

# Has Uncanny Valley Feeling an Impact on Learning: A Preliminary Experiment Performed in a French Elementary School

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## ABSTRACT

In order to test the eventual impact of uncanny feeling, as theorized by the Mori's concept of uncanny valley, on learning, we proposed to a class of 26 pupils of mean age 8 years 5 months to visualize *The Polar Express* and *Dark Crystal* movies and to test about four months after their ability to remember movie's hero, story and end. The high degree of uncanny feeling initially produced by *The Polar Express* was verified by means of a questionnaire and discussion in the class performed just after the first scene of the movie was stopped. When some weeks after the entire movies was shown to the pupils, this uncanny feeling appears to be weaker and when finally pupils were tested on their memories concerning both movies, answers got in *The Polar Express* case did not appear to be less relevant than those got for *Dark Crystal*. The reported experiment suggests that highly human-like faces do not prevent to transmit information to be learned by pupils, which tends to indicate that faces of future teaching robots could take human form.

## CCS Concepts

• Social and professional topics → Computing education → Children • Computing methodologies → Computer Graphics → Animation.

## Keywords

Uncanny valley; Robotic and Digital faces; Narrative learning.

## 1. INTRODUCTION

Educational robotics is a special branch of service robotics whose actual development is still limited. Due to the actual limitation in combining human like face expressions with complex language exchange required by the pupil-teacher relationship – without forgetting the security issue – attempts in educational robotics are generally limited to gesture stimulation and playing by means of small robots like AIBOT [1], NAO [2], [3] or iCat [4]. But, at our knowledge, little attempts have been made for adapting robots to a real teaching mode: the most original experiences, according to us, were performed with the development of robots dedicated to language learning, especially in Asia for English learning. Robots for assisted English learning are essentially machines able to repeat a lesson face to pupils which can either have the form of a robot toy placed on the teacher's desk [5] or can take the most sophisticated form of a wheeled robot with a screen displaying “an avatar face of a Caucasian woman” [6]. If it is mentioned a very positive acceptance of the robot in [7], but less positive when Shahid, Krahmer and Swerts [4] claim that “[...] children have more fun playing with the robot than playing alone, but have more fun still playing with a friend” (page 94), we have, at our knowledge, little indication about the positive acceptance of the mentioned assisted-language robots [8], [9]. Moreover, the issue of the robot appearance is generally little discussed in studies reporting use of robots at school, although it is well known since

the rediscovering of Mori's work that a robot with an appearance too close to this of a human being can induce a so-called “uncanny feeling” [10]. The origin of the uncanny valley is still largely debated. According to MacDorman, who played a great role in the rediscovering of Mori's ideas, Mori proposed ‘that the uncanny valley effect is a survival, an aversive response to proximal threats like dead or diseased bodies and dangerous species of animals’ [11]. In this last mentioned paper, MacDorman clearly shows the surprisingly actual dynamics in studies about understanding of Mori's uncanny valley. One reason of this difficulty to determine a clear origin to the uncanny valley feeling could come from the very large panel of psychological theories which can be considered in a more or less speculative way to explain this feeling [12]. Face to the actual difficulties to explain the phenomenon or to specify in which or which conditions it is operant or not, some practical choices can be made to be sure to avoid any uncanny valley feeling as, for young children, the use of robot toys, including the most recent small-size humanoid robots with the appearance of a cartoon hero. In the case of teaching robots for older pupils, it seems difficult to imagine a learning mode entirely based on robot-toys. In particular, a natural tendency would consist, without any doubt, to give to the robot face the appearance of a human face, as reported in [6], with the risk of falling into the “uncanny valley” like unintentionally proven by the designers of *The Polar Express*. Because it is actually hard to test real humanoid robots, as avatars displaying lessons in a class-room, we propose in this paper an alternative approach, characterized by two points:

1. The lesson to be “understood” by the pupils consists in the narrative structure of some animation movies and what we want to test is their ability to remember the content of this narrative structure,

2. Because this is the same uncanny feeling which is produced by a real artificial face or by this of an avatar, we think that comparing digital animation with real animation can be relevant for better appreciating the impact of uncanny feeling on future educative robots.

Our paper is organized as follows: in section 2, the considered assumptions and the associated experimental protocol are presented while section 3 reports results and develops discussion.

## 2. EXPERIMENTAL PROTOCOL

*The Polar Express* written, produced and directed by Robert Zemeckis is a 2004 American film which is the first all-digital film using the capture technique for animating characters with human features. At its time, the character animation was considered by some film critics as particularly worrying what was later expressed in saying that the film was dipping into the uncanny valley. But *The Polar Express*, based on the children's book of the same title written by Chris Van Allsburg is also a beautiful story about a little boy beginning to doubt about the

existence of Santa Claus. This is this narrative we tested, in a French primary school on the audience of a 26 pupils class of the last year level – called CE2 for Elementary Class level 2 – whose mean age at start of experiment was 8 years 5 months (+/-1.5 months). It is worthy to note that this is a habit in elementary French schools, in which pupils have to stay morning and afternoon 4 days a week, to show movies during school time either in link with a question addressed during the year or for presenting works the pupils have little chance to know. It is clear that the movies proposed to the pupils must guarantee the freedom of belief. Although *The Polar Express* is directly influenced by the Christian faith, the issue to believe or not in Santa Claus is shared by a large amount of French 8-9 years old children; moreover, *The Polar Express* can also be considered as an adventure film with characters of a similar age than boys and girls of the class. Our project also took advantage from the fact that, in the framework of an educational collaboration between the school and Toulouse's film library, it was scheduled to bring the class accompanied by their female teacher to the film library for watching *Dark Crystal*. We considered that *Dark Crystal* was particularly well adapted to be compared to *The Polar Express*. First, while *The Polar Express* introduced in film industry the capture technique for digital animation, *Dark Crystal*, directed by Jim Henson and Frank Oz, is a 1982 American fantasy film considered as one of the very summits of the animatronic technique applied to film industry. All characters of the film are indeed animated puppets and no digital technique is used in the film. In some way, *Dark Crystal* is the anti-*Polar Express* in that the characters are puppets mechanically guided by human operators and characters' faces do not try to accurately mimic a human face with, as a consequence, to avoid the conditions of dipping into the "uncanny valley". Secondly, the two considered films, *The Polar Express* and *Dark Crystal*, have interesting common features: in both of them 8-9 years old children can identify him/herself to the male or female hero of the movie; both films describe a quest: this of the missing crystal piece in the case of *Dark Crystal*, this of the meeting with Santa Claus whose proof will be brought by the hero in the form of a small bell, in the case of *The Polar Express*. Our analysis of a possible impact of "uncanny feeling" on understanding and remembering of a provided narrative information will be based on the comparison of these two movies. Let us insist on the easiness and natural character of this approach by opposition to experimental studies which required transporting children from school to external laboratories as reported, for example, in [13]. Moreover, the fact to test pupils in their classroom makes easier a study over several months with several questionnaires and discussions scheduled between pupils and their female teacher, as explained further.

We consider the following general assumption:

'Digital faces with uncanny feeling but deprived of horror or death elements have little impact on narrative information transmission and remembering of this information',

and its corresponding operational expression:

'No effective difference was found in interest, understanding and remembering between *The Polar Express* and *Dark Crystal* movies with 9 years old pupils of a French elementary class although strong uncanny feeling was initially felt by pupils discovering *The Polar Express*'.

To come back to our initial problem about the best shape to give to future educational teacher-robots, it could be said that the two considered films would correspond to a lesson in the form of a story given in the case of *The Polar Express* by robots with a look for an appearance very close to this of human beings while in the case of *Dark Crystal* the look for mimicking human beings is voluntary limited to a rough appearance. The test of the operational assumption was organized according to the following four step structure:

**Step 1:** In the first days of November, it was explained to the pupils that, during the two next weeks, they will see two films: one called *Dark Crystal*, when they came to the city film library and the other called *The Polar Express* which will be displayed on the school TV. It is also explained that, today, they will see the all beginning of *The Polar Express* – more accurately the first 3 minutes until the movie's hero gets on *The Polar Express*. Just after this first show, everybody will have to fulfill a questionnaire to give her/his feeling on the movie's hero (questionnaire 1 is given in annex while questionnaires 2 and 3 can be found on a work version of this paper, with same title, on the HAL French web site as on our Research Gate web site). Following the fulfillment of the questionnaire, a general discussion is also scheduled between the class and their female teacher. The discussion is recorded by means of a small tape recorder handed by the female teacher. This first step is devoted to verify the hypothesized uncanny feeling produced by the first apparition of *The Polar Express* boy hero. It was easy to verify that, how far *The Polar Express* was, no child even knows the existence of the movie.

**Step 2:** The week after, the class – in fact accompanied by another one teacher – is brought by her female teacher to the city film library to see *Dark Crystal* on a classic movie large screen. Such an extra scholar time activity was scheduled on half a day.

**Step 3:** One week later, *The Polar Express* is shown in the classroom from the beginning to the end without any interruption. Just after the projection was over, the second questionnaire is given to the children, with the aim to check the uncanny feeling and how the story is perceived by the children by comparison with *Dark Crystal*. A discussion is also engaged between the female teacher and his/her pupils as done in step 1.

**Step 4:** Early march, in the classroom, it was asked to the pupils to fulfill the two forms of the questionnaire 3 respectively entitled 'Remembering *The Polar Express*' and 'Remembering *Dark Crystal*'.

It is important to note that at each step of the proposed protocol, nobody else was present with the pupils except her female teacher and parents accompanying the children to the city's film library. This condition is important – and even may be essential according to us – for introducing no bias in the pupils replies as, also, to make easier the collaboration of the pupils to the study and we effectively check the very good collaboration of a large majority of class pupils to our study (unexpected drawings were even made by two children – see our early mentioned work version).

### 3. RESULTS AND DISCUSSION

We give in Fig.1 the results for first questionnaire under the form of histograms, corresponding to each question. It is amazing to

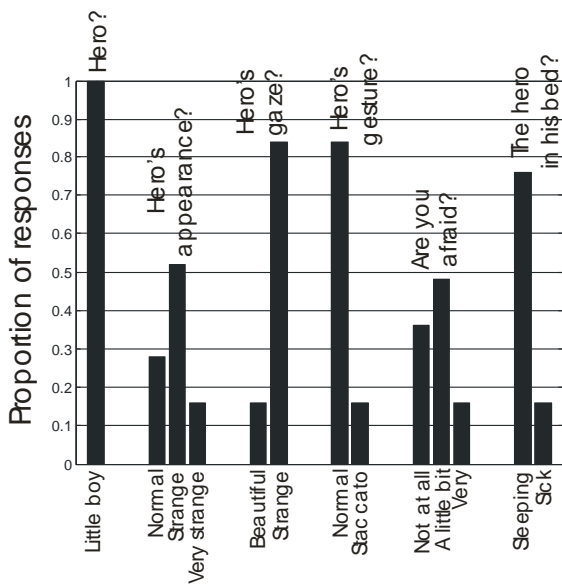
check how the uncanny feeling appears to be obvious for all children, as this can also be put into light after we attempted to gather the most significant reactions of the children during the exchange between pupils and their female teacher following the questionnaire fulfillment:

**Teacher:** how do you like the hero? **Several pupils together:** strange, strange!

**Teacher:** why? **A pupil:** his mouth, his eyes, his lips are too strange. **Another pupil:** I would not close my eyes like he does. **Another pupil:** the hairs are like the hairs of a *Play Mobil*. **Another pupil:** we have flesh on lips while he has only skin; it is like a monster; it has no lips. **Another pupil:** he walks like a robot; he is like a jointed *Play Mobil* and he walks like a *Play Mobil*. **Another pupil:** his way of thinking is also strange.

**Teacher:** could you explain? **The same pupil:** most of children either think that Santa Claus exists or they think he does not exist; the hero, he looks at a dictionary to see if Santa Claus exists because he is not sure at all that Santa Claus exists. **Another pupil:** his mouth does not smile.

It is interesting to note that the remarks made about the strangeness of the mouth of the hero of *The Polar Express* reminds the well-known technical commentary written by Jenkins in his blog when he criticizes the train driver character: ‘Also, the area around the mouth is not as emotive either’, he said by comparison with the performance of the actor “captured” by the computer [14].

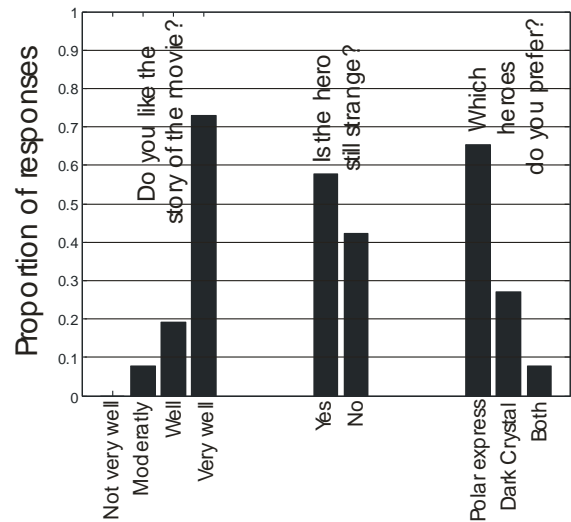


**Figure 1. Proportions of responses to the first questionnaire**

This first step of our protocol validates the preliminary assumption according to which most of children would find strange the hero of *The Polar Express* and also, as expected, although its “robotized” gesture is pointed out during the discussion, several children are able to explain what is disturbing in digital hero face. However, it is important to emphasize that, when the children see, for the first time, the hero closed eyes in his bed, most of the pupils (about 80%) do not associate his face

with a sickness idea: it is just sleeping. This remark also suggests that the uncanny feeling would appear there as a non-morbid strangeness feeling, while uncanny valley theory and its interpretation often associated, uncanny feeling and fear of death. It could be opposed that, may be, the answered children are little concerned with death but, as we would see it when analyzing replies to what happens in *Dark Crystal*, our pupils were clearly sensitive to death’s question as it appears in *Dark Crystal*.

We now give in Fig. 2 the results corresponding to the questionnaire number 2 i.e. after the pupils saw in their integrality both *Dark Crystal* and *The Polar Express*.

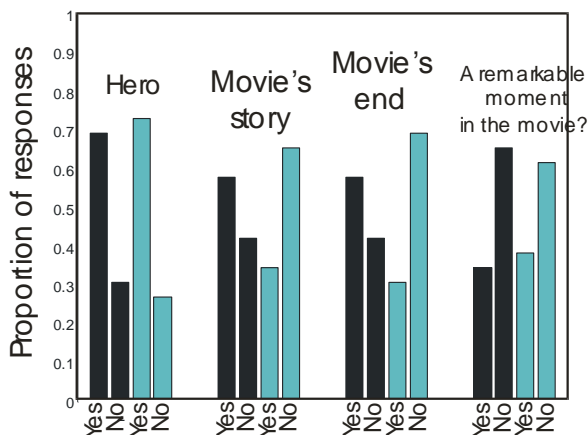


**Figure 2. Proportions of the responses to the second questionnaire**

As it appears from the pupils’ responses, the strange character attached to the *Polar Express*’ hero is still noted by about 57% among them but this proportion is clearly less than this we noticed after the pupils saw the hero of *The Polar Express* for the first time. In a more amazing way, almost 90% of the pupils like well or very well the film with a very large proportion of ‘very well’. Such a result is in opposition with several remarks made by film critics just after the film was released as reported, for example, in the Wikipedia entry ‘*The Polar Express*’ : Travers wrote for Rolling Stone that the film was “a failed and lifeless experiment in which everything goes wrong” [15], when Zacharek said in Salon, “I could probably have tolerated the incessant jitteriness of *The Polar Express* if the look of it didn't give me the creeps” [16], and Pevere of the Toronto Star claimed that “if I were a child, I'd have nightmares”. In fact, in the limited frame of our class’ study, it is as if the story told by *The Polar Express* and the associated issue about the existence or the non-existence of Santa Claus were finally more important for these 8-9 years old pupils than the strange appearance of its characters. Moreover, the pupils like better the heroes of *The Polar Express* than these of *Dark Crystal* may be because *Dark Crystal*’s heroes and their life quest are too far from the concerns of our pupils. The remark made by a pupil who was fearful of the way the baddies eat in *Dark Crystal* also suggests that, for some children, the character appearance and its behavior are considered as a whole. This would be another way to say that for these children the story is, lastly, more important than

the characters and, in a more general way, this could explain why, although still judged to be still strange the heroes of *The Polar Express* travelling towards the North pole are, in a large majority, liked. It is also particularly worthy to note the shared interest of the whole class for the proposed exercise: to see a film a film and to talk about it, as the female teacher noted it in her easiness to get children responses. This justified, for us, the attempt of testing four months later pupils' memories about the two movies.

Because it was expected in the third questionnaire to collect the memories of the pupils, the collected 'yes' responses were only recorded when they were accompany with mostly a text but also, in some unexpected way, with a drawing. It is also to be noted that some children use different color pencils for writing, for example, the letters of *The Polar Express*. These details show the interest took by most of children in participating to this exercise and the non-constrained character that they attached to it. The fact that the test was made with their teacher and only with her has, we can think it, favor such natural behavior. We give in Fig. 3 the percentage of positive and negative responses obtained for each question and both films.



**Figure 3. Proportions of responses to questionnaire 3: Do you remember – and you can say what – hero, movie's story, movie's end and a remarkable moment in the movie, for *The Polar Express* (in black) and *Dark Crystal* (in cyan or grey)**

In this preliminary study, we do not try to apply a statistical test to the validation of our hypothesis but obtained results clearly suggest that our operational assumption is verified: the uncanny effect perceived by all pupils at the initial presentation of *The Polar Express* was not a handicap for "learning" something from the movie. In the case of the asked remembering of the movie's story and end, we even obtained more positive replies for *The Polar Express* than for *Dark Crystal*. This could be simply explained by the more complex narrative structure of *Dark Crystal* by comparison with the story of *The Polar Express*. If we now look more in detail to the content of the pupils' replies, we attempted, first, to gather their replies to first question: 'Who is the hero of the movie?' in a limited number of categories as reported in Table 1. For the two movies, the most common reply is also the most general relevant category: a boy or little boy, to which could also be associated the child denomination, independently so of its specific medium character, digital or puppet. Only one child still mentions it is a 'strange boy' and only two describe the hero of *Dark Crystal* as a 'wood boy' or a 'puppet'. Some pupils try to be more accurate by specifying the

hero of *Dark Crystal* as a non-exactly human being or, in the case of *The Polar Express*, by specifying that the little boy does not believe in Santa Claus, but these responses are a minority.

**Table 1. Categorization of the pupils' replies to the question 'Who is the movie hero' (the number of replies for each category or sub-category is given between parentheses)**

Who is the hero of <i>The Polar Express</i> ? (17 replies)	Who is the hero of <i>Dark Crystal</i> ? (17 replies)
- A boy or a little boy or a young boy or a big boy (11)	- A boy or a little boy (10)
- The little boy who does not believe in Christmas father (2)	- A Gelfing written as each child felt it (4)
- A child (2)	- A wood boy (1)
- A strange boy (1)	- A puppet (1)
- Answer in the form of a drawing (2)	- A kind of talking animal but I don't remember which kind it was (1)
	- Answer in the form of a drawing (2)

Before analyzing the pupils' replies describing their remembrance of the story and the end of the film, we tried to synthesize in Table 2 the texts written by the pupils who specify a remarkable moment of the film.

**Table 2. Synthetic texts written by pupils who indicate a remarkable moment on the film**

**A remarkable moment in *The Polar Express* (9 replies)**

- The train that slips on the ice (2)
- Santa Claus giving the bell to the little boy (2)
- When the parents explain to the film hero that Santa Claus does not exist (1)
- The distribution of hot chocolate in the train and the acrobatics of the train's driver (1)
- The train's driver (1)
- The man who is a ghost (1)
- A character staring vacantly into space (1)

**A remarkable moment in *Dark Crystal* (9 replies)**

- The encountering between the little boy and the little girl (2)
- The fest where the little boy and the little girl dance together (1)
- The little girl flying (1)
- When the Gentiles take the diamond to the villains (1)
- When the small ball of hair moves (1)
- When the villains badly eat (1)
- When the bad guys die (1)
- I found the movie a little sad and a little frightening (2)

The number of replies is about half the number of replies obtained for designing the hero of the film but it is interesting to note that the pupils privileged happy moments; it is however more ambiguous replies like the pupil who simply mentions for *The Polar Express* 'the train driver' without we can say if he found

him pleasant or unpleasant but it is also interesting to note that two pupils mentioned that they found sad or frightening *Dark Crystal* which suggests, at least for some children, a prevalence of the story on the film's characters. It is clear that the requested task of briefly writing what was the movie's story and what was the movie's end for pupils having replying 'yes' to the questions 'Do you remember the movie's story/end?' was a bit more difficult task but it is interesting to note, especially, in the case of *The Polar Express* the weak loss of replies by comparison with the question 'Who is the hero?'. As previously, we attempted to propose a categorization of the pupils' replies in a limited of 'scripts' for which one we also give the variations, as reported in Table 3. Texts written by pupils often included spelling and grammar faults that we haven't try to express.

**Table 3. Synthetic texts written by pupils who replied 'yes' to the question 'Do you remember the story of the film?'**

**I remember the story of *The Polar Express* (15 replies)**

- A boy takes a train to meet Santa Claus (7)

variations: train is going to North Pole, Polar Express is named, other details on departure

- A boy is sleeping, he hears the noise of a train, he gets up and takes the train (5)

variations: the boys deeply sleeps or pretends to sleep, Polar Express is named, it is Christmas eve, the boy doubts in Santa Claus existence

- A boy who does not believe in Santa Claus takes a train to meet him (3)

variations: train is not mentioned, Polar Express is named.

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**I remember the story of *Dark Crystal* (9 replies)**

- A goblin takes part to the search of a crystal and brings back for to save one's own people (3)

variations: the crystal is placed on a bigger one, the hero meets a young girl of the same species

- A little boy lives adventures for to save one's own tribe (5)

variations: he meets a young girl

- A bad man has killed the hero's father and this last one gets his revenge (1)

We lastly synthesized in Table 4 the texts written by pupils to the question: 'Do you remember the end of the film?' that we attempt to classify from the most right answer to the most inaccurate.

**Table 4. Synthetic texts written by pupils who replied 'yes' to the question 'Do you remember the end of the film?'**

**I remember the end of *The Polar Express* (14 replies)**

- The hero meets Santa Claus, gets the bell, comes back to home, loses the bell and retrieves it again among his gifts (1)
- The hero retrieves the bell among his Christmas gifts (5)
- The hero gets the bell from Santa Claus (3)
- The hero meets Santa Claus and comes back to home (2)
- The hero meets Santa Claus and receives a bell (1)
- The hero meets Santa Claus (1)

- The hero now believes that Santa Claus exists and comes back to home (1)

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**I remember the end of *Dark Crystal* (8 replies)**

- The Villains die and the hero gets the crystal (1)
- The hero kills the Villains (2)
- The crystal gives life (sic) (1)
- The Gelfing successfully recreates the world from before (1)
- The village or the kingdom is saved (2)
- The hero comes back to home and is congratulated by his master (sic) (1)

It is interesting to note first the imbalance between the number of replies got for *The Polar Express* and this got for *Dark Crystal*. Moreover, the replies given by the pupils for explaining the end of the film are much more accurate and coherent for *The Polar Express*. As already noticed, *Dark Crystal* has a more complex narrative structure than this of *The Polar Express* and, even for an adult, it is not easy to explain what exactly happens during the last scenes of the film which includes various events mixing the fight between the malevolent Skesis and the benevolent Mystics, the death of the heroin and her rebirth. Pupils did sincerely their best for remembering this surprising final stage and, in the end, they have retained that the Gentles win and, for some of them, that the crystal plays a role in this victory. The replies concerning the end of *The Polar Express* are much more accurate with a lot of replies which have retained one or the other of the narrative elements which constitute the end of the film: the hero comes back to home after meeting Santa Claus, he finds the bell among his Christmas gifts. The fact that a large majority of the class was able to speak about the end of the film and the quality of the obtained replies suggests that the initial uncanny feeling was, in some way, forgotten in favor of a story – to believe or not to believe in Santa Claus – for which they lastly got more involved than for the fight between malevolent and benevolent races related in *Dark Crystal*. It is significant to note that one of the most pleasant moment remarked by the pupils was in *Dark Crystal* the "love story" between the hero and the Gelfing girl.

## 4. CONCLUSION

Because it is not yet possible to test robots giving lessons to pupils, it is difficult to specify the right form to give to these new educational machines. We decided to overcome this actual difficulty by comparing what is felt and remembered by a classroom of 8-9 years old pupils after they were shown the two typical movies *The Polar Express* and *Dark Crystal*. It seemed also interesting for us, ten years after its first commercial release, to come back to the question of the uncanny feeling associated to the characters of *The Polar Express*. It was so particularly remarkable for us to find again with an audience, ignoring completely the controversy about the film, the uncanny effect generated by the all beginning of *The Polar Express*, particularly marked in full agreement with other studies concerning young children but what suggests our study is that this uncanny effect becomes less significant with time, in our case when one week after *The Polar Express* was entirely viewed by the children. Such is result is not, according to us, in contradiction with experimental studies about uncanny feeling which are generally limited to immediate reaction face to images proposed to the subjects. And when we focused on what the pupils remembered several months after having saw the two movies, no difference appeared, in a point of learning point of

view, between the digital animation of *The Polar Express* with its initial uncanny feeling effect and the puppet-type animation peculiar to *Dark Crystal*, deprived of the ambiguous face items peculiar to *The Polar Express*. In a recent study, we attempted to relate the concept of the uncanny feeling to the Freudian concept of return of the repressed which is essentially a sudden and eerie effect when forgotten fears of our little childhood resurface [17]. Although we do not claim that Mori's uncanny feeling induced by human-like digital faces or robot heads can be considered as a new technological type of return of the repressed, it was in our limited reported experiment all as if, after the initial eerie surprise, the figures of *The Polar Express* were finally well accepted for telling a story they lastly better understand than the one of *Dark Crystal* because it is most closely linked to their personal concerns. Our conclusion, from this preliminary study, to be confirmed by other studies with more accurate educative materials would be: Appearance of the actors in a narrative production, with or without uncanny feeling – assuming it does not include horror figures – has a weak effect on the ability of learning the content of the visualized material.

### 3. ACKNOWLEDGMENTS

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### 4. ANNEX

#### Questionnaire 1. The all beginning of *The Polar Express*.

Who is the hero of the film?

- A puppet
- A little boy
- A cartoon hero

What do you think of the hero's appearance?

- It is normal
- It is strange
- It is very strange

What do you think of his gaze?

- It is beautiful
- It is strange

What do you think of his movements?

- They are normal
- They are staccato

What do you feel when you see the hero for the first time in his bed?

- You are afraid: not at all , a little bit , very
- You think that the hero: is sleeping , is sick

### 4. REFERENCES

[1] Yanamoto, S., Tetsui, T., Naganuma, M. and Kimura, R., 2006. Trial of using robotic pet as human interface of multimedia education system for pre-school aged child in

kindergarten. In *Proceedings of the IEEE SICE-ICASE international joint conference*, Bexco, Korea, 3398-3403.

[2] Fridin, M., 2014. Kindergarten social assistive robot: First meeting and ethical issues. *Computers in Human Behavior*, 30, 262-272.

[3] Nalin, M., Baroni, I., Kruijff-Korabayova, I., Canamero L., Lewis M., Beck A. Cuayahuitl, H. and Sanna A., 2012. Children's adaptation in multi-session interaction with a humanoid robot. In *Proceedings of the 2012 IEEE RO-MAN Conference*, Paris, France, 351-357.

[4] Shahid, S., Krahmer, E. and Swerts, M., 2014. Child-robot interaction across cultures: How does playing a game with a social robot compare to playing a game alone or with a friend? *Computers in Human Behavior*, 40, 86-100.

[5] Han, J., 2012. Emerging technologies robot assisted language learning. *Language Learning & Technology*, 16,3, 1-9.

[6] Ha-Won, J., 2010. S.Korea schools get robot English teachers. *Phys.Org*, <http://phys.org/news/2010-12-skorea-schools-robot-english-teachers.html>.

[7] Fridin, M., and Belokopytov, M., 2014. Acceptance of socially assistive humanoid robot by preschool and elementary school teachers. *Computers in Human Behavior*, 33, 23-31.

[8] Chang, C.-W., Lee J.-H., Chao P.-Y., Wang, C.-Y. and Chen, G.-D., 2010. Exploring the possibility of using humanoid robots as instructional tools for teaching a second language in primary school. *Educational Technology & Society*, 13, 2, 13-24.

[9] Aidinlou, N.A., Alemi, M., Farjami F. and Makhdoumi, M., 2014. Applications of robot assisted language learning (RALL) in language learning and teaching. *International Journal of Language and Linguistics*, 2, 12-20.

[10] Mori, M., 1970. The uncanny valley. *Energy*, 7, 4, 33-35 (in Japanese), translated by K.F. MacDorman and N. Kageki. *IEEE Robotics and Automation Magazine*, June 2012.

[11] MacDorman, K.F., and Chattopadhyay, D, 2016. Reducing consistency in human realism increases the uncanny valley effect; increasing category uncertainty does not. *Cognition*, 146, 190-205.

[12] Tondou, B. and Bardou, N., 2012. A new interpretation of Mori's uncanny valley for future humanoid robots. *International Journal of Robotics and Automation*, 26, 3, 337-348.

[13] Tinwell, A., and Sloan, R.J.S., 2014. Children's perception of uncanny-like virtual characters. *Computers in Human Behavior*, 36, 286-296

[14] Jenkins, W., 2004. The Polar Express: A virtual train wreck. *The Ward-O-Matic*, <http://wardomatic.blogspot.com>.

[15] Travers, P., 2004. The Polar Express. *Rolling Stone*, (18 November 2004).

[16] Zacharek, S., 2004. The Polar Express. *Salon*, (10 November 2004).

[17] Tondou, B., 2014. Fear of the death and uncanny valley: a Freudian perspective. *Interaction Studies*, 16, 2, 200-205.