Designing Animated Characters for Children of Different Ages

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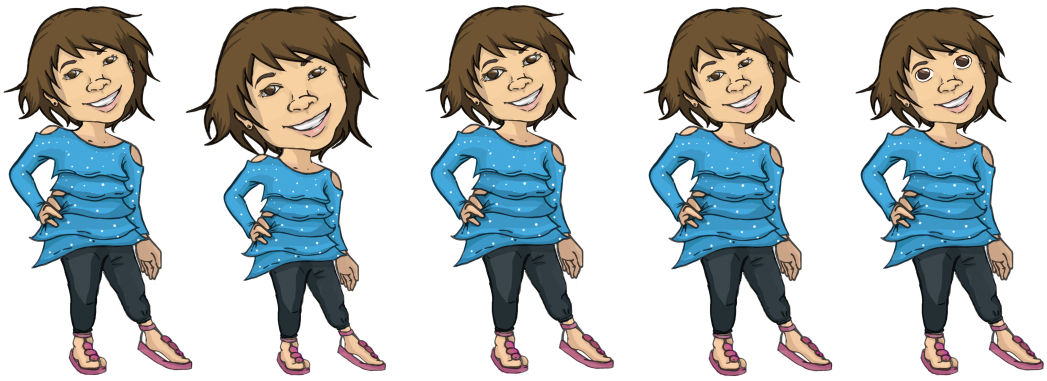

Figure 1. Left to right: One character is shown unaltered, with an enlarged head, with enlarged eyes, with eyes closer together, and with round eyes.

ABSTRACT
Animated characters are commonly used in children's television, movies, and applications. Artists seek to create characters that maximally engage their audiences and tailor these characters carefully. In order to examine the relationship between stylistic elements of animated characters and the target ages of their audiences, we performed a series of qualitative and quantitative studies. By using existing media, we determined that characters created for younger children have larger head height, larger eye height, and rounder eyes than those created for older children. However, we found no systematic differences by age when we had children express preferences for existing characters or create their own characters. These results suggest that current artistic trends do not accurately reflect the character design preferences of children.

Author Keywords
Animated character design; avatars; children; user studies; age preferences in design.

ACM Classification Keywords
H.5.1. Information Interfaces and Presentation (e.g. HCI): Multimedia Information Systems

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INTRODUCTION
Television programs, movies, and software applications for children increasingly rely on animation for storytelling and content. This trend is particularly true for media aimed at preschool-aged children. When we surveyed the websites for three prominent channels in the USA with programming for young children (PBS Kids, Nick Jr., and Disney Jr.) in late 2015, we found that they offered 109 programs, of which 96 were animated. Many of these programs also had corresponding games and activities that used the same characters. Additionally, all ten of the top ten highest grossing applications for kids in both the Apple App Store and Google Play include animation, and many include humanoid characters[1]. In this research, we examined common patterns in animated character design for children and gauged children's preferences for different designs. We examined whether differences in character design for children of varying ages corresponded to their actual preferences.

We performed a series of qualitative and quantitative studies to examine what patterns are present in character art for children of various ages and elucidate the relationships between those patterns and children's actual preferences. First, we had animators view animated characters from existing children's programming (television and movies) and describe the variables that they believed were manipulated for different target age ranges. We then validated a subset of the variables by quantifying character differences and finding correlations between specific variables and the intended age of the audience. Next, we created new characters that differed across

[1] Search performed December, 2015.

these variables for a set of three quantitative studies of four- to ten-year-old children that included selecting between existing characters and creating custom characters.

RELATED WORK

The design of animated characters has been investigated in the context of adult perception and opinion. Many animators believe that characters should be stylized and made less realistic in order to be more effective pieces of art [2]. Additionally, stylization provides opportunities to manipulate expression and appeal. The use of caricature can enhance recognition of illustrations [4] and increase the attractiveness and interest of cartoon characters [10]. Stylization has also been proposed as a method of avoiding the uncanny valley phenomenon [2]. The uncanny valley theory arose from the idea that people's perceptions of robots shift abruptly from attraction to revulsion as they become increasingly humanlike [13]. Complex relationships have been found between the degree of humanness of appearance and attractiveness of animated characters (e.g., [14]). More recently, research has examined how the extent of stylization (e.g., the level of abstraction, eye size, etc.) affects adult perception and found that stylization of face shape reduces perceived realism of characters and stylization of material can affect appeal [19]. Moreover, stylized face shapes had higher perceived intensity for emotional facial expressions [19]. These findings suggest that stylized face shapes can be more expressive than more realistic shapes, which may be useful for emotional expression comprehension. However, none of this research systematically examined children's characters and how development might affect the relevance and perception of specific types of stylization.

Animated media is often aimed at children, and its characters are frequently similarly youthful. In humans, youth corresponds to several aspects of head, face, and body structure. For example, infants and young children have significantly higher ratios of head size to body length (e.g., [15]). Their noses change size and shape with age, starting with a sunken bridge, small height, and greater proportional width [8, 5]. Their eyes are larger relative to the overall size of the face [5] and rounder in shape [6]. Additionally, the features of infants and children are positioned lower on the face than those of adults [5]. As individuals age, their craniofacial profile shapes also change [17]. Even three-year-olds can determine age categories (i.e., baby, child, adult) from these cues [11].

Many features of youthful faces are echoed and exaggerated in animated characters. Caricature has long been promoted as a way to add interest and personality to characters [16]. In the face, this process involves changing the positions, sizes, and shapes of individual features. By changing these facial cues, artists can change perceptions of social qualities using folk wisdom about how people analyze each other's appearances. For example, infant faces with larger eyes are perceived as more babyish, cute, and attractive (e.g., [7]), and adult faces with larger eyes are perceived as younger, weaker, more socially submissive, warmer, more honest, and more intellectually naive [9, 1]. Perceptions of facial "babyishness" can arise from changes in eye shape, eye size, eyebrow height, and chin width; in turn, these features impact perceived naiveté, strength, warmth, kindness, and honesty, regardless of overall perceptions of attractiveness or age [1, 12]. People are also more inclined to approach and protect those with "cute" baby faces (e.g., [3]), and this response can be over-generalized to include adults with stereotypically babyish features [12, 18].

METHOD

We performed three experiments with overlapping stimuli and methodologies. We examined how a subset of features are systematically manipulated by artists to create characters that they believe are appropriate for audiences of different ages. Additionally, we determined whether these assumed preferences exist in four- to ten-year-old children. Below, we describe the common features of the studies.

Variable Determination and Qualitative Analysis

We performed an analysis to determine what characteristics are common in modern animated television shows for kids between the ages of 3 and 11 years. First, we performed a survey using the Internet Movie Database (IMDb.com) to find children's television shows and movies that had (1) 3D animated characters produced in 2009 or later, (2) a user rating of at least 6 out of 10, (3) ten or more episodes (for television shows), and (4) English language content. We selected these characteristics because (1) 3D animation is increasingly popular in films and television as technology improves and its expense declines; (2, 3) medium-to-high ratings and episode orders beyond one season demonstrate reasonable success for a television show, indicating that the characters are appealing enough to retain viewers; and (4) we needed to find information about target audiences. Next, we used online resources from Common Sense Media (commonsensemedia.org) to verify the typical or recommended average viewing age for these media. Finally, we obtained images of the primary human characters for each film or program.

We used the resulting images from the remaining 22 movies and shows to perform a small, qualitative assessment of character design. We had specifically selected 3D-animated characters because of their increasing popularity and because their features are less likely to be squashed or stretched during the program, resulting in more accurate measurement. The images were categorized by target age (3 to 5, 6 to 8, or 9 to 11 years). Three animators and an animation intern from Disney Research identified systematic differences in character design across the age ranges. Six categories of differences were determined: head size; eye size, position, and shape; mouth size; feature/line hardness; and profile shape. Four variables were determined to be quantifiable in terms of differences and artistically feasible to systematically vary: head size, eye size, eye position (wide-set, close-set, typical distance), and eye shape (roundness).

To determine how these variables related to the targeted age of the programs, we measured individual characters. For 19 of the shows and movies, images of at least three humanoid characters were available. We identified the top three humanoid characters in each show or movie as listed on IMDb.com (i.e., based on number of episodes present)

in order to ensure that we were assessing major characters. For each character, we measured total height (heel to crown), head height (chin to crown), face width (at widest point), eye height (lid to lid), eye width (corner to corner), and interpupillary distance. We then created ratios. To determine relative head size, we divided the head height by total height. Next, we correlated this value with the appropriate viewing age provided by Common Sense Media and found that characters in shows for younger children have significantly larger head height to body height ratios, $r = -0.724$, $p = 0.0005$. We then calculated eye height divided by head height to see how large the eyes appeared in the head. We found a significant correlation between this ratio and target age with larger eyes for younger children, $r = -0.672$, $p = 0.0016$. When examining the ratio of interpupillary distance to face width, we found no significant relationship between how wide-set the eyes are versus target age, $r = -0.3055$, $p = 0.2035$. However, we left this variable in the analysis in order to have the correct number of experimental trials. Finally, we measured the width versus the height of the eyes and found a correlation such that characters with greater ratios (i.e., rounder eyes) were more likely to be targeted at younger children, $r = 0.859$, $p < 0.00001$. These findings validated our qualitative assessment that artists use head size, eye size, and eye shape as indicators for the target age group of the audience. We proceeded to use these variables for our quantitative research on child preferences.

Character Design

We elected to create our own characters to avoid any familiarity biases that children might have for existing characters. An artist created eight child characters (four boys and four girls, elementary school age) in a consistent style that had similar eye color, hair color, skin tone, and clothing color palettes (Figure 2). Then, each character was modified (as shown in Figure 1). For the head size condition, the head of each character was magnified by 1.4x and the scale of the body was adjusted to maintain the original total height of the character (and ensure participants would not select a character because it was bigger). To examine eye size, the eyes of each original character were magnified by 1.5x without further adjustment to the head or body. The distance between the eyes of each character was reduced by half to provide examples of various eye positions without any additional adjustments. Finally, new eyes in a round shape were substituted for the original eyes to assess eye roundness. These ratios were determined by our animators to produce plausible characters after modification.

An additional set of child character options was created for a mix-and-match tablet application. This set included four eye shapes in two sizes each (automatically scaling with head size for eight total eye options), four heads in two sizes each (automatically scaling with head size for eight total head options), two head sizes (regular and large), four t-shirts, and four shoes for one body in a gender-neutral outfit. In this case, the body size never changed; only the head size (i.e., a larger head resulted in a taller character). Example characters are shown in Figure 3.

Figure 2. The eight base characters created by the artist for the storybook task.

EXPERIMENT 1

In our first study, we examined whether the children preferred different design choices for the characters in the storybook and whether these preferences varied by age. The participants compared characters that were unaltered to those that were systematically altered on each variable: head size, eye size, eye position, and eye roundness.

Method

Details specific to this experiment are described below.

Participants

Sixty children (30 boys, 30 girls) between the ages of five and nine years participated in this research, which was approved by our Institutional Review Board. The group included 13 five-year-olds (8 boys, 5 girls), 8 six-year-olds (2 boys, 6 girls), 18 seven-year-olds (8 boys, 10 girls), 11 eight-year-olds (8 boys, 3 girls), and 10 nine-year-olds (4 boys, 6 girls). Two additional boys were excluded from analyses due to recording or behavioral issues. Participants were recruited using email lists and advertisements in local gathering places and compensated for their time. This experiment was one session in a series of short, unrelated experiments on different topics that combined to last less than an hour.

Characters

All pairs of characters at the choice points included one unaltered character and an altered character of the same gender with a different identity (e.g., comparing unaltered Girl 1 to

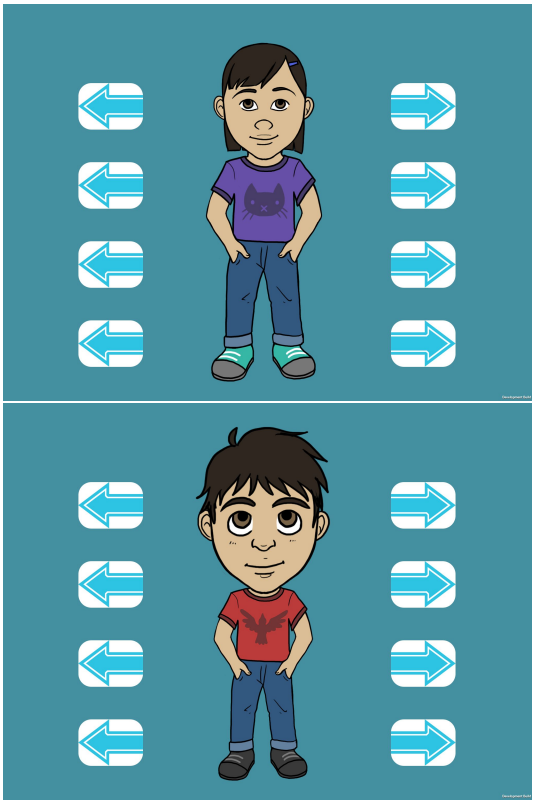

Figure 3. Sample characters from the iPad application.

enlarged head Girl 2). Each alteration was seen once. Forty-eight character combinations were created using a replicated Latin Squares design to create representative comparisons of all characters and alterations while counterbalancing presentation order for each pair (original versus altered) and assigned to participants in turn.

Storybook

A storybook was written that incorporated four opportunities for the reader to indicate character preference. In the story, the reader goes on a school field trip to the zoo with his or her illustrated classmates. When transitioning from one exhibit to the next, the reader is provided with two characters (printed on separate paper) with similar names and prompted to select one character with whom to attend (e.g.,"It's time for the elephants to take a bath! You need to pick a new partner to go with you. Do you want to go with Emma or Ava?") In total, the reader was prompted to make four choices. A sample page from the storybook is shown in Figure 4.

Procedure

The task was presented as a story game in which the experimenter needed assistance. Before beginning the task, the experimenter asked warm-up questions about other games they had played at the laboratory prior to the experiment and ensured the participant felt comfortable and ready to begin. Each page of the storybook was laid out separately along a large table. The experimenter or participant read the book aloud. At each choice point, the two options (with identity and order determined by the Latin Squares) were presented

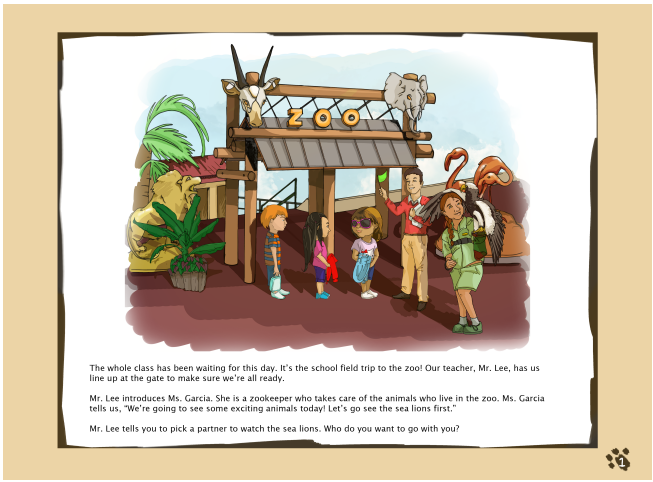

Figure 4. The first page of the storybook.

below the page. At each choice point, the child was asked which character they wanted to bring with them to the next page. The participant then moved the selected character to the picture on the following page. Each child had four choice points: two in which they chose one of a pair of girls and two in which they chose one of a pair of boys. No child asked whether there was a right or wrong answer, and the experimenter remained neutral about all selections. If a participant asked which character went with which name, s/he was told it did not matter and the names could go with whichever stimuli they wanted. Upon completion, the experimenter manually annotated the selections.

Results and Discussion

For the storybook, we categorized the image pairs (original vs. large head, original vs. large eyes, etc.) and tallied all of the results (240 trials in all). Out of the 240 pairs, the original was selected 146 times (146/240); the large head was selected 15 times out of the 60 potential times (15/60), the large eyes were selected 33 times (33/60), the close-set eyes were chosen 23 times (23/60), and the round eyes were chosen 23 times (23/60). These results significantly differed from those expected by chance, $\chi^2 = 16.700$, $p = 0.002$. We performed individual analyses for each condition. Specifically, the original characters were selected significantly more than would be expected by chance (146 vs. 120, $\chi^2 = 11.267$, $p = 0.0008$). When examining each other possibility, only the large head was selected significantly differently than expected by chance, with a bias against large heads (15 vs. 30, $\chi^2 = 15.000$, $p = 0.0001$). There were no significant patterns for large eyes, close-set eyes, or round eyes. We also examined whether any selection patterns correlated with age, and found no significant correlations (all $p > 0.15$).

Overall, the participants overwhelmingly selected the unaltered characters. When altered characters were selected, participant preferences did not vary systematically by age. The bias in preferences for the unaltered characters could arise from the idea that these are the characters that look most correct; that is, they reflect the intentions of the artist most accurately. Moreover, the unaltered characters might match better

with the handful of characters presented on the first and last pages of the book.

EXPERIMENT 2

We designed Experiment 2 such that the participants would have to choose an altered character and we could remove any bias towards unaltered art. Thus, we examined whether the results from Experiment 1 arose from a preference for unaltered characters.

Method

Our methodology was changed such that we only used characters that had been modified.

Participants

Twenty-six children (12 boys, 14 girls) between the ages of four and ten years who had not been in the prior experiments participated in Experiment 2. This group included 3 four-year-olds (1 girl), 6 five-year-olds (2 girls), 4 six-year-olds (3 girls), 5 seven-year-olds (4 girls), 2 eight-year-olds (0 girls), 4 nine-year-olds (3 girls), and 2 ten-year-olds (1 girl). No children were excluded from analyses due to recording or behavioral issues. Recruitment, compensation, and ethics approval were identical to Experiment 1.

Storybook

The same storybook was used as in Experiment 1, with only the alteration that no names were used for the characters to avoid the potential distraction of having a participant with a similar name (e.g., "You need to pick a new partner. Who do you want to go with you?"). The pairings included only images where the characters had been altered.

Procedure

The layout of the pages and the procedure were the same as in Experiment 1. The selection of the character choices differed as described above such that no unaltered characters were used. Pairings were designed to balance the number of characters from each condition that all of the participants saw, as it was impossible to balance this on an individual basis.

Results and Discussion

As in Experiment 1, we first performed a χ^2 analysis. We determined that no particular feature was selected more than would be predicted by chance (50% selection; 20 vs. 27 for the large head, 27 vs. 27 for the large eyes, 27 vs. 25 for the close-set eyes, and 30 vs. 25 for the round eyes), $\chi^2 = 2.975$, $p = 0.396$. Next, we examined whether any correlations could be found between feature preference and age. Again, we found no significant correlations (all $p > 0.10$). These results indicate that there are not consistent patterns in feature selection even if a potential bias towards unaltered features is removed. Additionally, no age-related biases were found.

EXPERIMENT 3

In this experiment, participants built their own characters on an iPad from a selection of predetermined pieces. This task was performed independently of any other media to avoid the potential issue of matching character styles to other material. Additionally, the characters had less distinctive styles than that in the storybook artwork to ensure that the various potential combinations of features all looked plausible.

Method

After completing either Experiment 1 or 2, all participants performed the task for Experiment 3.

Participants

The same participants from Experiments 1 and 2 were retained for Experiment 3, including one of the previously eliminated children from Experiment 1, an 8-year-old boy. Thus, 87 participants were included in the analysis, ranging in age from four to ten years.

Application

We designed an iPad application in which participants could create their own characters. Participants used four sets of arrows to scroll through options for eye shape and size; head shape, size, and hairstyle; shirts; and shoe color on the static, gender-neutral body. The eye and head options are described in the General Method section, and the application is shown in Figure 3. For this experiment, we elected to use an iPad rather than paper so that the children could more quickly select their preferred combinations of features by modifying each individually (i.e., they could select a specific head and then select the eyes rather than having to look through all possible head and eye combinations on paper). Because using the application ensured the ease and efficiency of feature selection, the results are likely faithful to the children's actual preferences.

Procedure

After completing either Experiment 1 or 2, each participant used the iPad application to create a unique character of his or her own by selecting the head, eyes, shirt, and shoes. When a participant was content with his or her final selections, a screenshot was taken to save the image.

Results and Discussion

For the application, we annotated each child's selection for head and eye variables. First, we examined whether there was an overall preference for a specific head size across all children. There were two options for head size: regular or large. Out of 87 children, 59 chose the regular-sized head and 28 chose the large head, which is significantly different than chance would predict, $\chi^2 = 11.046$, $p = 0.001$. Overall, regular head size was preferred. When we investigated the relationship between head size and preference, we found no significant correlation between age and preference for the larger head, $r = 0.18$, $p = 0.093$. In fact, the trend was such that older kids were more likely to select the large head. Second, we examined eye selection. Children were able to select close-set eyes (N = 24), wide-set eyes (N = 39), big eyes (N = 14), or round eyes (N = 10) for their characters. These selections were significantly different than would be predicted by chance, $\chi^2 = 23.023$, $p = 0.00004$. However, only two of the categories showed trends towards systematic preferences by age, and neither was significant. These non-significant trends were that younger children might be more likely to select wide-set eyes, $r = -0.206$, $p = 0.055$, and

less likely to select large heads, $r = 0.182$, $p = 0.093$ (in the opposite direction that the qualitative analysis would predict).

We conclude that when children were able to create their own characters, they showed a preference towards regular-sized heads and wide-set eyes. However, there were no statistically significant results that indicated systematic preferences that varied with age.

CONCLUSION

Our qualitative analysis identified three features that animators systematically vary depending on the age of their target audience: head size, eye size, and eye roundness. However, we did not find any age-related preferences in character designs when four- to ten-year-old children chose between existing characters or created their own. In general, there was a bias such that children disliked enlarged heads. These results suggest that designers creating animated characters for children's media and interactive applications need not follow these popular design trends for target audiences of different ages. Interestingly, our findings also suggest that the children have not had their preferences strongly influenced by programming for their own age groups.

Future work could include a wider variety of characters as starting points for modifications. While we created two sets to provide some variability, it would be useful to have sets that were originally drawn with large heads or other features so that they would look more natural than the calculated modifications. Particularly in Experiment 1, there is a possibility that children selected the images that looked "correct"; that is, how the artist intended them. Using a wider variety of characters as bases for modification would provide further support for the current findings. Explorations of character preference also could be expanded in the future to include 3D animated characters in order to produce results that more closely correspond to current media.

Additionally, future research should consider cultural and experiential factors. This research was focused on media created in the US to match the culture of the research participants. However, it is possible that the results could differ in cultures that commonly use different artistic styles, such as Japanese manga and anime. Moreover, it would be interesting to explore whether children's experience watching specific television programs, movies, and computer games could affect results for individuals within a single culture. This experience was not assessed in the current research.

SELECTION AND PARTICIPATION OF CHILDREN

We recruited children from Allegheny County, Pennsylvania, USA, where the population is approximately 1.2 million people. The study was advertised through postings in physical and online community bulletin boards. This research was approved by the Institutional Review Board at Carnegie Mellon University and participants were compensated for their time. Parents provided consent and children over the age of eight years provided assent.

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