Investigating the Effects of Self-Avatars and Story-Relevant Avatars on Children's Creative Storytelling

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ABSTRACT
Storytelling is a critical step in the cognitive development of children. Particularly, this requires children to mentally project into the story context and to identify with the thoughts of the characters in their stories. We propose to support free imagination in creative storytelling through an enactment-based approach that allows children to embody an avatar and perform as the story character. We designed our story creation interface with two modes of avatar: the story-relevant avatar and the self-avatar, to investigate the effects of avatar design on the quality of children's creative products. In our study with 20 child participants, the results indicate that self-avatars can create a stronger sense of identification and embodied presence, while story-relevant avatars can provide a scaffold for mental projection.

Author Keywords
Creativity; Storytelling; Embodied Interaction; Virtual Reality; Expressive Writing

CCS Concepts
•**Human-centered computing** → **User studies; HCI design and evaluation methods;**

INTRODUCTION
Creativity is defined as the ability to generate novel and successful output in a specific domain [1], and nurturing creative performance in children is a lasting concern. A common way to encourage creativity in children is through expressive storytelling activities. An example of such activities is the free-form pretend play (also referred to in literature as fantasy play [33], make-believe play [12] or story enactment [8]). Lev Vygotsky, the progenitor of *Social Development Theory*, emphasizes the role of pretend play in children's social and language development, and states that it has unique characteristics that allow it to serve as a Zone of Proximal Development (ZPD) [42]. Hence, storytelling and pretend play are used as learning tools in different stages of children's development, from learning social and language skills in early childhood to written expression and reading comprehension in classroom education during later years [30]. Owing to this importance, interactive storytelling support has become an important area of focus in HCI [17] and much effort has been invested to support storytelling activities and embodied story authoring tools in particular. Sugimoto et al.'s *Gentoro* system [35], Sylla et al.'s *TOK Stage-Narratives Creation* system [36], and Chu et al.'s *DIME* system [6] are a few examples of these efforts.

Avatars are a common feature that have been used in many interactive applications for children to support creativity in pretend play. Prior research has heavily addressed successful aspects of avatars for personalization and customization within interactive or immersive, predefined environments. However, this research on avatars has been situated primarily within the context of more performance-based tasks such as video games and digital exercise. We are interested in avatar design for creative applications, where the goal of the user is to produce creative products, such as stories. In this paper, we investigate two types of avatars in story creation interfaces for children: one where the avatar is the child him- or herself, and one where the avatar is a virtual, transformed representation of the child.

We posit that the design of the avatar used may have an effect on various qualities of the creative product generated by the child. Aspects of the avatar design can provide more or less support to scaffold the imagination of the child in mentally projecting onto the character being created in the story. For example, on the one hand, an avatar that fully represents the child may produce a high degree of identification, but may provide little support for the child to imagine a self-transformation

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into a given story character and create a story accordingly. On the other hand, an avatar that more accurately represents the story character may not allow the child to identify with it as easily, but may facilitate story creation. In this paper, we investigate whether the use of a self-avatar or a story-relevant avatar affects children's storytelling process differently, and if so, how.

The rest of this paper provides an overview of prior research on avatars, and then describes our theoretical foundation that is grounded in Kirsh's [22] concept of mental projection. We then present our research questions, study and system, and wrap up with a discussion on the implications of our results for the design of avatars in children's creative authoring applications.

BACKGROUND AND RELATED WORK

In this section, we present a brief review of the previous research on avatars in general, and more specifically, the use of avatars in creativity-oriented tools and applications.

Previous Research on Avatars

Avatars are virtual representations of users within a digital environment [41]. The importance of avatars is that they can affect the way users behave or feel in these contexts [21]. This importance has led to a body of research on avatars, from how users perceive or choose their avatar [40], to best practices in designing avatars and avatar creation tools [4]. In the designing of avatars, it is usually of interest to create a sense of identification between the user and their avatar [39]. Avatar identification is defined as the degree to which users perceive an avatar as similar to themselves and empathize with it [9]. The concept of identification has been widely investigated in video gaming and other online communities [21, 24, 39] as an indicator of players' interest, enjoyment, engagement, and sustained use.

Different methods of avatar customization have been investigated to create a sense of avatar identification, such as in prior research conducted by Falloon in 2010 [15]. Bailey et al. [3] demonstrated that customizing avatars can affect children's sense of presence and emotional engagement in an online video game. Messinger et al. [27] found that when people are given the choice of customizing an avatar of themselves, they tend to design the avatar to look similar to their real selves, but also make them slightly more attractive, hence creating a moderately enhanced version of themselves in the avatar. Moreover, Fox and Bailenson [16] found that facial similarity between the user and their avatar in an exercise application can result in better performance from the user. However, much of the research investigating avatars has addressed more performance-based activities. In these cases, such as in video games and digital exercise applications, the goal of the application is for the user to perform a generally predefined task, rather than produce some creative output. In this paper, we focus on story authoring systems where the purpose of the user is to create story content. While the experience of engaging with such an authoring system can be game-like, e.g., there is a clear goal of creating a coherent story, the content of this story is not predefined and will be generated by the user, which distinguishes these systems from games.

Avatars for Creativity Support

Research on avatars for creative applications is limited. Yee and Bailenson's work [43] showed that digital self-representations could alter our behavior; for example, a more attractive avatar can result in showing higher levels of self-confidence in a virtual environment. Following this idea, Guegan et al.'s work [18] demonstrated that embodying avatars that are perceived as more creative, for example, those resembling famous innovators and inventors can stimulate and encourage higher creativity performance. With respect to children's storytelling applications, many augmented and virtual reality systems have been proposed and studied that allow the user to create a story via body enactment through an avatar that is unlike the user (e.g., [25, 7, 8]. However, the focus in these prior projects has been on the performative nature of the activity, rather than on the design of the avatar.

In [29], the effect of avatar similarity on creative storytelling is investigated via puppet storytelling. They found a correlation between varying levels of a puppet's visual similarity to the user and the quality of the creative output, which they identified as the written story created after performing with the puppets. DeRooji et al. [10] also found that using avatars with higher self-similarity can lead to higher creativity demonstrated by the participants in their study. In our work, we investigate a similar question, with the key distinctions being that we provide users with a full body enactment system and that we compare avatar similarity through the method in which the user is transformed to create the avatar. While [29] varied similarity through different levels of facial morphing within the same method of puppet avatar creation, we are interested in comparing a totally transformed, story-relevant avatar, where all aspects of the user is changed into a new virtual representation, against an avatar that is essentially the user his- or herself, but transported into a virtual environment.

THEORETICAL FRAMEWORK

David Kirsh [22] defines the concept of *mental projection* as augmenting an external structure by adding mental structures to it. He states that human cognition relies on these external structures to *anchor* and support thoughts and ideas and make sense of them. He explains projection as the reason people tend to create diagrams, gestures, or other external representations of thought, especially for complex tasks like problem solving, rather than using mere imagination. These externalizations create a persistent reference that can be shared and can become more complex and involved as needed because they are not limited to a single person's cognitive resources [23].

The concept of mental projection has been applied in the context of creative storytelling for children in prior research. Chu et al.'s [8] approach to enactment-based creative storytelling, or *Performative Authoring* is based upon the concept of mental projection. It encompasses enacting ideas, using props in storytelling and creating video recordings of story enactment as different ways of creating externalized representations of a child's creative imagination. Another example within this line

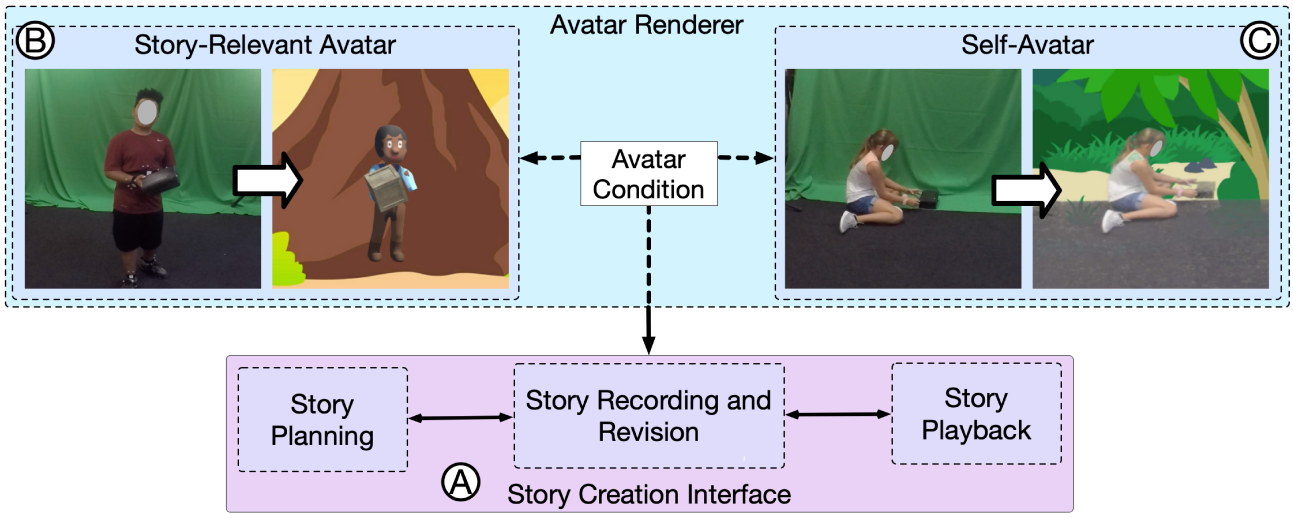


Figure 1: Diagram Flow of the Story Creation Interface and the Avatar Renderer. A) Story Creation Interface and its elements. B) Story-Relevant Avatar example. C) Self-Avatar example.

of research is Esteves et al.'s [14] work on comparing tangible and virtual versions of the four-in-a-row game. They found that regardless of the way the game is implemented, mental projection has a key role in how players perform the game, and each interface supports mental projection in different ways.

In the context of creative storytelling for children, to tell the story of a character, the child needs to be able to mentally project themselves onto the story character they have imagined and wish to portray. So, the story creation interface can support this mental projection by creating a visual representation of the child in their story, through an avatar that exists in the virtual story world. Thus, in our investigation, an avatar that is a direct external representation of the story character in a child's story may help to lower the need for mental projection on that specific issue. In contrast, an avatar without direct visual similarities to the story character might require a higher mental projection effort. The core question in this work is how this higher mental projection effort impacts the quality of the storytelling experience for the child user, as well as the quality of the story output created by the user.

RESEARCH QUESTIONS

We are interested in investigating the effects of a story-relevant avatar on the quality of children's storytelling, with the goal of informing avatar design in creative authoring applications for children. In our investigation, we make this comparison between the story-relevant avatar (an avatar resembling the story character) and the self-avatar (an avatar resembling the child user). Our study is positioned within the context of a story authoring application that allows children to create a digital story via the use of body-based enactment or pretend play. Our research questions were:

RQ1: Is there a significant difference in terms of children's sense of embodied presence and degree of identification with the avatar between the use of a self-avatar and a story-relevant avatar in an enactment-based story authoring application?

RQ2: Is there a significant difference in terms of children's quality of storytelling between the use of a self-avatar and a story-relevant avatar in an enactment-based story authoring application?

RQ3: Is there a relationship between the children's sense of embodied presence and degree of identification with the avatar and the quality of their storytelling from an enactment-based story authoring application?

STORY CREATION SYSTEM

To investigate the above research questions, we designed a story creation system that can allow the use of either a self-avatar or a story-relevant avatar for a child to enact a story. The user interface of the system is a Windows-based standalone application built using the Unity3D Game Engine [37]. It allows children to plan, act, record, revise, and watch their stories as multiple video clips. The flow of the interface's story creation process is shown in figure 1, and is described in more detail in the following subsections.

Story Planning

In our interface, a story is a collection of scenes that are ordered chronologically. The planning of the story is guided by a simple given story structure often used to explain event sequences to young schoolchildren - consisting of a Beginning, Middle, and End. These three sections of a story are represented by three rows that act as containers for story scenes on a timeline screen, shown in figure 2a-A. Here, the child user is given a visual overview of their story for the purposes of organization and story planning. The user can add scenes in each of the three sections, drag the scenes around for re-ordering, or delete a scene using the trash icon in the bottom left corner.

Scene Setup

A story scene is constructed by adding four scene elements that prepare the scene with the details needed for acting and recording. These elements are:

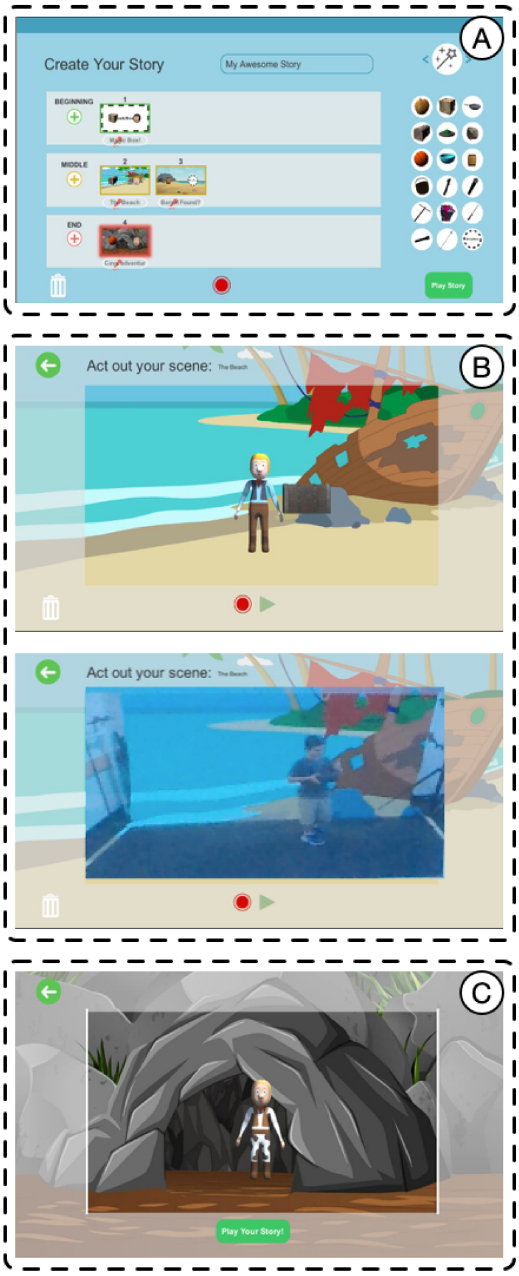
- *scene character* - who is in the scene?
- *scene prop* - what is in the scene or what is the character using?
- *scene background* - where is the scene taking place?
- *scene title* - what is the scene about?

The character, prop, and background choices are shown as icons on the right-hand side of the timeline screen (figure 2a-A). Some examples of the character, prop, and background choices are shown in figure 2b. An enlarged preview is shown when the mouse cursor is hovered over the icons, to make some of the smaller choices more visible. The elements can be added by dragging and dropping them onto the scene itself. There are also options for not choosing any character, prop, or background if the child so desires. The scene title can be typed in the field provided beneath the scene on the timeline. Once a scene has all four pieces of detail attached to it, the user may select it for recording.

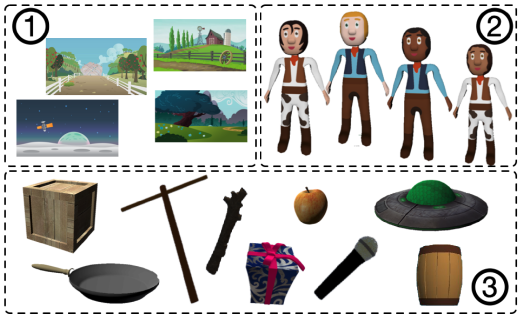
Story Recording

To create a story scene recording, the user clicks on the red recording button on the timeline screen. The recording screen is displayed (figure 2a-B) with the character that the user selected (if any). A prompt then instructs the user to pick up the physical prop that corresponds to the prop they chose for the currently selected scene in the interface. Following an approach similar to Chu et al. [8] for full body-enactment storytelling for children, the physical props are objects with generic shapes (a stick, a lantern, a ball, a racket, a cylinder, and a box) that children can actually handle to help them in their story enactment. We included props in this study because props have been shown to generally support children's creative performance [31, 26]. Each physical prop corresponds to multiple virtual props shown as prop choices in the interface. A few examples of the prop choices are shown in figure 2b.

After picking the prop, the child is instructed to get ready to act out their story and to step into the enactment area. The enactment area is a 10 ft by 10 ft space equipped with motion tracking cameras and a green screen. Depending on the child's avatar condition, the child either sees him/herself as the avatar or a cartoon avatar on the screen. The researcher starts and stops recording of the child's story enactment by clicking the record button in the interface upon receiving a signal to do so from the child actor. The recording of a scene produces a scene video that can be reviewed by the child. If the child wants to record the scene again, the video can be deleted and re-enacted/re-recorded as many times as he/she desires. Once the child is satisfied with the specific story scene, he/she can return to the timeline screen and enact/record the other scenes in their story.



(a) A) Timeline B) Recording C) Playback.



(b) 1) Backgrounds. 2) Characters. 3)Props. Note: Character choices are only available in story-relevant avatar condition.

Figure 2: Story creation interface and story detail choices.

Condition	Avatar	Voice	Prop	Environment
Story-Relevant Avatar	Cartoon character, generated via live motion capture of the user	Stream of user's voice with cartoon voice effect applied	Cartoon object selected in interface, generated via live motion capture of the prop	Cartoon background selected in the interface
Self-Avatar	Unchanged video stream of the user	Unchanged audio stream of user's voice	Video stream of physical prop associated with object selected in the interface	Cartoon background selected in the interface

Table 1: Summary of transformations in each avatar condition.

Story Playback

All recorded scene videos are added to the current story's video database and can be retrieved for viewing at any time from the timeline screen. After the child has finished all the scenes in the story, he/she watches all of the recorded scenes in the order they specified on the timeline using the playback function. For a story to be allowed to be played back in its entire, two conditions had to be fulfilled: (1) the story must contain at least one scene in each timeline category (beginning, middle, end), and (2) all of the scenes that have been added to the story timeline have to be enacted/recorded. We decided to limit the maximum number possible of scenes in a story to 5 scenes in each timeline category (15 scenes total) in an effort to keep the duration of the story creation process within a manageable scope. When the two above conditions are met, the green "Play Story" button is activated on the timeline screen. Clicking this button takes the user to the playback screen (figure 2a-C) where the entire story video can be watched. After watching, the child can return to the timeline screen to revise their story and scenes as desired.

Avatar Implementation

The story creation system supports two avatar types for the child users: the story-relevant avatar and the self-avatar. The researcher activates the rendering of the correct avatar type based on the condition that a child participant is assigned to by changing a variable in a system preference file. The story-relevant avatar transforms the child into a 3D cartoon character (a cowboy or cowgirl in the current study) that is specific to a predetermined story prompt during story enactment. Additionally, the child's voice is transformed into a cartoon voice during enactment. The physical objects that the child uses to support enactment are displayed as story-relevant virtual objects on the screen.

The self-avatar, on the other hand, is the direct streaming and recording of the child him/herself. Thus, the self-avatar takes on the appearance of the child and talks in the child's own voice. Furthermore, the physical objects that the child uses as props for enactment maintain their exact appearance in the virtual story. Both avatar implementations use the same cartoon-like story backgrounds.

The choice of having the prop virtually augmented in the story-relevant avatar condition and not in the self-avatar condition in our study design is because we are focusing on children's mental projection during enactment. The study design is such that children would have to mentally project both the story character and the object being used by the character in the story (e.g., a cowboy using a pickaxe) in the self-avatar condition while using the same base prop as in the story-relevant condition. Our study is designed such that children would have to mentally project both the story character and the object being used by the character in the story in the self-avatar condition while using the same base prop as in the story-relevant condition.

Figure 1E shows the two avatar implementations with respect to the overall system and an example view of the story-relevant- (B) and self- (C) avatars. Table 1 summarizes the different aspects of each avatar condition.

Story-Relevant Avatar Implementation

We implemented the story-relevant avatar using real-time motion capture via marker-based body tracking. Five optical markers each attached to an elastic Velcro band are placed on the child's wrists, ankles, and the torso. We also added optical markers to the physical objects used as props in order to track them. We set up 12 cameras from the *Optitrack* system to capture real-time 3D tracking data from all the markers in the enactment area. The tracking data is then transferred over a network to a computer running the story creation application. The tracking data is used to animate the corresponding virtual prop and the cartoon avatar. To obtain a fluid animation with the limited markers that the child wore, we applied Inverse Kinematic restrictions [34] to the raw tracking data from the body markers to estimate joint locations on the character's rig. The result is a cartoon character that moves smoothly according to the actor's body movements, although finer grain movements were not always reflected in the animation. Once a story enactment video is recorded, a pitch modification filter is applied to the resulting video file which transforms the actor's voice into a cartoon voice.

Self-Avatar Implementation

We implemented the self-avatar using a green screen setup. We placed the green screen on one side of the enactment space, facing a *Logitech* webcam connected to the computer running the story creation application. A chroma-keying effect is then applied to the video stream, replacing the green screen with the scene background previously selected in the story planning step. The child and the prop appear unchanged after this effect is applied; therefore the story avatar in this condition is the child's video image, and the prop retains its real physical look. Voice transformation is not applied in this condition and the child's own voice is heard in the recorded enactment video.

THE STUDY

The study employed a within-subjects design with the type of avatar as the independent variable. The independent variable had two levels: story-relevant avatar and self-avatar. The dependent variables included degree of character identification, level of embodied presence, game experience, story creativity, and writing quality.

Participants

We recruited a total of 20 children between the ages of 8 to 12 years for this study. The participants were recruited through the campus university mailing list and a local scout group mailing list. Four participants did not complete the entire study protocol (for example, not filling the questionnaires), and were thus not considered in the final data analysis. The final participant count comprised of 16 children (5 female, 11 male). All participants received a small toy as compensation after completing the study.

Study Protocol

A child participant attended two sessions, each approximately two hours long. The participant went through the study protocol for one condition per session. The sessions were scheduled on separate days for each participant to avoid him/her becoming fatigued. The order in which the conditions were experienced was counterbalanced across the study sample. The study protocol was as follows:

At the beginning of the first session, the child and parent received an information sheet, after which they were given a parental consent form and a minor assent form respectively to read and sign. The participant was then asked to fill out a pre-questionnaire for our baseline measures and demographic information. The researcher explained to the participant how to use the story creation interface and allowed him/her to practice creating, acting, and reviewing a few created scenes for 5-30 minutes until the child felt comfortable with the interface. While the researcher explained the interface to the child, the child's parent was asked to fill out a personality category rating questionnaire [11] pertaining to their child's personality.

Once the child announced that they were ready, the researcher gave him/her a story prompt to base their story upon. To avoid learning effects in the within-subjects design of the study, two different story prompts were used for the study, both following this general format: *A cowboy/cowgirl found a [story prop] in a [story location]. Create a short story about what happens next."* In the first prompt, the prop was a 'magic rock,' and the location was a 'ranch', and in the second prompt, the prop was a 'mysterious box', and the location was a 'beach'. The story prompts were counterbalanced across the two conditions over the participant sample, i.e., some participants received the first prompt for the self-avatar condition and the second prompt for the story-relevant avatar condition, while others received the second prompt for the self-avatar condition, and the first for the other condition. The story props (a magic rock/a mysterious box) and story locations (the beach/the ranch) were available in the story creation interface to select for their story scenes. However, participants were free to choose props or locations other than the ones mentioned in the prompt, as many other options were present in the interface.

Participants were then given as much time as they needed to create a story using the story creation system as per the assigned condition for the current session. When participants confirmed that they have finished their story and did not want to do any more revisions, they were asked to write down their story on paper. The researcher also encouraged them to include as much detail as they can in their writing, and emphasized that they could watch the scenes or the whole story as many times as they wanted during writing.

After the completion of the main story creation task and writing, participants were given a post-condition questionnaire to fill out by thinking about their experience throughout that particular session. They were then engaged in a short semi-structured interview about their overall experience, covering questions such as "What did you like/not like about the experience?", "Did the story creation activity help you in writing your story?", and "Which one of the avatars did you prefer and why?" (this question was only asked at the end of the second session). The study was concluded with the researcher bringing a small toy as a gift/compensation for the child's participation. We also provided the story enactment videos to the parents as keepsakes, if they asked.

Measures

The pre- and post-study questionnaires used 5-point Likert-scales, graphically depicted (5 squares with increasing sizes underneath the options "not at all" to "very, very much").

Baseline Measures:

The baseline measures for each participant consisted of the following:

The pre-questionnaire consisted of nine items, including 6 items for writing apprehension taken from Autman and Kelly's Writing Apprehension questionnaire [2], and 3 items for the creative self-efficacy scale proposed by Tierney and Farmer [38]. The creative self-efficacy items were: (1) I am good at coming up with new ideas; (2) I have a lot of good ideas, and (3) I have a good imagination.

The personality assessment came from Deal et al.'s Inventory of Child Differences - Short Version (ICID-S) Questionnaire [11] - a 50-item questionnaire designed to assess the personality of children and adolescents based on the Five-Factor Model (FFM).

Dependent Variable Measures:

Measures for the dependent variables in our experiment were obtained from the following four data sources:

The post-study questionnaire was a set of 29 items obtained from two sources: i) IJsselsteijn et al.'s Game Experience Questionnaire (GEQ) Post-game Module [20]. GEQ contains measures for the overall game experience, such as positive/negative experience, and tiredness. Although we distinguished our story authoring application from a game application earlier in the paper, the GEQ is still applicable because it has also been used in previous research to measure general user experiences, for example in work by Dionisio et al. [13] and Zhang et al. [44]; and ii) Van Looy et al.'s Avatar Identification Questionnaire [39], which contains questions for similarity identification and embodied presence dimensions.

Story essays were analyzed for two measures: the number of ideas in the story, and story richness.
Story enactment videos were analyzed for the number of ideas in the story.

	Baseline Measures		Dependent Measures		
Measure	Pre-Study Questionnaire	Personality Assessment	Post-Study Questionnaire	Story Essays	Story Enactment Videos
Scale(s)	Autman and Kelly (2017) Writing Apprehension; Tierney and Farmer (2002) Creative Self-Efficacy	Deal et. al (2007) Inventory of Children's Individual Differences - Short Version	Ijsselstein et al. (2013) Game Experience Questionnaire (GEQ) Post-Game Module; Van Looy et al. (2012) Avatar Identification Questionnaire	Story Complexity; Story Richness	Story Complexity

Table 2: Summary of the Measures Used in Our Study, and the Scales Included in Each Measure.

Table 2 summarizes the measures used in our study and the scales for each measure.

DATA ANALYSIS

Three main types of data were collected: story enactment videos, written story essays, and questionnaires.

Video Analysis Method

For the coding of the enacted videos, we adapted two concepts from prior approaches to story analysis: *idea digests* and *vignettes* [8, 5]. An idea digest is the decomposition of the story into units that contain a single idea or thought, and is a concept we also utilize in our analysis of the children's written stories. As this concept is intended for written text, we determined the number of idea digests in each story from a transcription of a given story's audio dialogue. In order to also capture the ideas from the enacted performances that are introduced through action, we also count the number of vignettes present in each enacted story. A vignette operates much like an idea digest - as a unit, it encapsulates a singular conveyed idea. The key distinction is that a vignette is a single idea conveyed through action alone, instead of speech. To avoid confounding the two, during the coding of the vignettes, the video of the child's enactment was muted, such that only distinct actions could be accounted for. The end result was a score indicating story complexity, calculated by the number of idea digests in a given story's transcribed speech, combined with the count of vignettes in a story video.

Using this method with two coders, we had a final inter-coder agreement of over 90% for both the coding of idea digests across all participant stories, as well as the coding of vignettes across half of the participants. The other half of participant vignettes were assigned to only one coder. The results of this analysis were standardized by the length of the story video in seconds, and a paired t-test was used to evaluate the data.

Written Story Analysis Method

The analysis of written stories was done using two methods:

a. Text Analysis

Following the narrative analysis method from [32], one of the authors coded each participant's story into an 'idea digest', a method we utilized in the analysis of the story videos as well. Analyses of the written stories were performed to obtain a measure of story complexity and 2 different measures of story richness. **Story complexity** was operationalized as the number of idea units in the idea digest of a story. The two measures of story richness were subsequently summed to produce an overall story richness score for each written story. A **normalized overall richness score** was then obtained by dividing the score by the total word count of the story. This way, even if a story was significantly shorter than another and naturally possessed fewer details and descriptors, we could still gauge a sense of its richness.

The first measure for story richness was the sum of all occurrences of 5Ws+1H (What/Where/Who/When/Why/How) in the idea digest. Borrowing from news narratives, which are often evaluated based on the 5Ws and 1H principle [19], this analysis comprised of identifying how many idea units addressing the who, what, where, when, why and how are contained in the child's idea digest of his/her story. This analysis was done by two coders who agreed on the coding protocol prior to analysis. The outcome of this procedure (summing up the total number of idea units detailing the 5Ws+H per story) was a score embodying the richness of the child's written story.

The second measure for story richness was obtained by coding for 'richness descriptors', operationalized as adjectives, nouns used as adjectives, adverbs, and descriptive verbs. For example, this sentence: *I was walking one day and found a rainbow-colored rock.* consists of two ideas (I was walking one day + I found a rainbow-colored rock.), and it contains an adjective (rainbow-colored) and one descriptive verb (walk).

b. Domain Expert Assessment

All written stories from both study conditions were given to an elementary language arts school teacher with over 15 years of teaching experience, who acted as a domain expert in the grading of the stories. The essays given to the teacher were accumulated in a single folder, without any information as to the study condition they were written for. Moreover, we corrected most of the spelling and some of the grammar errors in writing (without changing any of the story structures) to prevent grading bias because of language mistakes. The teacher used the Personal Narrative Rubric [28] with 4 score increments in three categories for grading: (1) Organization (beginning, middle, end), (2) Ideas and Support (plot and details), and (3) Conventions (sentence type, word choice), and an overall score. She also provided a short reason for each essay's final grade.

Statistical Tests

We ran repeated measures ANOVAs with creative self-efficacy as covariate to investigate the effects of type of avatar (story-relevant avatar vs. self-avatar) on the following:

[for the participants' **enactment experience**] avatar identification scores, and embodied presence scores;

[for the participants' **enactment story videos**] number of speech-based ideas (script complexity), number of action-

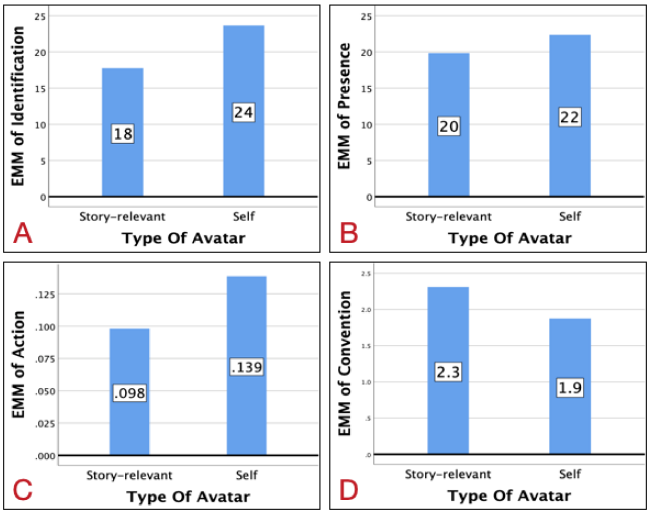


Figure 3: Result Plots. A) Estimated Marginal Means (EMM) of identification in the two avatar conditions. B) EMM of embodied presence in the two avatar conditions. C) EMM of vignettes in the two avatar conditions. D) EMM of language conventions grade in the two conditions.

conveyed ideas (action complexity), and normalized overall story complexity scores;

[for the participants' **story outcomes**] number of ideas (story complexity), number of details with respect to 5Ws+1H, number of richness descriptors, normalized overall story richness scores, and the teacher's rubric grades.

Furthermore, pearson's product-moment correlations were performed to find whether there are significant relationships between: i) identification scores and embodied presence scores across the two conditions; ii) identification and the various measures of storytelling quality, and iii) embodied presence and the various measures of storytelling quality.

RESULTS

We present the results of our various analyses below, grouped by the research question. Only significant results are reported and expanded upon.

RQ1: Effects on Avatar Identification and Embodied Presence

A significant difference was found between the self-avatar and story-relevant avatar conditions in terms of avatar identification score ($F(1,16) = 17.058$, $p = .001$). The self-avatar condition created a higher sense of identification ($M = 23.647$) compared to the story-relevant avatar condition ($M = 17.765$)(figure 3A). A significant difference was also found between the two avatar conditions on embodied presence scores ($F(1,16) = 4.506$, $p = .050$). The self-avatar also led to a higher sense of presence ($M = 22.353$) than the story-relevant avatar ($M = 19.824$)(figure 3B). We also found that identification and embodied presence scores across the two conditions are generally positively correlated ($r = .795$, $p = .000$).

RQ2: Effects on Quality of Storytelling

Storytelling quality was assessed from the analysis of story complexity of the enactment videos and story complexity, richness, and overall quality of the written stories. For the enactment videos, a significant difference between the avatar conditions was only found in the count of vignettes, or the action complexity scores $F(1,16) = 186.535$, $p = .000$. The self-avatar condition ($M = .139$) had higher action complexity scores than the story-relevant condition ($M = .098$) ((figure 3C)). No significant differences between the two avatar conditions were found in the text analysis of the written stories. A significant difference between the two conditions was found in the *conventions* subcategory ($F(1,15) = 5.787$, $p = .029$) of the teacher's grading, with the story-relevant avatar condition scoring higher than the self-avatar condition (figure 3D).

RQ3: Avatar Experience and Quality of Storytelling

Over the two avatar conditions, we found that avatar identification was positively correlated with normalized written story quality scores ($r = .351$, $p = .049$). A marginally significant correlation was also found across both conditions between embodied presence scores and the teacher's overall story grades ($r = 0.333$, $p = .058$).

DISCUSSION

Our study results showed that children feel a significantly stronger sense of identification and experience stronger embodied presence with the self-avatar than with the story-relevant avatar. This is in line with what the literature suggests in that people tend to prefer avatars that have a high visual similarity to themselves [27]. We also found that action complexity (number of action-conveyed ideas) in the enactment story videos was significantly higher in the self-avatar condition. However, a possible explanation for this is that the children were able to express themselves more freely without the constraints of the motion tracking system. Thus, we do not place too much emphasis on this particular result.

Most importantly, the results indicated that language convention scores of the children's written stories, as graded by an experienced teacher, were significantly higher in the story-relevant avatar condition. Kirsh's [22] theory of mental projection can help to formulate a possible explanation here. According to Kirsh, externalized visual structures embodying specific concepts can help us to move our thinking further, since they act as scaffolds that free up cognitive resources for those concepts instead of the person having to mentally project them in the external space. In that sense, the visualized cowboy/girl cartoon character acted as a scaffold for the concept of a cowboy/girl, enabling the children to focus on other aspects of the story such as language conventions as they wrote their story reviewing their enactment videos.

Besides these results, our study also showed that sense of avatar identification is positively related to the overall written story quality scores, and embodied presence is positively related to the written stories overall scores as graded by the teacher. These correlations are across the two avatar conditions, and thus indicate more general relationships with respect to avatar design and storytelling products quality.

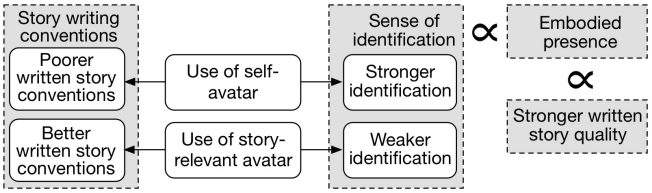


Figure 4: Results summary illustration

We summarize all our results in Figure 4. A more holistic consideration of all our results suggests a conundrum. The study results inform designers on the role of avatar design in embodied story authoring systems for children to influence aspects of user identification and the quality of the resulting story output (and how they may relate). On the one hand, a pathway to improving outcomes of children's use of creative authoring applications is to focus on creating avatars with which the child user identifies, and children appear to identify more with their self-avatars.

However, using a self-avatar avatar does not necessarily directly help children to produce better final written stories, since we did not find significant differences of avatar type on any measures of story richness and complexity. Using a story-relevant avatar, on the other hand, can help to improve the technical aspects of children's language (i.e., language conventions) in their final written stories because they are able to focus on this dimension of writing while specifying details (character's appearance, props used, etc.) that are already externally visualized.

Our results, therefore, show a clear design implication that further opens an interesting avenue for future HCI research on how to design avatars for story authoring systems that attempt to bridge the need for identification and quality story output. More precisely, we show that in a particular application, if identification is emphasized, self-avatars (i.e., enforcing mental projection of imagined story content) are preferred, but if story quality is emphasized, story-relevant avatars (i.e., providing visual externalization of story content) are preferred.

We also highlight here the possible importance of gender effects. Running a repeated measures ANOVA test with gender as a between-subject factor, we did find a significant difference between avatar type on the story complexity scores (number of ideas in the idea digest) despite the relatively small number of participants in our study ($p = .038$). There was a significantly higher number of ideas for female participants in the written story idea digests for the story-relevant avatar condition ($M = 21.932$) than the self-avatar condition ($M = 17.932$). However, we did not include this in the formal results because our sample sizes of males ($N = 11$) as opposed to females ($N = 5$) were not balanced. Thus, we interpret this specific statistical result with extreme caution, although we believe that it may be an interesting point to bring forth in the discussion here. Yet, some of our observations from our post-study interviews with the participants do reinforce this possible gender effect. When asked for their preference between the avatar types in the interview, all of the female participants answered that their preference is the story-relevant avatar, while the majority (67%) of the male participants had a preference for the self-avatar. Further investigation is needed in these areas to elicit the significance of this effect or to identify contributing factors.

CONCLUSION AND FUTURE WORK

In this paper, we investigated the effects of avatar type on identification, embodied presence, and story outcomes in an enactment-based creative storytelling application. We analyzed data both in terms of creativity and writing quality. Our results revealed a complex picture. To a large extent, they support the important role of avatar identification and the theoretical framework that externalized structures may support the need to scaffold mental projection. We propose from our research not only that avatar design for children's creative authoring applications is an issue that has potential for impact and thus should be considered, but also that it is a complex issue that we lack current understanding of in HCI, relative to avatar research in predefined contexts such as games and health applications. Future work should explore other ways of making avatars in story authoring contexts more story-relevant, and their associated benefits and weaknesses on the resultant creative products.

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