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A Robot as Persuasive Social Actor A Field Trial on Child-Robot Interaction

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Abstract. This article presents an exploratory user study designed in order to explore the persuasive effect of the humanoid RS Media robot by means of an experiment on uncertain knowledge. In the study an overall of 171 children (99 male, 72 female) between the ages of 6 and 17 took part. The experiment was set up as a card game based on the theoretical "Monty Hall Problem" in which the children had to choose that card out of three that would disclosure the treasure. During the game the robot advised the child to change his/her mind and choose another card. Three different pieces of advice could be given by the robot varying in their level of certainty. The basic assumption was that the more specific the hint is, the more credible and thus the more persuasive the robot will be experienced. The whole game was accompanied by a questionnaire in which the children had to state their level of certainty about their choice and the credibility of the robot on a rating scale between 0% and 100%. The results indicate a high persuasive effect on young children. As regards the hints it can be said that only easily understandable cues improve the persuasive effect.

1 INTRODUCTION

Child-Robot Interaction as a specialized research area of Human-Robot Interaction is paid more and more attention to in recent years. Robots can be seen as social interface for children in a variety of roles: companions, teachers, nannies etc. Several toy robots already exist which are commercially available to entertain children, like the robotics toy series of the WowWee robotics company [2]. However, entertainment will not be the exclusive future interaction scenario for Child-Robot Interaction. Research is already conducted with the aim to investigate the possibilities of robot therapy for children [9, 23, 25, 28]. Insights from theses studies show the potential of robotic technology for children lies not not only in entertainment, but also in supporting children's development. It is likely that robots will be introduced in class rooms and children's rooms in an educational role.

Based on the media equation, stating that media equal real life [30], we assumed that the social role of a teacher could be replaced by a robot. However, in that case it would matter to what extent children would follow the advice of a robot or trust in a robot. In this article we present an exploratory user study conducted with 171 children to explore the persuasive effect of the humanoid toy robot RS Media. We focused on how the detail level of the hint influences the persuasive power of the robot and the interplay between the perception of credibility and the child's decision certainty.

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Persuasive technology can be defined as technology especially designed to change beliefs, attitudes, or the behavior of another person or a group of people [12]. Key factors for successful persuasion are (1) the source of the message, (2) the strength of the argument, (3) and the influenced person being himself. According to Fogg computing systems which offer social cues and elicit social responses have a high persuasive power. Previous studies on the persuasiveness of robots have already shown promising results, indicating the high feasibility of robots as persuasive social actors [29, 15]. Based on this indication we decided to use the commercially available RS Media robot as interaction partner.

We assumed that in an uncertain situation in Child-Robot Interaction the level of detail of the argument and the child's personal certainty concerning with the decision play a major role for the persuasive effect. In uncertain situations humans have to base their decisions on likelihood estimations, e.g. in the outcome of an election. These beliefs that lead to a decision are determined by influencing factors, like representativeness of the argument and availability of knowledge. To create a situation of uncertainty the experiment was set up as a game, based on the so called "Monty Hall Problem".

Furthermore, according to the "Elaboration Likelihood Model" developed by Heesacker et al. [16], credibility is a major source factor for persuasive effects. This model states that people are more likely to be persuaded when the source of information is perceived as credible. This correlation of the information source and the persuasive effect could already been shown for screen agents [27]. In general, credibility can be seen as a key aspect for successful Child-Robot Interaction on the long term. Moreover, credibility plays a major role in supporting children's decisions in situations of uncertainty.

The paper is structured as follows: a short survey on related work is presented in Sec. 2, the user study including the theoretical concept of the "Monty Hall Problem", the research questions, study setting, and procedure are presented in Sec. 3. Sec. 4 discusses the results and insights gained, and research directions for future work will be given in Sec. 5.

2 RELATED WORK

Research on credibility has got a long history. Credibility has often been the object of research especially in the field of communication science, for instance the comparison of radio, TV, and newspaper [14] as well as recent research including online media [3],[20]. Hovland et. al [17] showed in their study that credibility consists of the two main principles *trustworthiness* and *expertise*. Based on this research Fogg and Tseng [13] investigated to what extent credibility matters in Human-Computer Interaction. Hereby they suggested a set of basic terms for assessing computer credibility. Bartneck [5] adapted Fogg's and Tseng's concept of credibility [13] to his model of convincingness. He could show that convincingness and trustworthiness highly correlate.

One of the most famous experiments regarding the credibility and persuasiveness of computing systems was conducted by Weizenbaum [37] with a virtual agent called ELIZA. This agent was able to simulate a psychotherapist and to keep the conversation going on by passively asking leading questions. At the end of the experiment, it was disclosed that people thought that they were talking to a human and that the conversational partner appreciated their problems. Throughout the study the subjects did not know that they were actually speaking to a computer program.
A similar study was conducted by Sundar and Nass [34] where people favored to interact with the computer over the human interaction partner. Studies which have been conducted lately, confronted their participants with questions regarding trustworthiness and believability of screen characters and fully embodied robots (see e.g. [5]; [31]).

In order to assess robots, scales were either adapted as done by Shinozawa, K., et al. [33] or newly developed [6]. Such scales were often used to assess the credibility of a source of information (TV, newspapers, web pages, etc., or an individual). Therefore, the source credibility is the amount of credibility attributed to a source of information by the receivers [8].

Shinozawa, K., et al. [33] could show that a 3D model of a robotic agent was rated higher in terms of source credibility by the means of McCroskey's credibility scale [24] than a 2D on-screen agent.
Kidd [19] also used a scale [7], actually developed for the media as well as McCroskey's one, to rate the robot's credibility. Hereby he found out that women tended to rate higher in terms of credibility than men. Additionally, people trusted robots that were physically present more, which is similar to the findings of [33]. The physical appearance of robots plays also a huge role in HRI. Powers and Kiesler [4] found out that certain physical attributes of the robot could change the human's mental model and that traits of the robot in that model are linked to people's intentions. For instance, certain physical characteristics, like the robot's voice and physiognomy, predicted impressions of a sociable robot, which in turn predicted the intention to take the advice of the robot and changed the people's perception of the robot's human likeness, knowledge and sociability.

Furthermore, it makes a difference if a robot recommends something or not. In their study Imai and Narumi [18] conducted a user study with a robot that gave recommendations. The participants in the experiment inclined to want what the robot recommended, e.g. this cup of tea is delicious and the other is not. Therefore, recommendation plays also an important role in HRI and in the credibility of robots. Additionally, credibility is tightly interwoven with trustworthiness and recommendation [13], whereas recommendation could be seen as a synonym for advice.

Another approach researched by Desai et al. [11] is to design an interface where the user can adjust the level of trust of a robot so it can decide more autonomously. For instance if the user controls a robot with a joystick and the robot notes many errors made by the user, so the robot suggests the user to switch to a higher level of trust. In such a level the robot could make more decisions without asking the human operator.

3 USER STUDY

The goal of the user study was to gain insights on the credibility and persuasive effect of the humanoid toy robot RS Media. The user study was set-up as a card game based on the "Monty Hall Problem", which will be described in more detail in the next section. A preliminary study [36] with adults could already prove the suitability of the "Monty Hall Problem" to create a situation of uncertain knowledge and to investigate credibility and persuasive power. However, the study revealed that adults tried to solve the "Monty Hall Problem" by probability reasoning which influenced the study setting negatively. We assumed that conducting the same study with children should limit this effect. The study was conducted in a big shopping mall during an "open University day" in Salzburg, Austria, in November 2008.

3.1 Theoretical Basis

The user study was based on the famous paradox called "Monty Hall Problem", also known as "Three Door Problem" or "Car Goat Problem". The roots of the name "Monty Hall Problem" go back to the 80's game show, "Let's make a deal" moderated by Monty Hall. In that show the candidate had the chance to win a car but he/she had to choose one door from three given ones. After the candidate had chosen the door, the show moderator opened one of the two doors left, which always contained a goat. Then he asked the candidate if he/she wants to change his/her decision and take the other door. Years later, the problem reached a wider publicity when Marilyn vos Savant published a puzzle in her *Parade*[1] magazine column as an answer to the following question of a reader:

> Suppose you are on a game show, and you are given a choice of three doors: Behind one door is a car; behind the others, goats. You pick a door, say number one, and the host, who knows what is behind the doors, opens another door, say number three, which has a goat. He says to you, "Do you want to pick door number two?" Is it to your advantage to switch your choice of doors?

The answer to this question is, yes. You should switch because the chance to win the car in the first choice is only 1/3. After unraveling one goat, not the candidate's door, the chance to win, if you stay, is still 1/3 (see Figure 1). However, if the candidate changes his/her opinion at this point of the game, the probability to win would be twice as high (2/3) as if the candidate would stay with his/her initial decision. This kind of logic is very difficult and only a few people realize it.

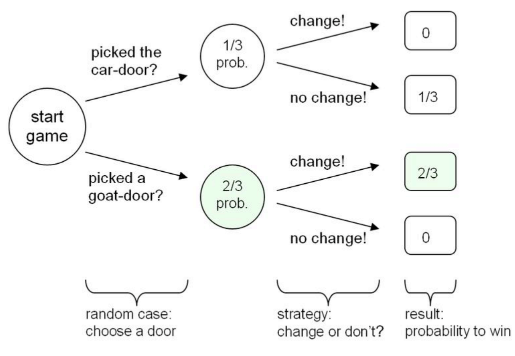

Figure 1. The "Monty Hall Problem'

The majority of the people would not take the other card due to the fact that they are thinking the probability of their first decision increased to 1/2. So, if the goods and odds are equal, why should I change my primary choice? In the end these people are acting intuitively wrong and even people with extensive statistical skills can struggle [26]. Therefore, this kind of probability problem can be used to study how to deal with uncertainty [22].

The study described in the following was inspired by Komatsu et al. [21], where people estimated the robot's abilities by acquiring how accurately the robot can detect a gold coin under three mountains in an imaginary video game.

3.2 Study set-up

The study was set up as a card game where the participating children should play together with the humanoid toy robot RS Media [2], see Figure 2. To test our assumption that the detail level of the hint influences the credibility and persuasive power of the robot, three experimental conditions were set up:

1. **Recommendation without hint** → The robot says: "I would take the other card."
2. **Recommendation with hint** → The robot says: "I would take the other card, because the chance to win is higher."
3. **Recommendation with explicit hint** → The robot says: "I would take the other card, because the chance to win is 66%."

Figure 2. Child interacting with the RS Media robot

During the user study, the RS Media robot was placed on a table and in front of it sat the child, see Figure 2. The built-in loudspeakers of the robot were muted because the ambient noise in the shopping mall environment was very high. Therefore, external loudspeakers were placed on the table with the robot and plugged into the line-out of a MP3-Player. The RS Media was still able to react to the environment, e.g. by rotating its head to the child in front of it, which is an important behavior when interacting socially [38]. A Wizard-of-Oz approach [10] was chosen for the audio output of the robot, in order to adapt the speed of the user study to the child's speed of decision making. When the experiment reached the point, when the robot's hint is requested, the experimenter pressed a button on the MP3-Player which triggered the robot's output depending on the experimental condition. The MP3-Player was put under the table where the subjects could not see it. During the study the experimenter changed the conditions after about ten to fifteen participants. In the end there was a distribution of 52 children with condition 1, 69 with condition 2 and 49 with condition 3. The experiment was intentionally set-up as between subject-design to eliminate a learning effect in terms of the "Monty Hall Problem".

3.3 Research questions

As our main research interest was to explore how the detail level of the hint influences the persuasive power of the robot and the interplay between the perception of credibility and the child's decision certainty as source for persuasion, the following main research questions were set up for the user study:

1. (RQ1): Do children follow the advice of the RS Media robot?
2. (RQ2): Which factors influence the credibility of the RS Media robot?

Based on these research questions the following hypotheses were supposed:

- H1: The experimental condition leads to a difference in the frequency of opinion change.
- H2: There is a difference in credibility depending on the experimental condition.
- H3: Credibility increases once the robot's prediction was correct.
- H4: There is an interaction between the child's opinion change and decision certainty.

3.3.1 Procedure

At the beginning of the user study the experimenter showed the child the three cards, one of which hiding the treasure (see Figure 3) and explained the game. Each card had the same back side and it was not possible to look trough or under it, in other words cheating was not possible. As the child was ready, the experimenter mixed the cards and told him/her to choose one card under which he/she supposed the treasure. After that the child was asked how certain he/she felt about the decision. Then the experimenter took a look below the other two cards, laid one blank card open and asked again how certain he/she felt about the choice. Now, the robot entered the game. The experimenter asked the robot, if the child should change his/her mind and go for the other card. Then the robot answered depending on the experimental condition. At this point the child had the possibility to switch or stay with his/her choice. Again the child was asked how certain he/she felt about the decision after the advice of the robot, if he/she believed in the robot's advice and if the advice was helpful. In the end the experimenter disclosed the secret and explained the "Monty Hall Problem".

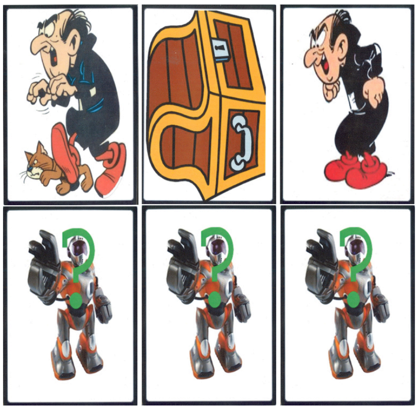

Figure 3. The Card Game

3.4 Instruments

As beliefs in uncertain situations are often expressed in numbers [35], the whole user study was accompanied by a questionnaire containing questions on the level of certainty of the choice (which had to be rated on a scale from 0% until 100% certainty, see Figure 4) and the credibility of the robot. According to [32], children at the age of seven are able to use such scales. For children older than 5.6 years using scales was the best predictor 84% of accuracy.

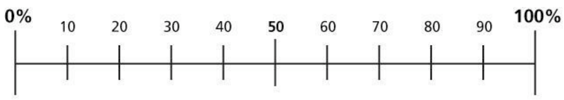

Figure 4. The Rating Scale for Certainty and Credibility

4 RESULTS

171 children took part in the study. Some of them knew the robot, as they have seen it before in toy stores or on television in an advertisement for the "open University day". However, none of the children ever before played with the robot. 66 of the participating children were between 6 and 10 years old, 60 between 11 and 12 years, and 45 were older than 13 years. In 96 of the cases the robot gave the right advice in 73 the wrong one.

4.1 Did the children follow the advice of the robot (RQ1)

Regarding the question if the children followed the advice of the robot, 46.2% of the children did not take the advice and 53.8% of the children changed their decision based on the advice of the robot. The detail level of the advice influences the chance of children to switch to the other card (H1). However, an administered χ^2 test could not show a difference between the probability of change between the three different experimental conditions ($\chi^2(2) = 1.73, p > .05$). Nevertheless, there was a tendency that a reason for the given advice increased the probability of change. If the robot gave no reason why to change to the other card (condition 1), there was no opinion change by trend, as can be seen in Table 1 (see count vs expected count). If the reason was easy to comprehend, the child will more likely change his/her opinion. Interestingly the effect did not occur for the third experimental condition with the highest detail level of advice. We assume that this hint was hard to comprehend for the children and thus the effect did not occur.

Table 1. Cross table: age, experimental condition, and opinion change

Age	Con		No Change	Change	Total
6-10	Con1	Count	5.0	10.0	15.0
		Expected Count	4.5	10.5	15.0
	Con2	Count	6.0	17.0	23.0
		Expected Count	7.0	16.0	23.0
	Con3	Count	9.0	19.0	28.0
		Expected Count	8.5	19.5	28.0
11-12	Con1	Count	8.0	6.0	14.0
		Expected Count	7.6	6.4	14.0
	Con2	Count	13.0	13.0	26.0
		Expected Count	14.1	11.9	26.0
	Con3	Count	11.0	8.0	19.0
		Expected Count	10.3	8.7	19.0
13+	Con1	Count	15.0	8.0	23.0
		Expected Count	13.8	9.2	23.0
	Con2	Count	10.0	10.0	20.0
		Expected Count	12.0	8.0	20.0
	Con3	Count	2.0	0.0	2.0
		Expected Count	1.2	0.8	2.0

A strong effect could be observed regarding age groups. Younger children were significantly more often persuaded to change their previous decision, whereas older children (13+) did change their decision not as often as expected ($\chi^2(2) = 11.39, p < .01$).

4.2 Factors influencing the credibility of the RS Media robot (RQ2)

The age group had an influence on the credibility of the RS Media ($F(2, 159) = 5.29, p < .01, \eta^2 = .06$). Age group1 children had a higher belief in the robot (age group1 mean: 59.77, SD: 32.00; age group2 mean: 44.49, SD: 30.10; age group3 mean: 40.68, SD: 31.52). There was a significant interaction between age group and the prediction correctness ($F(2, 159) = 4.29, p < .05, \eta^2 = .05$). As can be seen in Figure 5, the younger the children were, the higher they rated the initial credibility of the robot. When the prediction was correct, the credibility of the robot was rated higher in the final assessment by all age groups. When the prediction was incorrect, the credibility was rated lower in the final assessment by all age groups, but the drop of credibility was strongest in the youngest age group. Gender and education did not significantly influence the credibility assessment.

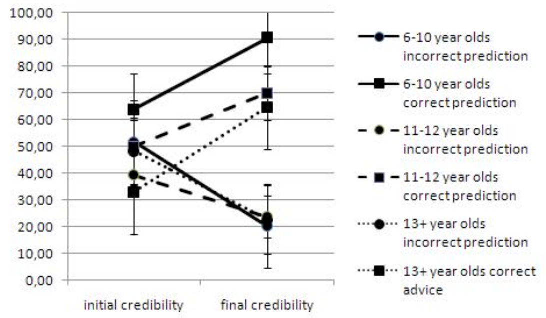

Figure 5. Influence of Age and Prediction Correctness on Initial and Final Credibility

4.2.1 *Increase in credibility if the robot was right*

In general, there was no difference between the conditions concerning final credibility of the robot ($F(2, 158) = 1.07, p > .05, \eta^2 = .01$). However, after considering the effect of an incorrect advice of the robot, the credibility dropped substantially indicating a main effect of the correctness of advice ($F(1, 158) = 179.08, p < .01, \eta^2 = .53$). In other words, the final credibility was mainly dependent on the correctness of the prediction and not so much on the level of detail of the advice. Moreover, an increase in credibility during the game could be observed, when the robot gave a correct prediction, whereas if it gave a wrong prediction the credibility substantially decreased ($F(1, 163) = 89.10, p < .01, \eta^2 = .38$) (see Figure 6).

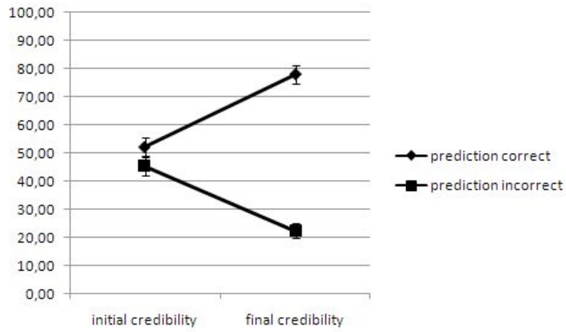

Figure 6. Interaction between Credibility and Prediction Correctness

4.2.2 *Difference of credibility depending on the level of detail of the advice (H2)*

When considering the correctness of the robot's prediction in the analysis, we found a significant interaction between the experimental condition and the correctness of the precondition ($F(2, 158) = 3.52, p < .05, \eta^2 = .04$). Children who received an advice with the highest level of detail (condition 3) rated the final credibility especially low, if the advice turned out to be incorrect.

4.2.3 *More detailed - more helpful (H3)*

The helpfulness of all hints was perceived very heterogeneously as the broad standard deviations for the mean ratings in all three conditions show (mean: 35.58, SD: 34.86, mean: 45.65, SD: 32.70, mean: 52.31, SD: 35.99).

However, there was a significant difference of the perceived helpfulness between the three conditions ($F(2, 166) = 3.04, p = .05, \eta^2 = .04$)). The condition with no reason given was rated less helpful than the condition with the most specific hint ($p < .05$). Interestingly this finding could be partial due to the fact that the factor of age was strongly influencing the perception of helpfulness, as the three age groups were not equally distributed in the experimental conditions (see Table 2). General, younger children assessed the helpfulness of all hints higher than older children, whereas gender and education had no effect.

Table 2. Mean helpfulness of advice

Con	Age	Mean	SD	N
1	6-10	49,00	38,79	15
	11-12	37,50	30,43	14
	13+	25,65	32,94	23
	Total	35,58	34,86	52
2	6-10	61,09	28,12	23
	11-12	39,04	29,09	26
	13+	36,50	36,89	20
	Total	45,65	32,70	69
3	6-10	65,78	36,73	27
	11-12	35,53	28,23	19
	13+	30,00	14,14	2
	Total	52,31	35,99	48
Total	6-10	60,25	34,52	65
	11-12	37,54	28,67	59
	13+	30,67	34,11	45
	Total	44,44	34,74	169

4.2.4 *Opinion change and level of certainty (H4)*

The children were asked about the level of certainty with respect to their choice three times during the game. It was found that the children's perceived certainty was influenced by the time of the game play and the opinion change. Children who decided to change after the robot's advice were more insecure in the beginning than children, who did not change their preference, but the discrepancy between the children vanished after the robot gave its advice ($F(2, 336) = 19.32, p < .01, \eta^2 = .10$) (see Figure 7).

5 Conclusion

The goal of the exploratory user study was to gain insights on the credibility and persuasive effect of the humanoid toy robot RS Media. Our basic assumption was that the higher the detail level of the advice, the higher the persuasive power of the robot would be in a situation of uncertainty. In other words we expected that children participating in the user study under the experimental condition 3 (the robot says: "I would take the other card, because the chance to win is 66%") would result in a high credibility rating and opinion change rate. However, we found out that this was not the case

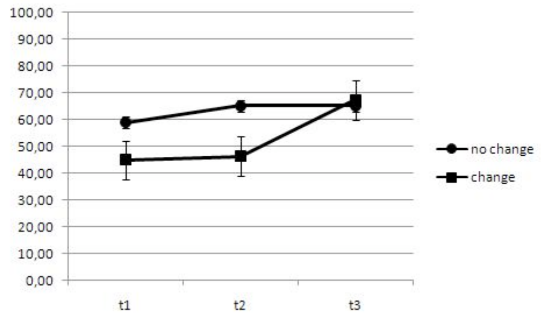

Figure 7. Interaction of Opinion Change and Level of Certainty

for the children. Although the third condition hint indeed included the highest amount of information, the formulation was probably not child-adequate.

We assume that the younger children could not fully grasp the knowledge the robot made available. Therefore they did not produce a higher opinion change rate than condition 2 (the robot says: "I would take the other card, because the chance to win is higher"). This assumption needs to be tested again with a homogeneous sample to exclude age effects.

It is interesting to note that children, who were unsure in the specific situation, gained a higher level of confidence through the advice of the RS Media robot. This finding raises the suggestion that robots could be incorporated in situations which are complex and lead to uncertainty. Furthermore, we could show that younger children were more often persuaded by the RS Media robot. A direction for future research is to test, if the persuasive effect is even higher for pre-school and kindergarten children. However, one has to consider the side-effect that as soon as the prediction of the robot was wrong, the credibility dropped immensely, in other words: "a liar is not believed even if he speaks the truth". These findings should be taken into account, if robots were integrated into the education of primary school children. For a purposeful integration, it will be necessary to consider two ethical guidelines for persuasive technology: (1) Persuasion should be based on prior (real or counterfactual) consent - The teacher should not use the persuasive robot to persuade children of something he/she him/herself would not consent to be persuaded to do. (2) Persuasion should, if possible, favor factual feedback over other means of persuasion - The content that the persuasive robot is teaching the child, should be objective and demonstrated by reproducible facts. Moreover, replacing human teachers by artificial persuasive robots could lead to so called "post social relationships", in which children tend to prefer being engaged in asymmetric, conflict-free artificial interaction than putting effort in dealing with humans and interpret their actions.

In general this study showed that the RS Media robot can serve as persuasive actor and thereby supports the media equation: media equal real life [30]. This means that persuasive effects, which would have occurred when a human advised a child, also occurred when the human was replaced by the robot. However, for future research it will be relevant to identify if the same persuasive effect can be revealed, if the robot replaces the role of a human adult or the role of a human child. To increase the validity of the experimental results, a test condition, without any robot replacement, needs to be introduced.

Moreover, possible differences between screen agents and embodied robots need to be examined. Furthermore, the variability of shapes (antropohmorphic, zoopomorpic, and cartoon-like) must be taking into account. Even the sound of the voice and if it matches the robot's embodiment could have an influence on the robot's persuasive power and should be therefore experimentally controlled.

A further aspect is the choice of the game. All children told us that they did not know the "Monty Hall problem", when asked at the end of the study. However we can not rule out the possibility that the children assumed that the robot would trick them into choosing the wrong card. This may be especially the case as finding the treasure underneath a card is known as a game of con artists. Research in these areas will help us to derive more concrete design implications to build more persuasive robots. However, the most important implication of design for this case study is that the RS Media robot can serve as persuasive actor and that the persuasive power lies in the comprehension to the message and is not a matter of detail level.

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