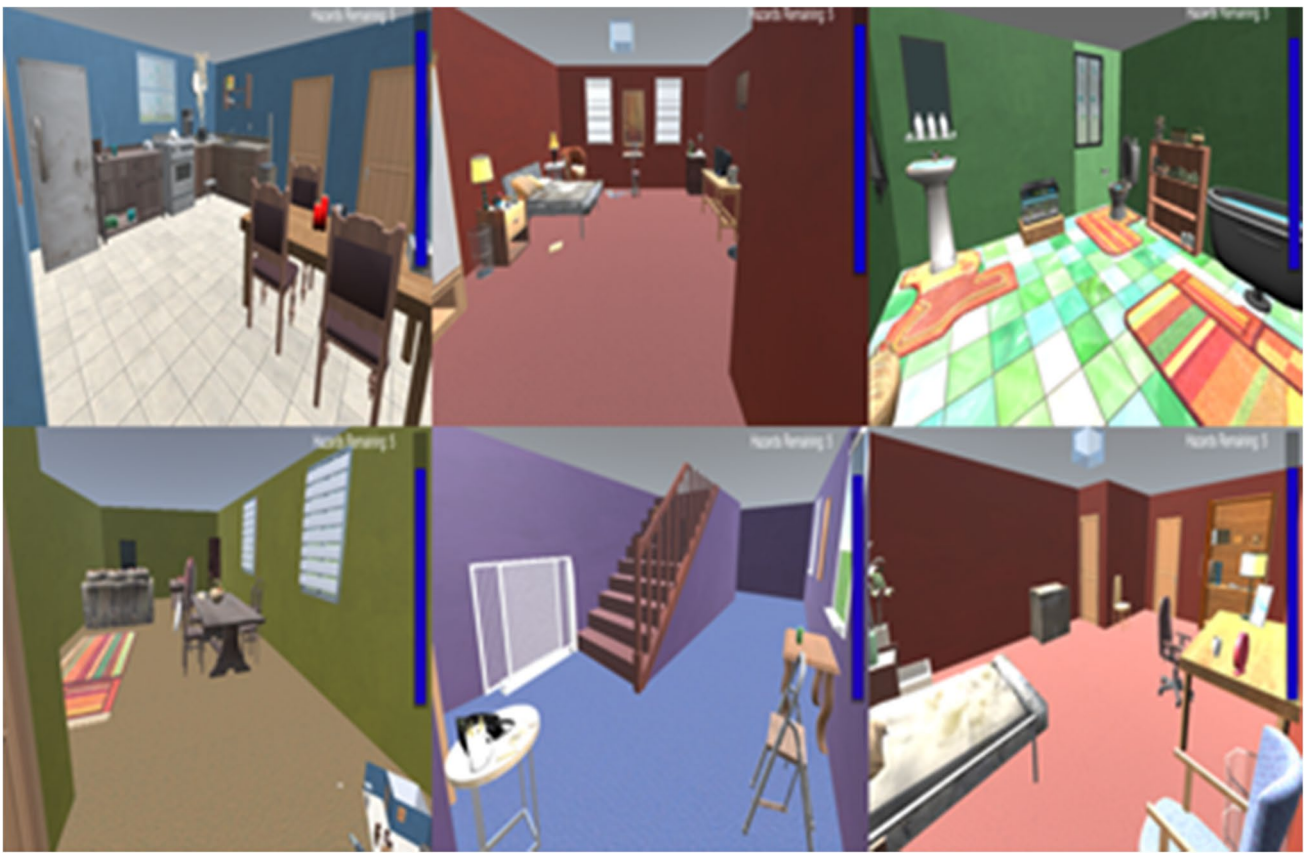

Fig. 2 Images of the six room designs in home safety hero

previous level. The game includes three phases: Identification (30 levels), Resolution (12 levels), and Distraction (12 levels). We developed phases based on recommendations for how to learn new skills through practice. Such learning involves selecting appropriate actions, which is present in the Identification and Distraction Phases (Diedrichsen & Kornysheva, 2015; Wolpert & Landy, 2012), as well as executing those learned actions (Resolution Phase; Muller & Sternad, 2004; Reis et al., 2009; Shmuelof et al., 2012). Prior to beginning the levels, teens are presented with a storyline that different monsters (e.g., Burn Monster) have placed hazards in the house with the intention to harm hypothetical

children. The monsters are described to provide teens with various examples of different hazard types. In the levels, a hazard counter and a progress bar are provided to increase parental engagement. At the end of levels, congratulations screens are included to also increase parental engagement with the game. Teens can stop levels and return to where they left off, although teens played all three phases in one session.

Identification phase In this phase, teens locate hazards in the levels and then click on those hazards. There are three blocks of levels for finding five hazards (e.g., all burn hazards), seven hazards, and 10 hazards. At level 18, the hazards are mixed up (e.g., burn hazards with poison hazards) in four blocks of levels for finding four hazards, six hazards, eight hazards, and 10 hazards. Designing levels by hazard type and increasing the number of hazards per levels provide a scaffolded learning experience for teens by slowly increasing level difficulty and promoting mastery (Azar et al., 2018b).

Resolution phase This phase involved teens finding hazards and then selecting the best choice for resolving the hazard. Once teens selected a hazard, text appeared, and a voiceover described what the hazard is and acknowledges that they are concerned with the hazard being in the home. On the right-hand side of the text, teens were presented with four possible icons for dealing with the hazard, including doing nothing, putting the hazard out of reach, locking it up, or telling the child to avoid the hazard without removing it (see Fig. 3).

Distraction phase In this phase, teens located hazards, like the Identification Phase, while also being distracted by sounds and/or information they were asked to memorize. This phase included four blocks of levels, where difficulty of the distraction and amount of memorized information increased. The levels ranged from asking parents to click on hazards while they hear a distracting sound (e.g., premature baby crying) to clicking on hazards while a child moves around the room, trying to resolve hazards nearest to the child first, and being asked to remember information from a phone call (e.g., location of a picnic).

Data recorded For all phases, reaction times for finding each hazard per number of hazards in the level were recorded, along with number of times they clicked a hazard while accounting for the total number of hazards in the level (called "clicks") and total number of fails (i.e., measured as running out of time in the level). For the Resolution Phase only, total number of incorrect solutions was also recorded. For the Distraction phase only, total number of incorrect answers was also recorded.

Data preparation and analytic plan

Game play Descriptive statistics were calculated for number of fails and ratio of clicks per level. There were 216 hazards across all levels in the Identification Phase, 48 for Resolution Phase, and 120 for Distraction Phase. The ratio of clicks is divided by the total number of hazards to provide a final number; numbers closer to one for clicking indicates a rate of clicking similar to the total number of hazards in the levels. This number provides information about whether teens were randomly clicking hazards or other places in the game. Percentages were computed by dividing the number of correct solutions or correct answers by the number of incorrect solutions or incorrect answers to form final scores.

To calculate reaction times for game play, the average total time to identify or resolve hazards while accounting

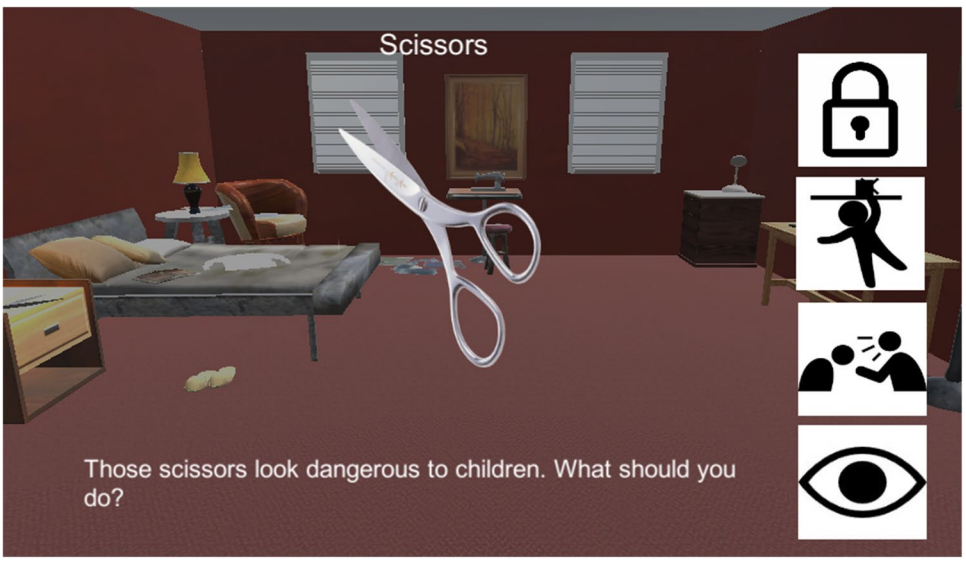

Fig. 3 Image of the resolution options

for the total number of hazards per level were calculated for each play and across the Identification, Resolution, and Distraction phases. There was one score for "single play group" per phase, and four scores per phase for the "multiple play group". Means and standard deviations are included in Fig. 3 for Identification and Distraction Phases and Fig. 4 for Resolution Phase. We conducted three one-way Analysis of Variances (ANOVAs) to compare the first play of the "single play group" to the fourth play of the "multiple play group" across three phases, while accounting for teens' history of game play. Similarly, we utilized one-way ANOVAs to compare first play of the "single play group" to the second and third plays of the "multiple play group" across all three phases (Fig. 5).

Engagement To assess teens' engagement with *Home Safety Hero*, the mean and standard deviation were calculated for the *Perceived Engagement* subscale. We conducted an independent samples *t*-test to compare both groups on their perceived engagement with *Home Safety Hero.*

Results

Game engagement

Engagement data indicates that teens found the game engaging, regardless of their condition ($M = 4.36$, $SD = 0.49$, range: 3.33 to 5.00). When comparing the "single play group" ($M = 4.37$, $SD = 0.53$, range: 3.33 to 5.00) to the "multiple play group" ($M = 4.35$, $SD = 0.49$, range: 3.83 to 5.00), the independent samples t-test revealed no differences in engagement between the groups, $t(17) = 0.08$, $p = .939$.

Game descriptive statistics

Only one teen failed a level because she ran out of time and was unable to find the fifth hazard. Descriptive statistics for clicks, number of correct solutions, and number of correct answers are presented below for the groups separately.

Single play group clicks and incorrect solutions and incorrect answers For the Identification Phase, the average number of clicks for their only play was 1.90 ($SD = 0.39$). For the

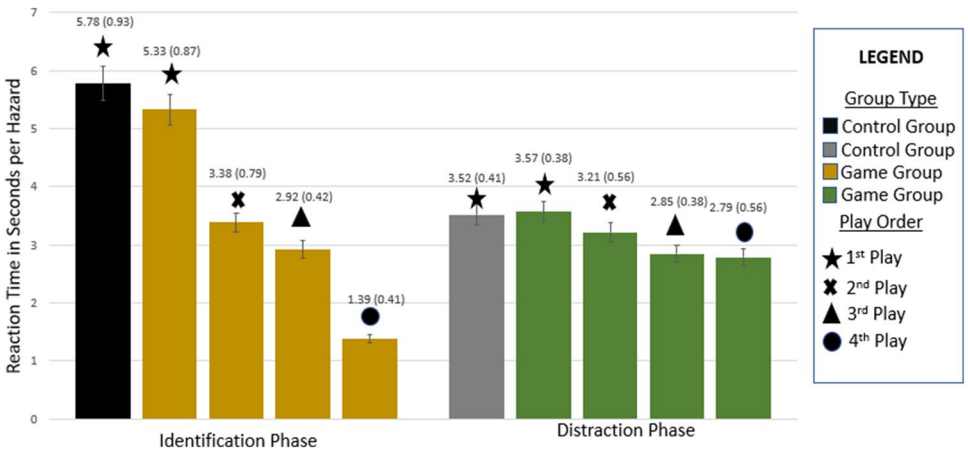

Fig. 4 Means (standard deviations) for identification and distraction phases

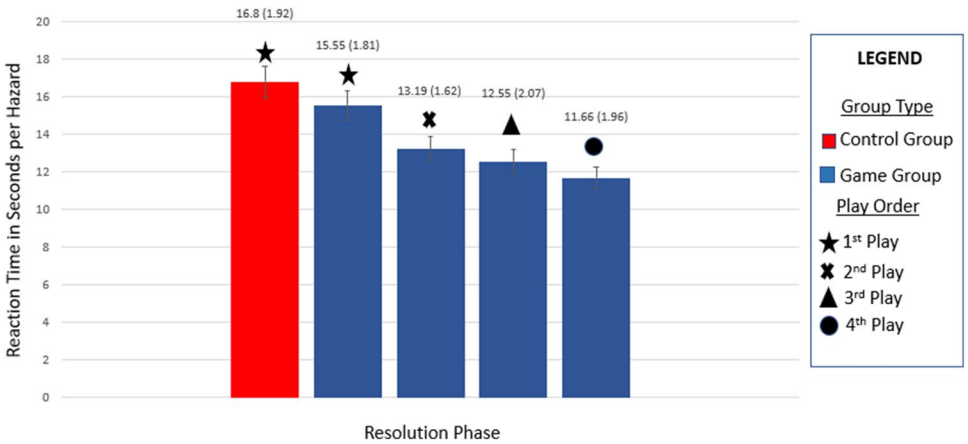

Fig. 5 Means (standard deviations) for identification and distraction phases

Resolution Phase, the average number of clicks for their only play was 1.72 (*SD* = 0.40). For the Distraction Phase, the average number of clicks for their only play was 1.42 (*SD* = 0.18). Incorrect solution for the Resolution Phase was 21.58%. Incorrect answers were provided 3.93% for the Distraction Phase.

Multiple play group and incorrect solutions and incorrect answers For the Identification Phase, the average number of clicks for the first play was 1.89 (*SD* = 0.41), the second play was 1.74 (*SD* = 0.18), the third play was 1.71 (*SD* = 0.14), and the fourth play was 1.36 (*SD* = 0.15). For the Resolution Phase, the average number of clicks for the first play was 1.73 (*SD* = 0.36), the second play was 1.23 (*SD* = 0.10), the third play was 1.21 (*SD* = 0.10), and the fourth play was 1.19 (*SD* = 0.11). For the Distraction Phase, the average number of clicks for the first play was 1.43 (*SD* = 0.18), the second play was 1.11 (*SD* = 0.12), the third play was 1.09 (*SD* = 0.10), and the fourth play was 1.09 (*SD* = 0.12). Incorrect solutions for the Resolution Phase were 21.58% for the first play, 17.36% for the second play, 13.44% for the third play, and 12.5% the fourth play. Incorrect answers for the Distraction Phase were provided 4.17% for the first play, 3.33% for the second play, 2.08% for the third play, and 0.83% the fourth play.

Game play reaction time

Comparison of the first play between the groups There were no main effects of group found for the Identification Phase, $F(1,17) = 1.05$, $p = .319$, Resolution Phase, $F(1,17) = 1.38$, $p = .256$, and Distraction Phase, $F(1,17) = 1.67$, $p = .201$, while controlling for history of game play.

Comparison of second, third, and fourth play for the multiple play group to the first play of the single play group Significant main effects of group were found for the Identification Phase, $F(1,17) = 144.50$, $p < .001$, $\eta 2 = .04$, the Resolution Phase, $F(1,17) = 22.34$, $p < .001$, $\eta 2 = .03$, and the Distraction Phase, $F(1,17) = 4.73$, $p = .043$, $\eta 2 = .02$, while controlling for history of game play (see Table 1). Comparison of the first play for the "single play group" and the fourth play for the "multiple play group" revealed that the "multiple play group" were significantly faster for their fourth play when compared to the first play for the "single play group" across all phases. Similar patterns were also found when comparing the second play with the first play of the "single play group" (Identification: $F(1,17) = 32.05$, $p < .001$, $\eta 2 = .03$; Resolution: $F(1,17) = 12.26$, $p = .003$, $\eta 2 = .02$) and third play with the first play of the "single play group" (Identification: $F(1,17) = 61.06$, $p < .001$, $\eta 2 = .04$; Resolution: $F(1,17) = 14.70$, $p < .001$, $\eta 2 = .02$; Distraction: $F(1,17) = 6.05$, $p = .024$, $\eta 2 = .02$). In addition, the "multiple play group" was faster for the fourth play versus the first play of the "single play group" across all phases (Identification: $F(1,17) = 144.50$, $p = .001$, $\eta 2 = .06$; Resolution: $F(1,17) = 22.34$, $p = .001$, $\eta 2 = .03$; Distraction: $F(1,17) = 4.73$, $p = .043$, $\eta 2 = .02$). Such findings indicate that reaction times were significantly faster for the "multiple play group" in the second and third plays when compared to the first play of the "single play group". For the Distraction Phase, the model for the second play of the "multiple play group" and the first play of the "single play group" was not significant, $F(1,17) = 0.09$, $p = .772$, suggesting no differences between the groups.

Discussion

The purpose of *Home Safety Hero* is to provide an injury prevention program with the integration of serious game principles to deliver home safety skills training via computer. The aim of the game is to increase parents' knowledge of home safety risks utilizing a scaffolded, tailored approach. Serious game principles make it possible to increase difficulty overtime and to address problems in attention that might make it difficult to monitor and scan the home environment for potential threats. Furthermore, the game allows the learning process to be slowed down and includes multiple trials. Multiple trials are critical in injury prevention programs as it promotes the refinement of skills and helping skills become more automatized and increase learning

Table 1 Average reaction time in seconds over multiple plays of the identification, resolution, and distraction phases

	1st Play Comparison	1st Play of Single Play Group versus 2nd Play of Multiple Play Group	1st Play of Single Play Group versus 3rd Play of Multiple Play Group	1st Play of Single Play Group versus 4th Play of Multiple Play Group
Identification Phase	$F(1,17) = 1.05$, $p = .319$	$F(1,17) = 32.05$, $p < .001$	$F(1,17) = 61.06$, $p < .001$	$F(1,17) = 144.50$, $p < .001$
Resolution Phase	$F(1,17) = 1.38$, $p = .256$,	$F(1,17) = 12.26$, $p = .003$	$(1,17) = 14.70$, $p < .001$	$(1,17) = 22.34$, $p < .001$
Distraction Phase	$F(1,17) = 1.67$, $p = .201$	$(1,17) = 0.09$, $p = .772$	$F(1,17) = 6.05$, $p = .024$	$(1,17) = 4.73$, $p = .043$

Reaction times are reported in seconds and were averaged across all levels for each phase and combined to form final scores for each play across the three phases. Tukey's post-hoc tests were conducted to examine differences across play for each of the phases

potential and ultimately knowledge. Allowing multiple trials can also make learning easier for parents with slow processing speed (Azar et al., (2016). *Home Safety Hero* was designed with voice-overs and the presentation of injury risks in various sensory modalities (e.g., visual illustrations of risk factors, voice-overs describing risks and resolution strategies); these strategies make it possible to compensate for potential literacy issues or learning problems. Fostering effective learning requires an acknowledgement of individual differences in parents' cognitive abilities and rates of learning new skills, making individually tailored programs delivered via serious games especially attractive (Azar et al., 2019). Another important aspect of *Home Safety Hero* is the focus on multiple types of hazard categories simultaneously. Many of the previous injury prevention programs utilizing technology typically focus exclusively on one or two risks (e.g., fire safety; see Wright & Azar, in preparation for further review). Focusing on multiple types of hazards is important for providing parents with a greater breadth of knowledge regarding home safety risks.

Home Safety Hero measured the amount of fails, ratio of clicks, and incorrect solutions and incorrect answers. Only one teen failed a level by running out of time. The level failed was level five; the room for level five includes a hallway with stairs in which players must navigate around a small corner. The other rooms do not require players to look around corners. Level five was designed in such a way because of the need to train parents on home safety related to stairs (i.e., falling). We believe that the participant might not have realized that they had to maneuver their cursor around the corner; observations of their game play indicate that the participant eventually realized they could go around the corner. A concern with the development of *Home Safety Hero* was that players might not scan the rooms for hazards and instead engage in haphazard clicking until they identified the hazards and were able to pass the level. Thus, we integrated a click counter that records every time players click in the level, with click ratios closest to one indicating an almost one-on-one ratio of clicking and hazard amount in the level. Teens' clicking was almost equivalent to the number of hazards in the levels (e.g., clicking seven times in a level with seven hazards), which suggests that they were not randomly clicking during the game play. They were legitimately engaged with the game to search for and find hazards.

Another component recorded by *Home Safety Hero* is the reaction times to identify or resolve hazards in each level. We found that there were improvements in the speed of identification, with and without distraction, and for selecting appropriate resolution of risks for the fourth play of the multiple play group when compared to the first play of the single play group, with similar patterns found for the second and third plays of the multiple play group versus the first play of the single play group. Such a finding indicates that the improvements in identification and resolution were evident even with one additional play. These results suggest that teens in the "multiple play group" could spot the risks significantly quicker and more accurately for each additional play when compared to the teens in the "single play group" and that they acted quicker when resolving risks for each additional time they played the game; similar patterns were also found when selecting incorrect solutions for the resolution phase and incorrect answers for the distraction phase. Finding improvements in identifying hazards and resolutions is consistent with the purpose of other prevention programs that utilize web-based or computer software (van Beelen et al., 2014).

When connections are made between new material and prior knowledge, learning occurs, and this learning is integrated into an existing knowledge base as a script (King, 2007). Repeated trials and the scaffolding of learning materials by increasing difficulty in *Home Safety Hero* has the potential to create a script for home safety information that might be stored in a knowledge base for later access. This script can be activated in the real world and guide parents' behaviors concerning home safety. Prior research by Azar et al. (2016) revealed that parents often attribute home injuries to luck, indicating that it is possible that some parents rely on biased scripts when they deal with home safety. It is possible that *Home Safety Hero* might support the development of new scripts concerning home safety and promote parents' ability to recognize that they are able to control injuries in the home. Once parents realize that they have the potential to control risks in the home, they might experience self-efficacy regarding their ability to mitigate risks and protect their children.

Our findings highlight the potential of *Home Safety Hero* for helping to promote knowledge and action regarding home safety in young parents. Despite this potential, there are still some future directions we want to acknowledge. Because of issues regarding funding for the parenting teen program (e.g., state removing funding to support teen fathers), we were not able to recruit fathers for the study. Follow-up investigations that also include fathers is important, as well as additional research with adolescents from various racial backgrounds. The rooms in *Home Safety Hero* were designed with minimal clutter to help facilitate learning and reduce frustration. An updated design for the game might include a difficulty adjuster that could make it possible to increase clutter and that would better adapt the difficulty of the levels to parents' existing knowledge (e.g., using a pre-test to alter content they are exposed to). Another aim of future investigations would be to modify the game to include more immersive virtual reality. Such virtual reality could involve augmented reality that could "place" hazards in parents' own home environment for them to identify and resolve. Furthermore,

more advanced virtual reality might make it possible for parents to "pick-up" hazards and perform corrective measures for those hazards. Another possibility for future research is to demonstrate the generalization of the game to the real-world. To do this, behaviors could be observed in a laboratory setting designed as a home with hazards present or observations could be made in the actual homes of parents. The purpose of this study was to showcase the design of the game and the potential for some basic-level learning to occur. It is important that performance in the game is compared to real-world applications of home safety. Research should also utilize longitudinal designs and randomly assign participants to multiple play conditions versus single play conditions, and then follow-up on self-reports or emergency room records of children's injuries at a later time to determine effectiveness of the game.

We did not find any differences between the single play group and the multiple play group when it came to their engagement with the game. Overall, teens regardless of their condition found the game engaging and the ratings of *Home Safety Hero* were better than what was found in prior studies using this instrument to assess engagement (O'Brien & Toms, 2009). Because we did not find differences between the teens on engagement, it appears that playing the game multiple times does not diminish teens' engagement with *Home Safety Hero*. *Home Safety Hero* was designed to increase difficulty gradually to allow teens to proceed at a comfortable pace, which might have prevented frustration and decreases in engagement. The game also integrated praise and rewards for success to provide consistent encouragement for parents; praise and reward increase engagement and motivation (Cook et al., 2013; Mozelius, 2014).

Directly practicing parenting skills in a first-person virtually simulated environment closely resembles how parenting skills are learned in the real world but it does so in a way that promotes autonomy and mastery. *Home Safety Hero's* design has the potential to increase accessibility of home safety interventions and extend the reach of universal injury prevention programs. Furthermore, serious games, like *Home Safety Hero*, can also address relational challenges that might provide barriers to building trust with providers and could diminish satisfaction with services and increase attrition. Serious games have the potential eliminate or reduce these barriers. Teens in the multiple play group were able to improve their ability to identify and resolve home safety hazards across multiple plays in comparison to teens in the single play group, despite increases in difficulty and distraction.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors indicate that they have no conflict of interests that impacted this study.

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