Keeping up appearances: Interpretation of tangible artifact design

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ABSTRACT
The design and interaction of physical game artifacts is becoming increasingly important for the design of digital tabletop games. In this paper a study is described investigating the differences in interpretations of realistic and abstract game artifacts comparing children and adults. A game was created on a digital tabletop as a carrier for the user evaluation presented in this paper. The appearance of the game artifacts was explored and a family of each of the artifacts was created. The interpretations of each of the individual artifacts and their different visual appearances were tested to determine whether children rank and interpret the functionalities of the artifacts differently than adults.

The results showed that overall the understanding of abstract artifacts compared to realistic ones was best for both children and adults. It also indicated there was no significant difference in the interpretations of the realistic and abstract artifacts between children and adults.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation (e.g. HCI)**]: User Interfaces – *Input devices and strategies (e.g., mouse, touchscreen), User-centered design.* K.8.0 [**Personal Computing**]: General – *games.*

General Terms
Design, Human Factors.

Keywords
Semiotics, Tangible Interaction, Digital tabletop games, Interaction design

1. INTRODUCTION
Traditional board games often evoke and support social interaction. A social environment is created by players sitting face-to-face, gathered around the same table, competing or collaborating to reach their goal. Physical game artifacts can be of use in this process, e.g. by making those artifacts players' representations or artifacts of desire.

With the rise of computer games and game consoles, many of these benefits of board-games have been reduced or even ignored. Most computer games lack direct and social interaction, since players interact through the system, using buttons and consoles, instead of directly with each other. On the other hand, these games introduce other qualities, e.g. direct feedback, save options, levels of increasing difficulty and graphic animations.

Different technologies aim to combine the advantages of board games and computer games e.g. digital tabletops. These games use computer technology but also aim to create a social experience by letting people interact with a tabletop screen using different interacting styles. These interaction styles allow a user to have more freedom when interacting with the system, e.g. through orientation of physical artifacts, communicating through gestures and making use of several input media [20, 22 25, 35]. Many games have been created using digital tabletops, see e.g. [1, 17, 18, 19, 20]. At the same time, digital tabletops allow for the creation of games that can control the action possibilities of users e.g. by enforcement of rules [26]. The game described in this paper is meant to help children deal with social interaction through the creation of rules and physical artifacts that force the players to collaborate. In this paper we will focus on the design of the game artifacts.

Within the area of game design, several topics can be distinguished e.g. gameplay, game mechanics and game interface [4]. The interaction possibilities a user has with the game (game interface) and the medium used for the interaction (game mechanics) are important because they contribute to the gameplay and create the overall game experience. By using digital tabletops, the interaction between the user and the system can be enhanced by physical game artifacts (game mechanics). They allow for these physical artifacts to be linked to a digital artifact or digital information within the game. This gives users the possibility to directly interact with the digital interface through natural interaction possibilities; e.g. moving, placing, stacking, rotating, adapting or sharing of physical game artifacts to achieve the desired action. Also, it is shown that the visual appearance of artifacts can evoke different responses of users and influence certain aspects of gameplay [5, 6]. However not many tests have been done to determine in what way changes in the appearance of physical artifacts can cause for different

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interpretations of the artifacts' functionalities nor how this can be used to enhance the interpretations of the artifacts.

The study described in this paper deals with creating various visual appearances of the functionalities of game artifacts using different three-dimensional signs. The focus of our study is to find out whether realistic or abstract artifacts are easier to interpret correctly by children or adults. Furthermore, it is investigated whether there is a difference between these two groups.

First, some research is presented involving digital tabletop interaction and the appearance of artifacts. Next, the designed game and game artifacts will be described. Finally a user evaluation is shown and the results will be discussed.

2. RELATED WORK

The following section will describe the interaction with digital tabletops and the tangible interfaces that can be used with them, as well as possible design solutions for physical game artifacts.

2.1 Digital tabletop interaction

Digital tabletop games make use of two of the most important elements that distinguish traditional board games from computer games [18]. Firstly, a social environment is created between the players of the digital tabletop game. Many (board)games involve face-to-face interaction, allowing players to directly communicate with each other and thus being able to make use of natural gestures [19, 20, 35]. In (multi-player) computer-games players can only interact through the interface of the computer or console, creating a less natural and less social interaction. Secondly, digital tabletop games can make use of digital as well as physical interfaces. Physical game pieces, used in most regular board games, can visualize the state of the game and the interaction of the players with it. The placement of these artifacts and the orientation of the artifacts on the surface of the tabletop can be used as a means for communication between the players, visualizing the actions of the players throughout the process [25, 27, 28]. This type of physical communication is not present in computer-games. In these games the interface is multi-functional and therefore the undertaken actions are no longer visible after the action is finished. Combining both digital elements (images or updated information) with physical elements (play pieces or artifacts with a clear functionality) allows for interesting interaction possibilities that can create a new game experience.

Some projects have already started to combine board games with computer games. Research is done within the field of pervasive games, focusing on exploring possibilities of both digital and physical qualities to improve gameplay within a digital tabletop environment [17, 18].

Magerkurth et al. [18] have created several game prototypes in which they focus on exploiting the realm of digital technology. The game Knightmage makes use of a digital surface, a wall display and a personal PDA for each player. This allows for the players to collaborate to reach their goal (exploring medieval places) but also to strive for personal riches and keep personal information private [22, 35]. The Monopoly adaptation for STARS [18] also shows how a game can benefit from digital information, as the digital game is able to keep extensive overviews of the player's financial status and even allows secret alliances.

Although these games mainly focus on the digital benefits of digital tabletops, using physical objects can create a different kind of experience as well. The next sections will describe how tangible interaction can be used to interact with a game or system.

2.2 Tangible interaction

Tangible interaction deals with the creation of physical artifacts which can incorporate full-body interaction. It designs both the digital interaction as well as the physical aspects needed to control the interaction [32]. Therefore it is important to understand how physical artifacts can be used in and linked to the several interaction media. Ullmer and Ishii [32] state that there are four important characteristics of tangible interfaces:

- The physical artifact is linked to the digital function.
- The physical artifact allows the user to have free control over movement and interaction.
- The representation of the physical artifact is linked to its function.
- The physical state of the artifact shows the actions of the system.

Using this kind of interaction, Fitzmaurice et al. [10] created a drawing system that uses physical blocks to adjust images and allows for more natural interaction with the system. Magerkurth et al. [18] have also created several games using the physical attributes and possibilities of digital tabletops. In these games, digital information and (the placement of) physical elements are linked to create a better and more immersive gameplay. Candyland [18] encourages children to play with physical play pieces on the surface of the screen to find out what effect these actions have on the environment around them. Furthermore, Mandryk et al. [20] have created the game False Prophets, which encourages physical and social interaction between the players. Players can interact in the real-world as well as with the game board and artifacts to achieve their goals.

These games were used to encourage players to invoke in different interaction styles provided by the system. It illustrates the many interaction possibilities created by using digital tabletops. Not many studies have focused on the appearance of and interaction with the actual game artifacts. However, we think the visualization of the artifacts is also important and needs to be designed according to the system the artifacts will be used for.

2.3 Form follows function

When designing artifacts with a particular function it is important to understand the visual elements that allow perceivers to create an interpretation of the artifact. Artifacts in our environment can be interpreted by people in different ways. These interpretations depend on the appearance of the artifacts [11]. The shape and visual appearance of artifacts are used by perceivers to create an interpretation of the functionality of the artifacts. People's personal experiences with similar products, as well as their emotions, influence the way the product is interpreted [6].

In order to make artifacts or products better understandable, signs can be used. These signs can be visualized in a 2-dimensional way, e.g. through icons used on a video player to

help make the functions better understandable, but they can also be visualized in a 3-dimensional way e.g. through elements in the appearance of the artifact or product itself.

2.4 Semiotics

Semiotics is an area of design that focuses on the creation of signs and their meaning. Signs are used to create a link between the real world and the artifact. A sign represents something that a perceiver needs to interpret in some way [3, 21]. An example of an everyday sign is a traffic light; green means go and red means stop. According to Peirce [see 3, 34] a semiotic sign can be explained as the relation between a referent, a form and a meaning (Figure 1). The referent is the artifact that the sign resembles, the form is the shape of the sign itself and the meaning is the way the sign is interpreted by a perceiver.

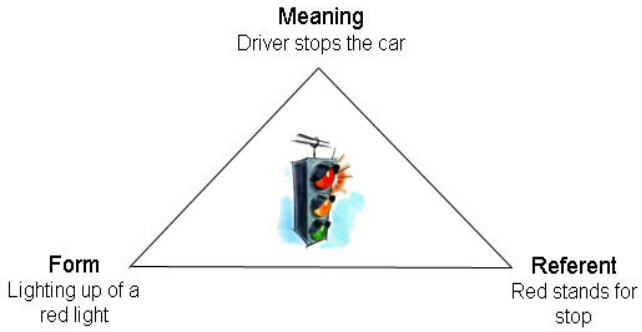

Figure 1. Visualization of a semiotic triangle showing the interaction between meaning, form and referent, based on [34].

There are three divisions that can be made within the area of signs. However it is argued that these categories are often combined [9]. Still, there is always one category more present in an artifact than the others. These divisions are [3, 8]:

- *Iconic signs* resemble the artifact in a realistic way; the sign still resembles the actual object. This allows perceivers to link the sign to the object without any knowledge.
- *Indexical signs* create a link between the function of the artifact and the sign; the acting out of the function is shown through the sign.
- *Symbolic signs* have a less clear link to the artifact, making it necessary for the user to learn the relationship between the artifact and the sign through experience; the sign is more abstract.

For example, the sign of a message e.g. an email can be shown either in an iconic way, such as an envelope that still has a resemblance to a normal envelope, or in a symbolic way like a letter in a bottle, which is often seen by people as a secret message and therefore has to be known by the user. An example of an indexical sign is the image of a printer on a computer screen, showing the actual printing; the action is shown in the sign.

In order to make signs understandable for a perceiver, the interaction between the referent, meaning and form needs to be taken into account. These aspects work together to create the proper interpretation of the artifact. There are different areas within semiotics that deal with the creation of this interaction: semantics (creating meaning through signs), syntactics (connecting signs together), and pragmatics (how signs are being used by man) [3, 15, 33]. The area of semantics is used in the study presented in this paper to visualize the game artifacts using iconic and symbolic appearances to represent the functionality of the artifacts. The other areas within semiotics are used for the evaluation of the created artifacts.

2.4.1 Semantics

Semantics is the area that focuses on creating meaning through a products' appearance. Artifacts and products around us can have different semantic functions [5, 6, 23, 24]:

- *Describe:* visual elements of the artifact are described and used to explain functionality and basic information of the artifact.
- *Express:* design expresses values and qualities and what the artifact means.
- *Signal:* design signals the user to act in a specific way.
- *Identify:* design identifies origin, nature and product area.

While affordances are also often considered in this respect, these focus on physical elements that indicate the functionality of a product as well as the interactions required for it to function [15]. Semantics on the other hand do not merely focus on the physical aspects of a product to show its meaning [7, 36]. The focus lies on the entire appearance of a product which is used to convey a products' meaning, making use of a person's knowledge of (similar) products. Although the functionality is shown through the artifact design, the focus lies on the communication of a product. This communication takes place through signs and signals in the visual appearance of the artifacts.

2.4.2 Use of semiotics in interface design

The differences between iconic and symbolic signs in computer interface design (two-dimensional signs) have been investigated in the following studies. Ferreira et al. [7, 8] showed how existing user interfaces can be redesigned while making better use of signs and their conveyed meaning. When evaluating the understandability of computer interfaces, they found that there was no large difference between the recognition of iconic or symbolic signs. However, signs that were interpreted right by the majority of the users were mostly iconic signs. They stated that users tend to base guesses of the meaning of a sign on the visual elements that are available in the sign and that they can link to an artifact or action in their mind.

Signs in three-dimensional artifacts have been studied by Bakker et al. [1]. They developed a digital tabletop game that makes use of a set of iconic and a set of symbolic play pieces in order to determine the difference in gameplay as perceived by the participants. By letting participants, a group of men and women in the age of 19 to 50, play the game and answer questions it was concluded that the iconic play pieces were best understood.

The above-mentioned studies have focused on creating the right visual appearance (using signs) of an interface or interface parts (artifacts). However to our knowledge it has not yet been tested how different people react to these visual appearances to find out which one is best for what kind of artifacts. Apparently young children and adults look differently at artifacts around them and interpret them in different ways [31]. Therefore the study described in this paper is conducted with children as well as adults. The results of both groups are compared to each other.

3. THE GAME

In order to have a carrier to evaluate the interpretations of the game artifacts, a game was created and implemented on a digital tabletop using the ReacTIVision technology [14] (Figure 2).

The game was created to encourage social interaction between children and focuses on improving this interaction through the gameplay. The game is called 'Totti' and is set in 19th century Northern America, where the Indians lived. There is only one main character (the Indian) that is used by all four players and should be moved around the game-board. The Indian needs to travel from one Indian village to another in order to get information from the villagers. This information concerns the hiding places of pieces of an ancient totem-pole. By fulfilling a request from a village, the Indian can find a piece of the totem-pole and build up the entire pole. When the pole is finished, the evil that is approaching the villages can be defeated.

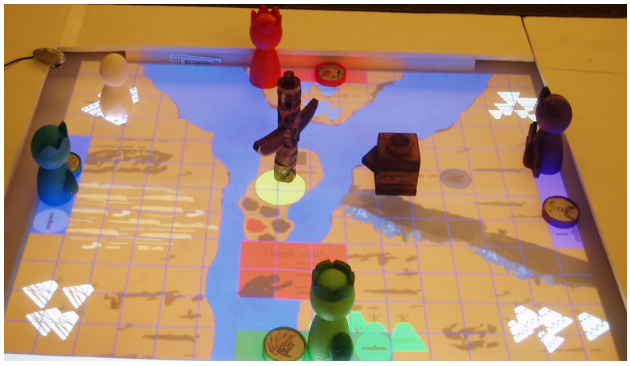

Figure 2. Digital tabletop game Totti.

Totti is played by four players, each represented by a god (the god of Water, Earth, Fire and Air). These gods cannot be moved around on the game-board, but can use their powers to help the game progress. They can use certain artifacts to help the Indian cross obstacles during his travels, e.g. cross a river or climb a mountain, and the gods can use their powers to fulfill a request of a village. Often more than one power is needed, forcing players to collaborate. The game focuses on one general goal (the building of the totem-pole) and all players need to help the Indian reach this goal.

3.1 Design goal

An important aspect of the design process of a game is the creation of the appearances of the game artifacts. A good visual appearance can increase the interpretations of the artifacts within the game and create a more immersive gameplay. Therefore the goal of the design process described in this paper is to create the game artifacts in such a way that they resemble their functionalities through different visual appearances. These will be tested to find the best understandable one for children and adults. The designed game was only used as a carrier to create a context for the use of the artifacts, which is needed for the evaluation. In this paper, the design and evaluation of the artifacts of the gods will be discussed. As stated before, these artifacts represent the players in the game.

3.2 Design of game artifacts

The functionalities of the game artifacts were explored and visualized in various ways in order to test different appearances of artifacts. A schema was created as proposed in [5, 36] in order to explore what different visual elements could be used to visualize the different artifacts. Examples of these elements are the outfit (robes), crowns, color and an individual object. In the end we decided to have the same groups of elements visualized in each artifact of a certain level of abstractness. For example the realistic artifacts of each family contain the following elements (visually adapted to the specific family): a robe, a crown, a specific color, the artifact's basis, facial expressions and a small object representing its functionality (see Table 1). In this way there is consistency within families as well as across families. Each of these families of artifacts represents the same god, meaning they all share the same referent.

Different categories are established through the different (amounts of) visual elements the artifact contains. The amount of visual elements is explained as the level of *iconicity* within an object. Using the theory of semiotics as described by Peirce [see 3, 34], the categories of artifacts distinguish between iconic and symbolic artifacts. The iconic artifacts have a clear visual link with the things they represent and are realistic looking, while symbolic artifacts have a less clear link with the artifacts they represent; they include more abstract elements and need to be learned by the players through experience. In our situation however, these levels of iconicity vary between different layers of artifacts. Within the artifact families a difference can be detected between "*carrier*" artifacts (artifacts that resemble the god and its power, see Table 1) and the "*functional*" artifacts (artifacts that only resemble the power of the god e.g. water, see Table 1). Both carrier and functional artifacts range from realistic to abstract, but the most abstract artifacts are the ones representing only the functionality. Therefore, the levels of iconicity are not linear throughout the entire artifact families. For this reason we will refer to the different artifacts within a family as abstract or realistic, indicated by the level of *abstractness*.

This division allows for the interpretations of the artifacts to be evaluated in different artifact categories. The different appearances will be tested with children and adults.

The goal of these design families is to distinguish between the visual elements used by children to identify the artifacts and the ones used by adults. By only showing the participants one artifact at a time, it can be observed at what point during the evaluation participants recognize and interpret the artifact correctly.

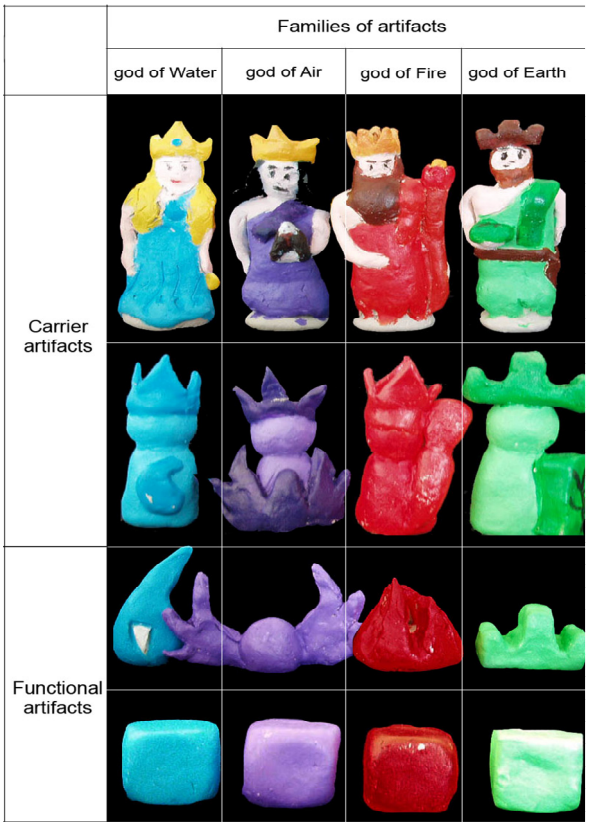

Table 1. Different categories of artifacts of the gods of Water, Air, Fire and Earth.

4. USER EVALUATION

The focus of this study was to determine the differences in interpretations of visual appearances in realistic and abstract artifacts comparing children and adults. This was translated into the following three research questions:

1. What is the effect of different levels of abstractness on the interpretation of game artifacts?

2. What elements in the artifact appearance do participants use to interpret the artifacts?

3. Can participants rank the artifacts according to the amount of abstractness present in each artifact?

A pilot-test was performed to evaluate the questions and the set-up of the evaluation. The responses given by the participants of the pilot-test were helpful to create an evaluation that was less biased and more focused on the desired responses. This includes covering the artifacts up during parts of the evaluation so the participants would not be biased by other artifacts and directing participants' actions by focusing their attention on specific artifacts instead of all artifacts at once. More questions also needed to be created to evaluate different aspects of the interpretation of the design of the artifacts. With help of this information, an extensive protocol was set up for the final user evaluation.

4.1 Procedure

In total 22 children (14 boys and 8 girls) in the age of 10 – 13 and 15 adults (9 male and 6 female) in the age of 20 – 53 participated in the user evaluation. Before starting the evaluation, the participants were asked to fill in a short questionnaire asking for their name, age and computer usage over the years. The entire evaluation lasted for 30 minutes.

In order to focus the user evaluation on the visual appearances of the artifacts, the game artifacts were tested separately from the game and before any of the participants had played the game. The participants received a short introduction on the purpose of the evaluation as well as some basic information about the game. They were explained about the basic rules, involving an Indian and gods, as well as the fact that the artifacts were part of a bigger scheme, representing the gods within the game. They were not given information about the exact functionality of each artifact or which gods were present in the game.

The user evaluation was divided into three parts (Table 2). Each participant went through the three parts in the same order. The order of the different parts was determined by the information given to the participants during each part. Part 3 showed the different levels of abstractness to the participant, which made it necessary to place part 2 of the evaluation before part 3; here, the participants needed to link the artifacts according to their level of abstractness.

Table 2. The step-by-step procedure of the user evaluation.

Intro-duction	Participant receives a short explanation about the game, including the plan procedure for the evaluation
Part 1	Participant is asked to explain the functionality of different game artifacts
Part 2	Participant is asked to make groups of artifacts according to similarities in their visual appearance
Part 3	Participant is asked to create a line of objects of one specific artifact-family
Outro	Thanking the participants and end of the experiment

Part 1 - Identify game artifacts

For this part of the user evaluation, only one artifact at a time was shown to the participant, starting with the most abstract artifact (see Figure 3, artifact 8) and proceeding to the most realistic one (see Figure 3, artifact 1). The participants were asked to describe what they thought the artifact represented, what it could represent in the game and what its' functionality in the game could be. All questions were answered verbally to ensure completeness of the answers. This part of the evaluation was executed with two different artifact families (water and earth) and the order of the two families was counter-balanced.

Part 2 - Visual similarities of artifacts

At this point in the user evaluation, the participants had seen all the artifacts and were explained that all artifacts of one color represented several instances of one character in the game. They were then told they needed to find four different colored

artifacts they found to be similar. The participants were given one specific artifact and asked to find the matching artifacts in different colors. As an example, the four different colored blocks were used. This part of the evaluation was done with two categories of artifacts. The exercise was followed by a question on their decision making process.

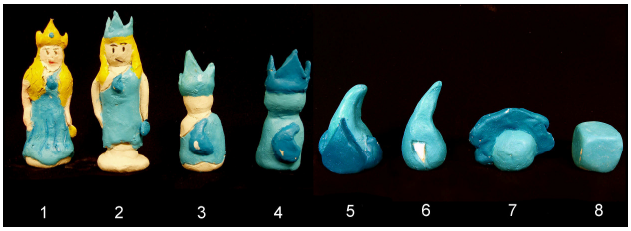

Figure 3. Levels of abstractness in the god of Water artifact family.

Part 3 - Distinguishing between levels of abstractness of artifacts

The participants were asked to make an overview of the red or the purple artifact families (not the green or blue ones they used in the first part of the evaluation), starting with the most abstract artifact and decreasing in abstractness up to the most realistic designed artifact. They were also asked to describe what they looked for in the artifacts to make their decision. These answers were compared to the actual designed families of the artifacts.

4.2 Measurements

For the evaluation of part 1, a framework was used to categorize the interpretations of the game-artifacts into different levels. As described in the literature overview a product can have specific functions e.g. to describe, to express, to exhort and to identify [5, 6, 23, 24]. These were used to list the specific elements in the visual appearance of the artifacts and to determine the order of importance. Table 3 explains the different functions and the points assigned for the recognition of each of them. The highest score possible per artifact is 4 points.

Table 3. Scoring protocol for the visual elements identified by participants in the artifacts.

Describe	Describing visual attributes of artifacts.	0.5
Express	Linking artifacts to experiences or artifacts in the "real-world".	1-1.5
Describe & Express	Describe the visual attributes of the artifact and what it resembles in the "real-world" (e.g. god of Water).	1-2.5
Identify	Naming functionalities of the artifact; it was assumed that representation was also known.	3
Identify and Associate	Stating entire representation of the artifact (god of ..) and its functionality.	4

As stated by Chandler [3] there are different levels of interpreting an artifact. These levels are denotation (information given by artifact) which is based on the visible references of the artifact and connotation (symbols referring to meaning of artifact) which needs knowledge of and experience with an artifact. Some elements, e.g. more or less color, can be categorized as denotation, while others e.g. making a distinction between human and non-human artifacts can be categorized as connotation. For the evaluation of parts 2 and 3 these different levels on which humans can interpret artifacts were used to set up a scale of the visual elements describing the artifacts. The elements named by the participants were rated according to the amount of effort required from the perceiver to relate the visual elements to the functionalities of the presented artifacts. The elements rated lowest on the scale received 1 point and the elements rated highest on the scale received 5 points.

5. RESULTS

Part 1 - Identify artifacts

Two artifact families were used for this part of the test (god of Water and god of Earth). The points scored for each artifact were added for both the children and the adults. The results of both artifact families can be found in the graphs (see Figure 4 and Figure 5). The differences in interpretation of the artifacts by children and adults is shown through the pairs of lines; the left line of each pair visualizes the points scored by children, the right line of each pair visualizes the points scored by adults.

In Figure 4 and 5, the results of a 95 % t-test of the differences between children and adults are shown. It can be seen that the levels of significance vary from a p-value of 0.66 (t = -1.9) (see Figure 5, artifact 1) to a p-value of 0.72 (t = -0.36) (see Figure 4, artifact 6) in the blue objects of the god of Water. The green objects of the god of Earth vary in p-values from 0.21 (t = -1.29) in on of the abstract objects (see Figure 5, artifact 5) to 0.99 (t = -0.18) in one of the realistic objects (see Figure 5, artifact 4).

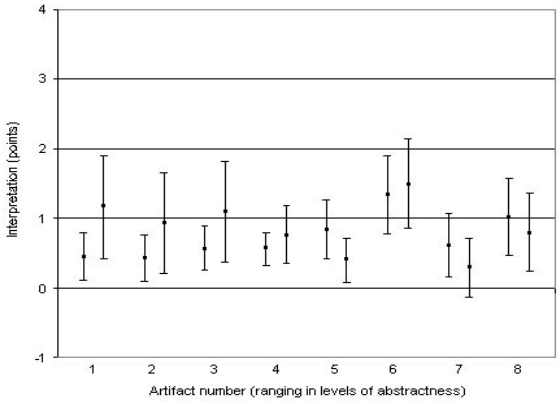

Figure 4. Difference in interpretations of the god of Water artifacts comparing children (left lines of each pair) and adults (right lines). The understandability was rated between 0 and 4 points, where 4 points indicate complete understanding of the artifact's functionality. The artifact abstractness ranged from realistic (1) to abstract (8).

Out of the average points scored for each artifact, it can be concluded that overall the carrier artifacts (see Figure 3, artifacts 1–4) were better understood by the adults, while the functional artifacts (see Figure 3, artifacts 5–8) were better understood by

children. However, no significant difference was found. More studies can be done to investigate whether there are actually significant differences between the interpretations of realistic and abstract artifacts comparing children and adults.

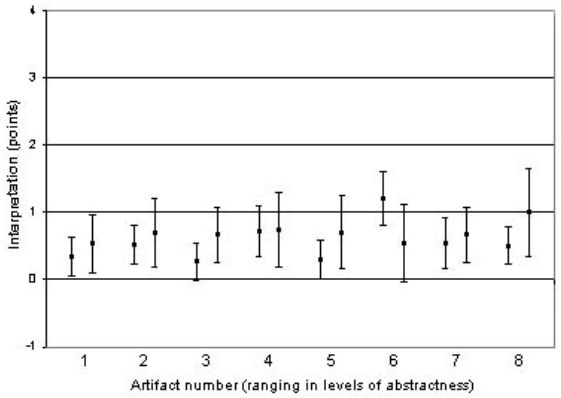

Figure 5. Difference in interpretations of the god of Earth artifacts comparing children (left lines of each pair) and adults (right lines). The understandability was rated between 0 and 4 points, where 4 points indicate complete understanding of the artifact's functionality. The artifact abstractness ranged from realistic (1) to abstract (8).

In Figure 6, it can be seen that the artifacts that were best understood by all participants are part of the abstract artifact category (see Figure 3, artifact 6). These artifacts have a quite high level of abstractness; they resemble the functionality, but no longer the representation of the digital artifact. It can be seen that the most abstract artifacts (see Figure 3, artifact 8) were also understood quite well by all participants.

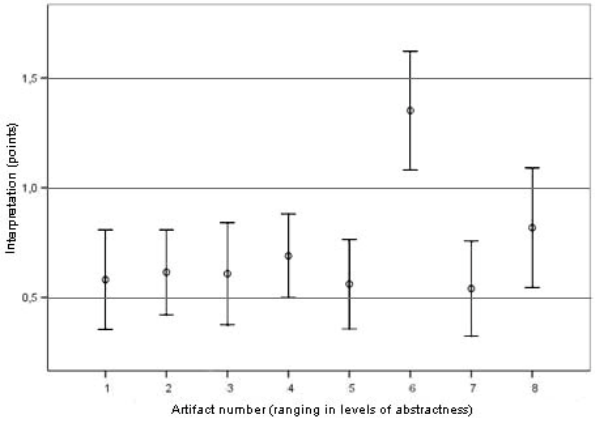

Figure 6. Level of understandability per artifact combining children and adults. The understandability was rated between 0 and 4 points, where 4 points indicate complete understanding of the artifact's functionality. The artifact abstractness ranged from realistic (1) to abstract (8).

Part 2 - Visual similarities of artifacts

The elements named by the participants were rated to the amount of effort that is needed from the perceiver to establish the decision, making use of a pre-determined list of elements. In this part of the evaluation these elements were used to link similar artifacts together.

To determine if there is a difference between how children view artifacts and how adults do this, the first element named by each participant was used to determine the average amount of points collected for both groups. The results from part 3 were also used.

The average amount of points showed that the children scored 1.85 points, while the adults scored 1.95 points. A 95% t-test has shown there is no significant difference between all of the values (p-value = 0.52, t = -0.64).

Part 3 - Distinguishing between levels of abstractness of artifacts

For this part of the evaluation, no specific list of results was set up. The main focus of this part was to see how well participants could distinguish between more or less abstract artifacts. The participants were asked to explain on what elements in the visual appearance of the artifacts they had based their decisions. It was found by the answers given by participants that they had the least problems distinguishing between the most realistic artifacts, since the differences were mostly based on colors and slight changes in shape. Participants had more trouble with the abstract artifacts. The differences between these artifacts are based on larger differences in shape (the entire artifact is changed) and therefore participants found it harder to name the elements that determine the level of abstractness of these artifacts.

6. DISCUSSION

The hardest part of this paper's study was to design the artifact families on different levels of abstractness. In order to create the specific functionalities for each of the god artifacts, a schema was set up as proposed in [5, 36]. The artifacts were explored in various ways, designing the visual elements in each successive artifact at a higher level of abstractness. However, during the design process of the abstract artifacts, we found it difficult to determine the right shape for the gods, as well as for water, earth, fire and air (we chose for a droplet, a leaf, a flame and wings). Because the concepts of droplets and water are more closely tied together than e.g. a leaf and earth, this might have influenced the results of this experiment. On the other hand, the understandability between water and earth did not differ significantly and both children and adults were consistent in their preference for the rather abstract artifacts representing only the functionality. When artifacts have to be designed for a game, attention should be paid to designing the link between the artifact and its functionality within the game in a similar fashion across artifact families. This improves the understandability of the game and does not disadvantage players with certain game artifacts.

No significant differences were found in the interpretations of realistic and abstract artifacts between children and adults in this user evaluation. Both children and adults understood best the second artifacts of the abstract category (see Figure 3, artifact 6). This shows us that having only one or very few elements to

identify the artifact can be enough to interpret the artifact correctly. Many visual elements might be confusing. However, it can be argued that the way the artifacts were designed has contributed to this fact. In the different families, the artifact of a god has been designed. The focus of the visual appearance throughout the family of artifacts was on the gods and their powers, instead of on the powers itself (which is actually represented in the different functionalities of the artifacts). This resulted in two different design layers within the artifact families that were tested (namely the "carrier" and the "functionality" layer) on one scale. Therefore the abstract ones are the artifacts that only represented the functionality of the artifact. If the artifacts would have been worked out with the focus on the power instead of the god with the power this might have influenced the results.

Related to this, based on informal observations we have the impression that for the abstract artifacts (see Figure 3, artifacts 5-8) the participants focused directly on the functionalities, while for the realistic artifacts (see Figure 3, artifacts 1-4) they tended to think only about the representations and seemed to forget the functionalities. It is interesting to note that the realistic artifacts, the so-called carrier artifacts, which are commonly used in many board games (see e.g. chess pieces) scored lower than the functional artifacts. This shows that the design of artifacts as is used in many board games nowadays does not seem to contribute to the understandability of the functionalities of these artifacts.

To increase the understandability of the gameplay, artifacts within a game should be designed according to their functionality. In our case, signs were used in the design of each functional artifact that resembled the god's power. In the carrier artifacts however, signs were used to represent the god, which shaped the entire design of the artifact and a representation of the power was just a small element in the design. We think that in order for an artifact to resemble its functionality best, all (semiotic) elements in its design should contribute to the interpretation of the artifact. Therefore we would redesign our carrier artifacts and focus the appearances of these artifacts on their functionalities, making them into functional artifacts as well. This means to remove the visual elements referring to gods and focus on the artifacts' powers instead, creating more symbolic artifacts.

Another methodological issue of our work was that participants often explained artifacts while referring back to other, related artifacts they had already seen during the evaluation. Therefore in this evaluation it was not always clear if the interpretation was measured using the individual artifacts. For this evaluation, we assumed that once a participant recognized an artifact, the participant would also recognize the next artifacts as being the same. This turned out to be false, which resulted in not having a clear transition between understanding and not understanding the representation of each artifact family. This could have been helpful to determine the level of abstractness that is understandable for either children or adults. Setting up the evaluation in a different way could have prevented this.

During the evaluations it also became clear that the experience participants had with computers played a role. Especially the older participants, who started to use the computer at a later age, found it more difficult to place the artifacts within the context of a game. Participants who had more experience with games however were able to explain certain artifacts and their functionalities using aspects of games they already knew or had already played before.

While identifying the green artifacts, children had more difficulty identifying the abstract artifacts, compared to the blue artifacts (Figures 4 and 5). This can be explained by the fact that the link between a water artifact and water is easier to make than the link between a leaf artifact and earth. Children might find it harder to make a conceptual step like this than adults do. On the other hand we saw that the adults found it easier to identify the most realistic artifacts than the children did.

7. CONCLUSIONS

The main goal in this project was to determine the differences in interpretations of realistic and abstract artifacts comparing children and adults. Three research questions were set up to evaluate certain aspects of the interpretation of artifacts.

1. What is the effect of different levels of abstractness on the interpretation of game artifacts?

The results of the evaluation showed that there was a difference between the interpretations of the groups of participants. The adults were found to have a better understanding of the realistic artifacts, while the children understood the abstract artifacts better. However, this difference between children and adults was found not to be significant.

What can be concluded is that out of all the different artifacts, the second artifacts of the abstract category (see Figure 3, artifact 6) were identified best (Figure 6). In this respect the amount of abstractness in artifacts makes a difference for the interpretation of the artifact.

2. What elements in the artifact appearance do participants use to interpret the artifacts?

The evaluation has shown that there is no significant difference in the way children or adults interpret the visual elements in physical artifacts. It can be concluded that both children and adults only reach one of the lower levels of recognition during the evaluation, denotation. This shows that the first interpretation of people of an artifact is mostly based on visible references, while emotional and deeper interpretations come later on.

3. Can participants rank the artifacts according to the amount of abstractness present in each artifact?

The last part of the evaluation showed that participants find it easier to distinguish artifacts based on their colors than they do based on their entire shape. Simple visual elements (e.g. color, size) were found to be the easiest to use as a distinction between separate object categories. Therefore these elements should be used to create a link between the artifacts while creating a category of artifacts that have a shared functionality.

Summarizing it can be concluded that although there is a small difference in the artifacts understood best by children and adults, the difference is not significant. Also, there is no difference in the identification of the game artifacts given by children and adults.

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