Behavioural Science Institute

Exploring Curiosity Using an Educational Game in Children’s Science Museum: Does Uncertainty Matter?

Iordanka Chakarova
s1011801
i.chakarova@student.ru.nl

Master Science Thesis

Supervised by:
1. Prof. Bert Steenbergen
2. Dr. Erik Bijleveld

Date: 1st of July, 2019

Radboud University

Abstract

Research has shown that both video games and science museums have the potential to enhance children's curiosity towards knowledge. In this study, I conducted a field experiment at a children's science museum in Sofia, Bulgaria. I created levels of uncertainty in a city-building simulation game, based on Loewenstein's (1994) information-gap theory, viewing curiosity as emerging from awareness of a gap in one's knowledge, provoked by uncertainty. In a between-subjects experiment with children (age 8-12), I hypothesize that exposure to higher uncertainty will lead to more requests for educational information (i.e. will make children more curious towards knowledge). Further, I hypothesize that trait curious children will also pose more requests for information in the particular experimental setup. Results did not show significant differences in *information requests* due to the uncertainty manipulation, nor due to trait characteristics. However, further exploration of the data revealed significant gender and age differences, with girls and older children requesting more information. Additionally, a significant correlation was found between children's ratings on how interesting the provided information was, and the frequency of their *information requests.* Based on these outcomes, I provide recommendations for better uncertainty gap modifications in educational games.

Keywords: curiosity, children, information-gap, uncertainty, state curiosity, trait curiosity, video games, science museums

Contents

Introduction

- The psychology of curiosity ... 3
- State and trait curiosity ... 5
- Educational games in children's science museums ... 6
- Study hypotheses ... 6

Methodology ... 8

- Sample ... 8
- Design ... 9
- Instruments ... 10
- Measurements ... 15

Results ... 18

- Preliminary analyses ... 18
- Confirmatory analyses ... 20
- Exploratory analyses ... 21

Discussion ... 22

- Study limitations ... 24
- Implications and suggestions for future research ... 25

References ... 27

Appendix A. Information list ... 27

Appendix B. Questionnaire. ... 35

Appendix C. Figures ... 36

Appendix D. Tables. ... 37

Exploring Curiosity Using an Educational Game in Children's Science Museum: Does Uncertainty Matter?

Curiosity has been established as an influential factor navigating people's behavior and it is an important part of learning motivation (Engel, 2009). Through their development children explore the world in an innate manner, but an environment encouraging their curiosity could induce their interest, ability to confront uncertainty and cultivate inquiry learning approach (Grossnickle, 2014). However, curiosity is mainly researched with adults or with the mediating role of parents and teachers, when it comes to children (Jirout & Klahr, 2012; Wu, Kuo, Wu, Jen, & Hsu, 2018). This study emphasizes direct behavioral measurements of children, but takes into account the trait characteristics of the child, aiming to build comprehensive operationalization. Additionally, children's museums have been established as potential curiosity-inducing environments and video games are seen as promising learning tools (Andre, Durksen, & Volman, 2016; Rowe, Lobene, & Lester, 2017). Nevertheless, these two has not been related until now, in a mutually connected, ecologically valid system, in search of children's curiosity mechanisms, and therefore the following study tests an established model of curiosity, using an educational game in children's science museum.

The psychology of curiosity

From an evolutionary perspective, curiosity could be seen as a product of opposition to exploitation versus exploratory behavior (Oudeyer, & Smith, 2016). Furthermore, curiosity towards knowledge is expressed by constant seeking and questioning, fueled by intrinsic motivation (Oudeyer, Gottlieb, & Lopes, 2016). In the early ages of psychology, James (1890) distinguished two primary dimensions of curiosity: (a) common curiosity, which he conceptualized as irritated feelings brought by novelty and (b) scientific curiosity, which he proposed to be related to specific items of information. In the 1960s, Berlyne (1966) recognized the need of a more structured approach towards curiosity and located the concept in two dimensions (a) perceptual vs. epistemic curiosity and (b) specific vs. diverse. The perceptual vs. epistemic curiosity distinction concentrates on the difference between curiosity towards novelty (mainly regarding the surrounding environment and often attributed to animals) and the curiosity towards scientific knowledge and abstract ideas, attributed to humans. The specific curiosity applies in the case of puzzles and riddles, or specific tasks, while the diverse one connects with general information seeking process, often induced by boredom. This categorization gave the ground of the so-called second wave of curiosity research in the 1970s and 1980s (Day, 1971; Olson, & Camp, 1984) which concentrated greatly on measurement techniques, rather than conceptualizations. Based on these distinctions and the accumulated research data, the information-gap model was born in the 1990s.

A leading account in curiosity research is the work of George Loewenstein who defines curiosity as a form of cognitively induced deprivation resulting from the awareness of a gap in one's understanding or knowledge (Loewenstein, 1994). According to his information-gap model, curiosity emerges when attention becomes focused on the knowledge gap, created by uncertainty. Further, he addresses the environmental stimuli that create curiosity in a particular situation as curiosity's situational determinants. Thus, the information-gap model treats curiosity as a cognitive process which emerges in situations that trigger awareness of the existing gap.

Moreover, similar to the need for assistance and independence in Vygotsky's zone of proximal development (1978), the information-gap should be neither too big, or too small (Gentry, et al., 2014). In case the gap is too big, most probably curiosity would not occur, as the individual does not have a framework in the acquired information will be meaningful. On the opposite, if the gap is too small, this also hides the risk of information to be perceived as less interesting, as the existing knowledge could compensate for the gap.

In addition, curiosity is strictly related to one's reference point or previous knowledge and interest in a certain field. The present study aims to test to what extent curiosity is predicted by uncertainty, using knowledge related to sustainable development and ecology. Uncertainty is any departure from the unachievable ideal of complete determinism (Walker, et al., 2003). Therefore, any lack of information, rules or feedback could be treated as uncertainty. In the framework of the information-gap model, uncertainty plays an important role in evoking curiosity, as it directly corresponds with the cognitive awareness of a state of deprivation and the need to close the gap.

State and trait curiosity

Curiosity measurements could refer to general trait characteristic or could be observed as a behavior after exposure to particular stimuli, reflecting state curiosity (Berlyne, 1966). Further, Loewenstein (1994) suggests that the information-gap model is providing meaningful insights mainly for state curiosity or observing reactions to stimuli in a certain environment (i.e. situational determinants). Additional understanding of the reactions provoked by situational determinants seems meaningfully related to more broad personality characteristics of a curious individual (Naylor, 1981; van Schijndel, Jansen, & Raijmakers, 2018).

Litman (2008) separates the curiosity towards knowledge, or epistemic curiosity, in two conditions: positive intellectual interest (I-type), and informational deprivation compensation (D-type). The first distinction emphasized the pleasure of obtaining new knowledge and understanding, while the second one accents on the desire to acquire a specific solution or answer. Those two components combine in a conceptual operationalization of trait curiosity, including both mastery and performance oriented learning and behavior. Based on this distinction, a questionnaire for children's I/D-type trait curiosity has been developed and validated (Piotrowski, Litman, & Valkenburg, 2014), providing a valuable measurement tool for children' general personality traits, related to curiosity.

Educational games in children's science museums

Science museums are informal learning spaces allowing interactive learning, hands-on experience and free exploration (Andre, et al. 2016; Lucas, McManus, & Thomas, 1986; Martin, Durksen, Williamson, Kiss, & Ginns, 2016). Moreover, research has shown that children science museums are environments that induce curiosity (Koran, Morrison, Lehman, Koran, & Gandara, 1984) and interactive games, part of the museum's exhibitions, are recognized as a valuable learning tool (Rowe, Lobene, Mott, & Lester, 2017). Further, video games have been used for both understanding and inducing curiosity (Kilb et al., 2014; Maureira & Kniestedt, 2018; Wouters, Oostendorp, Boonekamp, & Spek, 2011).

All in all, game-based, interactive and hands-on tools have demonstrated the potential to create a more exciting learning environment for children, in which they could navigate their progress according to their interests with fewer efforts and apprehension, as curiosity-based learning is negatively correlated with feelings of anxiety (Litman & Spielberger, 2003). The current study is adding to the curiosity research paradigm by exploring the potential situational determinant role of science museum environment through a game-based instrument.

Study hypotheses

In this study, I performed a game-based experiment in a museum environment, by modifying an existing educational game. I further collected behavioral data of children, by measuring the amount of their information deprivation and demonstrated interest. Importantly, to manipulate uncertainty, I created two versions of the game, containing lower and higher uncertainty levels. Modification of the game was done by removing information and feedback provided to the players. The independent variable consisted of Low-uncertainty and High-uncertainty condition. To operationalize curiosity, I reasoned, based on the information-gap model that children will want to close the created gap with additional information and understanding. In order to measure curiosity, I provided children with up to 10 information pieces, related to the game and I measured the number of their *information requests*, with the following hypothesis:

H.1. *Children in the High-uncertainty condition will pose a higher number of information requests, thus they will express higher situational determined state curiosity.*

In addition, following Litman's trait curiosity conceptualization (Litman, 2008), I combined direct children behavior measurements of state curiosity, with their trait curiosity scores on the I/D-type trait curiosity questionnaire (Piotrowski, et al., 2014), filled in by their parents. This accounted for the general behavioral patterns of children when confronted with ambiguity and novelty, potentially leading to more prominent expression of curious behavior when confronted with uncertainty. Hence, it was hypothesized that:

H.2. *Children scoring higher on the I/D-type trait curiosity questionnaire will pose a higher number of information requests.*

Methodology

Sample

Between March and May 2019, 98 eight- to twelve-year-old children (*M* = 9.82, *SD* =1.21), together with their parents, were recruited to participate in a study about children's curiosity. The study took place in the largest children's science museum in Eastern Europe – "Muzeiko", located in Sofia, Bulgaria. Children and their parents were recruited at the museum and via online advertising in parent's groups on social media. Participants who registered for the study and met the participation criteria (i.e., the child was of the required age and accompanied by his/her parent) received tickets to enter the museum as an incentive. Participants, who were already visitors of the museum, met the conditions and showed interest to participate, received a present from the museum gift shop. The data collection took place in the second floor of the museum, dedicated to future challenges and ecology.

Approval from the Ethical Committee of Social Sciences of the Radboud University Nijmegen was obtained. The current study was also preregistered at the Open Science Framework (https://osf.io/xbg7a). Before the start of the study, institutional approval from the director of the museum was achieved and prior participation, parental consent, and children's assent were acquired. Parents and children were informed that they will participate in a study about enhancing children's curiosity and learning motivation with video games. Parents gave consent both for their own participation in the study, and for their child's, and had sufficient decision time given after being presented with the study information letter.

Power analysis simulated power with the paramtest package in R (Hughes, 2017). By using that method, simulations repeatedly generated random data, based on the predefined linear model. Then, each data set was analyzed and the proportion of results that were significant was counted. Thus, a simulation with 1000 iterations showed that a total of 100 children, alongside their parents, were sufficient to detect small effects (α = .05, 79% power) with at least one piece of *information requested* mean difference between the two conditions.

Design

The study design was between-subjects, with two conditions. In the Low-uncertainty condition, children played the educational game, part of the “Muzeiko” interactive exhibition, in its original version. In the High-uncertainty condition, children played a version of the game with reduced information and feedback, thus a game with a higher level of uncertainty. Children were randomly allocated to conditions.

In both conditions, children were presented with the opportunity to receive a set of ten pieces of information. The information was delivered in two game pauses, on the fifth and tenth minutes, through a total of fifteen minutes of gameplay. Thus, the dependent variable *information requests* was measured on a scale from 0 to 10 in total. Parents filled in the I/D-type epistemic curiosity questionnaire (Piotrowski, et al., 2014), consisting of ten questions, measured on a scale 0 to 10 (Appendix B).

The theoretical framework suggested a linear relationship between the amount of uncertainty and the desire to fill in the gap in knowledge and understanding. Thus, the first hypothesis examines through linear model *information requests* of children predicted by uncertainty. The second hypothesis examines a linear relationship between state and trait curiosity, with the trait curiosity questionnaire scores added as a predictor of the number of *information requests* posed by the children.

Procedure

After giving consent for participation, parents filled in the questionnaire on a tablet device, providing also additional information, such as demographics and additional trait characteristics of the child. Afterward, children played the version of the game they were assigned to, on a touch screen computer, in a designated, semi-isolated area. The children were informed that the game's purpose is to build their own sustainable city, well-balanced between the needs of humans and nature, and this is measured by the number of stars they receive. They have also been told that they have fifteen minutes to play the game, with two pauses in which, if they want, they could see some additional information related to the game.

On the fifth and tenth minute, the game was paused and children had the opportunity to express a desire to see information related to the game's educational content up to ten consecutive times. The information was presented to the children on a tablet device. After finishing the fifteen minutes of gameplay, children were asked to assess how difficult was the game, if it was interesting and fun and how interesting were the ten information pieces. Children total gameplay time was recorded. After finishing the experimental procedure, parents and children were debriefed about the study and had the opportunity to ask additional questions. Parents were provided with the opportunity to fill in their email addresses in case they wanted to receive a summary of the study results. The museum team also received a summary of the results.

Instruments

Game. The educational video game "Balance" is dedicated to sustainable development and is part of the "Muzeiko" museum interactive exhibition. It is displayed and played on a big touch screen monitor, inviting children to start building a city. The game purpose is to build a city that is balanced between the city infrastructure, and the surrounding nature (Fig.1)

Figure 1. “Balance” interface

The game starts with five empty slots for stars, which are indicating the success of the balance that the player achieves. The final goal is to collect all five stars, which shows that the city is developed both to accommodate the needs of people, with schools, and hospitals, fire station, and enough electricity, and with sufficient amount of parks, recycling and purifying stations. Buildings and items in the city can only be repaired and destroyed, but not moved. The field in which the city could be built is also restricted, which creates a challenge in order to put all the needed elements in a balanced manner. That balance could be traced with the help of two bars, indicating the levels of development of the city and nature. Meanwhile, the citizens of the city are also giving feedback on their needs or complaints. The buildings are also providing feedback on their needs for electricity or roads.

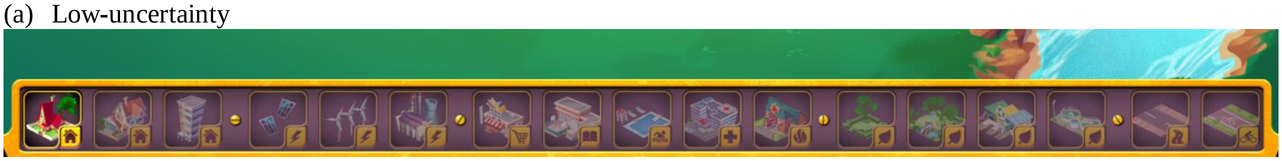
The game begins with only a few building options that the player can choose from, and with time and sufficient development, the rest of the building options are shown. If all buildings options are open, the player can choose from a small house, a big house and a building – accommodating a different amount of people, but also producing a different amount of pollution. The electricity choices are between wind turbines, solar panels, and a coal-based power station. The first and the second are producing electricity free of pollution, but in relatively small amount, with solar panels producing more electricity, but also taking more space. The power station is significantly polluting the city, but it produces a lot of electricity and in more developed stages of the game, its pollution can be compensated with nature enhancing buildings. The player can build a school, supermarket, hospital, sports center and a fire station, all of which improve the city, but also pollute it, with electricity demands and trash production. To some extent, this can be compensated by the last set of building opportunities, containing a small garden and a big park, trash recycling and water purifying station. The player can as well choose between car roads and bike lanes in order to create the infrastructure of the city and to connect the different buildings.

The game poses an additional challenge because, after a certain time period, buildings start to dissolve and need repairmen, signified by blinking, creating a distraction. If not repaired, the building or item disappears and could bring back the player to a lower level and/or to cause losing a star. Due to that, the more the player achieves and builds, the harder the game gets. In addition, if majorly polluted, the air in the city becomes gray, causing almost full inability to see the game field, in its worst stage. In that case, the player should destroy some of the buildings causing pollution and rethink the balance strategy.

Creating uncertainty levels. The game was modified in several ways for the purposes of this study. First, after observing the usual gameplay time and its variability within children playing at the museum, the gameplay was prolonged by modifying the times in which new building opportunities are shown. This was done in order to assure that the majority of the children will play at least ten or more minutes, in order to achieve the collection of the dependent variable. Second, a pause was installed, as usually such feature does not exist in the original version of the game, but it was needed for the proper dependent variable collection.

Lastly, using this modified version, a High-uncertainty level was developed. This was done with three modification of the game – one reducing the information of the building possibilities (Fig.2), one reducing the feedback from the citizens (Fig 3) and one reducing the information of the building properties (Fig.4).

(a) Low-uncertainty



(b) High-uncertainty

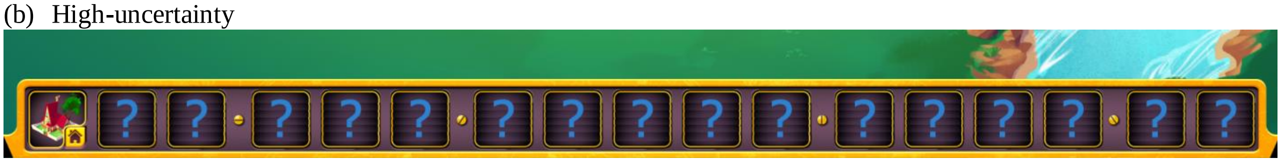


Figure 2. Building possibilities

(a) Low-uncertainty (b) High-uncertainty

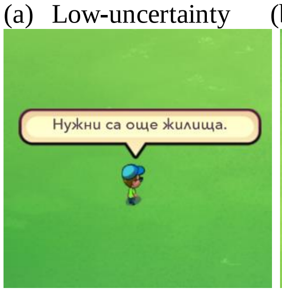


Figure 3. Citizen's feedback. Text in-box translation: *"You need to build more houses for us."*

(a) Low-uncertainty (b) High-uncertainty

Figure 4. Building's properties information. Text in-boxes translation top to bottom: *"House"; "Small family house. Develops the city"; "Build now"*

Information. A group of ten children in the required age group was initially used to define the nature and the amount of the potentially interesting information related to the game educational content. This was done by giving them the opportunity to ask questions during gameplay and asking them to what extent they found different pieces of information interesting and useful. As children level of shyness and eagerness to ask questions significantly varied even at that first stage, the chosen method for this study was to provide a pre-prepared set of information, instead of accounting on children's spontaneous requests. The final set of ten information pieces was also consulted with children's school curriculum in the subject "Human and nature" as well as the European educational program to a global model for environmental education and sustainability "Eco-schools" manual (https://www.ecoschools.global/lesson-plans-for-teachers). Finally, the initial group of children assessed how this information corresponds with the game and how interesting and useful it was. The full list of ten information pieces provided to the children during the study can be found in Appendix A.

Measurements

Information requests. Jirout & Klahr (2012) advocate for the use of behavioral measures of curiosity, especially when it comes to studies in children. Their argumentation is based on the inability of children to properly asses their own feeling-of-knowing (Lockl & Schneider, 2002). Further, they are stating that influencing curiosity by modifying uncertainty is among the most specific and reliable measurement methods, as it subsumes a majority of other established interpretations, namely a preference for novelty, complexity and unknown. Additionally, they argue that uncertainty measurements could be assessed by using a forced choice protocol, requiring a selection from a set of options, with the only difference between them being the levels of uncertainty. Thus, children's state curiosity was measured by counting the times' children requested to see information, thus became curious towards the provided knowledge, in order to fill as much as possible the gap created by the implemented uncertainty.

In the game pauses children were provided with the choice to see up to ten information pieces. The question if they want to see one more information piece was asked up to five consecutive times per pause. In case they had pressed "*Yes*", another fact was displayed. In case they wanted to indicate they have seen enough, and they want to return to the game, children needed to answer "*No*" to the question, and the game was resumed, as well as their playing time. Children's choices for the two pauses were further summed up to create scores from 0 to 10, which indicated the level of curiosity of children towards the provided information, operationalized as their *information requests.*

Trait curiosity. The independent variable trait curiosity was measured with the validated I/D-type epistemic curiosity questionnaire (Piotrowski, et al., 2014), consisting of ten questions – five of which related to children the expression of interest, and five related to the expression of deprivation when confronted with novelty. As the questionnaire was used in Bulgarian, it was translated from English and then back-translated by two native speakers, one with expertise in the social sciences, and one with an English linguistics diploma. Any discrepancies between the two versions were eliminated. The original English version of the questionnaire can be found in Appendix B. Parents assessed the ten statements of the questionnaire using a slider, with scores between 0 (*Almost Never*) to 10 (*Almost Always*). The internal reliability of the questionnaire was good (Cronbach's $\alpha = .89$). In addition, parents were also asked to assess their child's preference to topics like ecology and sustainable development and to what extent their child liked to play video games in general. This was done using a slider, with scores between 0 (*Almost Never*) to 10 (*Almost Always*).

Control variables. As previous studies indicated inconsistent outcomes, but also possible variations due to gender and age differences (Jirout, & Klahr, 2012; Langevin, 1971; Stoner & Spencer, 1986; Vidler 1977), those measurements were included as control variables. In addition, the perceived difficulty of the game rated from the children with a slider from 0 (*Very easy*) to 10 (*Very hard*) and the game performance (0 to 5 stars) was assessed, in order to control for the possible effect of making the game too hard, due to the uncertainty modifications. Children were asked to rate each one of the ten pieces of information provided, with a slider on a scale from 0 (*Not interesting*) to 10 (*Very interesting*) after finishing the game so that the effectiveness of the measured dependent variable *information requested* could be taken into consideration. Children were also asked if they liked the game and if they found the game fun (answering *Yes* or *No*) so that the effectiveness of the used stimuli could be evaluated.

In order to account for children's reference point towards the game topic and provided information, parents were asked to assess to what extent children express interest towards sustainable development and ecology topics, with a slider on a scale from 0 (*Almost Never*) to 10 (*Almost Always*). Further, parents assessed if their children like to play video games, again with a slider on a scale from 0 (*Almost Never*) to 10 (*Almost Always*).

Statistical analysis

The study investigated the linear relationship between state curiosity and uncertainty and trait and state curiosity with a linear regression model. Prior to the start of the main analysis, descriptive statistics were assessed. Data was also checked for missing or impossible values. Randomization check was performed to ensure that children did not differ in age and gender per condition. Univariate distributions and bivariate relations were examined, as well as possible outliers. Assumptions for linear regression were also examined, namely linear relationship, multivariate normality, little or missing multicollinearity, no autocorrelations, and homoscedasticity.

The linear regression model included the dependent variable *information requests* predicted by children being either in the Low-uncertainty or High-uncertainty condition. After that, trait curiosity composite scores from the questionnaire were included as a predictor in the linear regression model because the theoretical framework of the study suggested possible relation. Further, control variables, which showed significant correlations with the dependent variable, were included in the model. Lastly, exploratory analysis of the possible interaction between children state and trait curiosity, as well as between their gender and age, were explored as possible predictors of children's *information requests*.

Results

Preliminary analyses

Descriptive statistics. The initial observation of data revealed that the majority of the parents (70%) that took part in the study with their children had a university degree, and a significant amount of them were women (86%). From the 98 parent-child dyads participating in the study, 51% were recruited in the museum; the remaining participants had registered to participate in advance. A substantial amount of children had already visited the museum in the past: 28% had visited at least once; 44%, multiple times. The number of previous visits did not significantly correlate (p <.05)with any of the study's measures.

Preliminary analyses were performed to examine patterns of missingness, and bivariate associations among all study variables in the R statistical program (R Core Team, 2019). Six outliers (> M +/- 3SD) for the variable gameplay time were removed, as they showed children with a gameplay time less than ten minutes, indicating that children did not get to encounter the second sets of facts, measuring the dependent variable. Hence, all further analysis proceeded with 92 child-parent dyads. Pearson correlations were performed and Levene's test of equal variances and variance inflation factors (VIFs) were calculated.

Randomization check. Welch's *t*-tests were performed and indicated non-statistically significant differences per condition for children's gender $t(86.86) = -5.34$, $p = .594$, and age $t(89.79) = -0.31$, $p = .779$. Further, children did not differ per condition in terms of their Trait curiosity questionnaire scores $t(82.23) = -0.24$, $p = .808$. Thus, there were no non-random patterns for those variables, included in the main model. Table 1 presents the means and standard errors of the study measures separately per condition.

Correlation analysis. Correlation analysis (Table 2) indicated that the *information requests* were related to children's gender (r = .22, p = .033), namely girls requested to view more pieces of information, compared to boys. *Information requests* were also positively related to children's age (r = .22, p = .036) so that older children were requesting to see more pieces of information. Children who demonstrated more interest in the form of *information requests* also rated the information as more interesting (r = .22, p = .040).

Children's performance, operationalized as the number of stars they attained after fifteen minutes of gameplay, was also significantly correlated with their gender and age. In particular, older children (r = .21, p = .042) and boys achieved more stars (r = -.26, p = .012). Children's performance was also connected with the perceived difficulty of the game, with fewer stars achieved when the game was perceived as more difficult (r = -.22, p = .035).

A strong positive correlation was observed between the curiosity questionnaire presented to the parents and the question about children's interest in ecology and sustainable development issues (r = .60, p < .001). Lastly, the rating children gave to the game and the provided information were correlated, with finding the information interesting positively correlating with finding the game fun (r = .47, p < .001) and liking it (r = .41, p < .001).

No other significant correlations emerged. However, couples of relations were positioned very close to this benchmark and may give some additional perspectives. For instance, the relation between the scores given by parents on the Trait curiosity questionnaire, and the gender of the child (r = .19, p = .063) and between parents assessing children as liking video games, and children's performance on the game (r = .19, p = .066). In sum, the correlation table (Table 2) indicated that the main dependent variable *information requests* was mainly related to the gender and age of the children, but not to the condition they were assigned to.

Confirmatory analyses

The analyses in the following section were carried out as they were initially pre-registered. Levene's test indicated equal variance per condition for the outcome variable *information requests* with $F(1,90) = .02$, $p = .898$. Further, equal variance per condition was also observed for the trait curiosity scores $F(1,90) = .01$, $p = .993$; for children's information rating $F(1,90) = .45$, $p = .052$; for children's age $F(1,90) = .85$, $p = .357$ and gender $F(1,90) = .29$, $p = .593$.

The first linear regression model tested if the condition in which children were assigned predicted the amount of information they will request, with the expectation that children in the uncertain condition will score a higher number of *information requests* (Table 3). This hypothesis was not supported, $F(1,90) = .35$, $p = .556$ and a standardized coefficient of $\beta = -.06$, $p = .556$. Despite that the predictor was not significant, if anything, the results were in a direction opposite to the initial hypothesis (i.e., children in the uncertain condition requested less information than the one in a certain condition).

The second hypothesis stated that the questionnaire scores of children with higher levels of I/D-type trait curiosity will have a positive correlation with the number of *information requests.* In order to examine the second hypothesis, the averaged sum of the questionnaire for the parents, measuring children's trait curiosity was added to the model as a predictor of children's frequency of *information requests*. This hypothesis was also not supported with trait curiosity ($\beta = .11$, $p = .317$) showing no significant relation with the dependent variable, $F(2,89) = .68$, $p = .509$.

Further, children's gender and age were added to the model as control variables, in order to account for the reactions of the uncertainty modifications, due to children's age and gender

(Table 3). This resulted in adjusted $R^2 = .10$ and $F(5, 86) = .68$, $p = .014$. Gender emerged as statistically significant ($\beta = .23$, $p = .027$), as well as age ($\beta = .21$, $p = .039$) and information rating ($\beta = .22$, $p = .034$). However, there were still no significant effects of uncertainty condition and trait curiosity. Visualizations of the significant effects of gender and age are presented in Appendix C.

Exploratory analyses

In addition to the testing of the pre-registered hypotheses, the interaction between Trait curiosity scores and Condition was also tested in order to examine the possibility that generally trait curious children could potentially react differently, in situations with different level of uncertainty involved. However, this interaction did not show to be significant ($\beta = -.40$, $p = .597$). Further, the interactions between the significant predictors of *information requests* – Gender X Age ($\beta = .14$, $p = .171$); Gender X Information rating ($\beta = .05$, $p = .595$) and Age X Information rating ($\beta = -.11$, $p = .302$) were also not significant. Therefore, the interaction between those variables did not show different information ratings per age group or gender, neither any gender differences per age group.

Finally, closer inspection of the distribution of the dependent variable, *information requests*, showed indication of a potential ceiling effect, with 25% of children scoring a maximum score of 10. Thus, a substantial proportion of the children expressed a desire to see all the available information pieces, potentially suppressing or masking the effect of uncertainty condition. To examine this possibility, a smaller data set was created where the maximum scoring children were removed and models were re-run. However, this resulted in the same significance patterns. Specifically, there still was no significant effect of Condition on *information requests* (β = -.08, p = .496) and also no significant effect of Trait curiosity on *information requests* (β = .12, p = .344).

Discussion:

The research community persistently agrees that an extensive definition with the ability to grasp all manifestations and nuances of the curiosity phenomenon still does not exist. Yet, curiosity as a dynamic concept is defined by its relation to the unknown and uncertainty. However, the current study over the effect of an educational game uncertainty manipulation did not show to be supported in the information-gap theory framework. Despite widely recognized and referred to, the information-gap model is attempting to grasp a multidimensional concept with various expressions. Therefore, it is possible that on certain occasions, namely in game design, curiosity indicating and maintaining are working in a different manner.

On the other hand, the nature of game design requires constant testing and improving. This study tested if a game modification of uncertainty can make children more curious towards the educational content of the game. However, in general, results did not show indications that this uncertainty manipulation increased curious behavior. As research suggests that gaps in knowledge trigger curiosity depending on their size (they should be neither too small nor too big, following the information-gap model), it might be the case that the uncertainty manipulation was either too weak or too strong. Another possible explanation for the observed null results is related to children’s reference point, namely, what was their previous knowledge of sustainable development and ecology. Moreover, despite the study design was following closely the information-gap model principles, it is possible that individual susceptibility towards the created uncertainty could be part of the unexplained variance of the study model. Therefore, in the particular game context, some children could have needed more, less, or differently introduced uncertainty, in order to provoke their curiosity towards the provided information.

The trait characteristics of children assessed during the study showed good reliability and relation with the direct curiosity measure and the interest in sustainable development topics. However, such information, despite valuable for the trait characteristics of children, relied heavily on the perception of parents. This posed a risk of a social desirability bias of parents, wanting their children to possess the positive features related to curiosity. In line with this argument, the rejection of the second hypothesis pointed out towards the lack of predictive value of the questionnaire with respect to the actual behavior expressed by the children during the experiment.

In terms of the significant variables predicting the *information requests,* several perspectives should be mentioned. Loewenstein (1994) points out that gender and age differences are giving contradictory results in the curiosity research paradigm. Hence, they were not central hypotheses measures, but nevertheless, they have produced significant outcomes in the particular experimental setup. Namely girls and older children posed more *information requests*. Those gender differences could be interpreted as different strategies while playing the game. This is also supported by the relation between gender and performance (number of stars achieved), which showed that boys in general performed better than girls. As the provided information was presented in a context in which children should account on their reading skills and motivation, those results seem to be in line with a significantly higher intrinsic reading motivation demonstrated systematically by girls (McGeown, Goodwin, Henderson, Wright, 2012; Zhang, 2018). Thus, speculatively, boys seemed to rely on a trial-error strategy, demonstrating a more specific type of state curiosity, following Berlyne (1966), while girls may have demonstrated higher epistemic curiosity traits related to the desire to fill the information-gap with knowledge.

In addition, age differences, with older children scoring higher in the number of *information requests*, is in line with Loewenstein's argument of one's reference point in relation to curiosity. Specifically, that curiosity grows exponentially with knowledge acquired because the more one knows in a certain area, the more s/he focuses on the yet unknown (Loewenstein, 1994). Thus, older children encountering more frequently topics like sustainable development and ecology in school or in media, had a smaller information-gap, compared to younger children, for which this topic could be yet too foreign for their level of cognitive development and focused interest.

Lastly, rating the information as more interesting demonstrated logical relation with the number of *information requests.* Thus, irrespective of the gender or age of children, if they were interested in the type of information presented, they have posted more *information requests*. Interestingly, children's rating for the provided ecology related information (Appendix A) did not correlate with their parents' stating how interested their child is in ecology. Thus, here too, a potential social desirability component may be a factor.

Study limitations

The current study conducted a real-life experiment, in a children's science museum, with an existing and functioning educational video game. Despite the benefits with such an ecologically valid setup, undoubtfully this also created some limitations. Firstly, a significant amount of factors and thus possible confounds in the museum environment, may have interfered and were part of the model's unexplained variance. Secondly, the study used an already existing game, which created numerous limitations, with a predetermined basic game-play, educational content, graphic design, level of difficulty and feedback. A game produced from scratch with strict experimental goals may be a more precise experiment tool. But on the other hand, enhancing a video game's motivational and entertainment features could turn out to be a very hard task, especially when it comes to a game with educational content. Thus it is worth mentioning that, despite eventually causing some methodological flaws, the game used in the current study had demonstrated a great level of liking from all children that participated in the experiment.

Children's previous knowledge (i.e. reference point) about sustainable development and ecology has not been assessed in detail prior to the start of the experiment, despite an overall interest of children in such topics was assessed by parents as a part of the questionnaire. Thus, it is possible that the negative responses to the opportunity to request more information could be also related to the fact that some children perceive this information as something that is not new for them.

Finally, in order to be either visitors of the museum or to participate in a study related to children's curiosity (with an incentive a free visit to the museum), it is logical to assume that the parents of the children in the sample group had been predisposed to raise their children emphasizing on curiosity towards knowledge as a value. This could limit the generalizability of the study outcomes.

Implications and suggestions for future research

This study suggests that more in-depth and precise understanding of game-based uncertainty should be a focus of future research. Specifically, a more systematic exploration of the knowledge gap and its relation to information requests should be investigated. In addition, different types of possible uncertainty game manipulations and their effect should be categorized, in order to establish persistent and replicable outcomes.

Moreover, as the theoretical model suggested, children's reference point and previous knowledge are of great importance when it comes to inducing curiosity. Hence, the examination of curiosity prompting intervention should primarily start with a screening of children's previous knowledge and understanding regarding the chosen topic. This process has the potential to give meaningful outcomes that will point out towards more precise uncertainty modification. Moreover, the current field study had posted a lot of challenges, as discussed in the limitations section. A lab-based study might give a better perspective over uncertainty manipulations in game design, as well as consistent gender and age differences measures, by applying systematic manipulations over the knowledge gap. Finally, future research should also concentrate on the long-term learning outcomes of game-based induced epistemic curiosity, namely measuring if situational generated curiosity has the potential to fuel the intrinsic desire for long-term knowledge deepening.

Curiosity towards knowledge and understanding of the complexity of the world is part of every scientist's first steps (Whitesides, 2018). New technology, hands-on interactive media, and video games are becoming more and more prominent in children's everyday life, with indications that this process will continue for future generations. Understanding and encouraging curiosity through the means of interactive technology and game mechanics can help children navigate themselves in the unknown, in a world full of wonders.

References

Andre, L., Durksen, T., & Volman, M. L. (2016). Museums as avenues of learning for children: a decade of research. *Learning Environments Research*, *20*(1), 47-76. doi:10.1007/s10984-016-9222-9

Berlyne, D. (1966). Curiosity and Exploration. *Science, 153*(3731), 25-33. Retrieved from http://www.jstor.org/stable/1719694

Day, H. I., Berlyne, D. E., & Hunt, D. E. (1971). Symposium on intrinsic motivation: a new direction in education. Retrieved from https://eric.ed.gov/?id=ED067324

Eco-schools: Lesson plans for teachers (2019). Retrieved from https://www.ecoschools.global/lesson-plans-for-teachers

Engel, S. (2009). Is curiosity vanishing? J Am Acad *Child Adolesc Psychiatry, 48*(8), 777-779. doi:10.1097/CHI.0b013e3181aa03b0

Gentry, J. W., Burns, A. C., Dickinson, J. R., Putrevu, S., Chun, S., Hongyan, Y., Gentry, R. A. (2014). Managing the curiosity gap does matter: What do we need to do about it? Paper presented at the Developments in Business Simulation and Experiential Learning: Proceedings of the Annual ABSEL conference. Retrieved from: https://journals.tdl.org/absel/index.php/absel/article/download/751/720

Grossnickle, E. M. (2014). Disentangling curiosity: dimensionality, definitions, and distinctions from interest in educational contexts. *Educational Psychology Review, 28*(1), 23-60. doi:10.1007/s10648-014-9294-y

Hughes, J. (2017). paramtest: Run a Function Iteratively While Varying Parameters. R package version 0.1.0. https://CRAN.R-project.org/package=paramtest

James, W. (1890). The principles of psychology, Vol II. NY, US: Henry Holt and Company. vi 704 pp., doi:10.1037/11059-000

Jirout, J., & Klahr, D. (2012). Children's scientific curiosity: In search of an operational definition of an elusive concept. *Developmental Review, 32*(2), 125-160. doi:10.1016/j.dr.2012.04.002

Kilb, D., Rohrlick, D., Yang, A., Choo, Y., Ma, L., & Ruzic, R. (2014). The game of curiosity: using videogames to cultivate future scientists. *Seismological Research Letters, 85*(4), 923-929. doi:10.1785/0220130182

Koran Jr, J. J., Morrison, L., Lehman, J. R., Koran, M. L., & Gandara, L. (1984). Attention and curiosity in museums. *Journal of Research in Science Teaching, 21*(4), 357-363. doi:10.1002/tea.3660210403

Langevin, R. (1971). Is curiosity a unitary construct?. *Canadian Journal of Psychology/Revue canadienne de psychologie, 25*(4), 360. doi:10.1037/h0082397

Litman, J. A. (2008). Interest and deprivation factors of epistemic curiosity. *Personality and individual differences, 44*(7), 1585-1595. doi:10.1016/j.paid.2008.01.014

Litman, J. A., & Spielberger, C. D. (2003). Measuring epistemic curiosity and its diversive and specific components. *J Pers Assess, 80*(1), 75-86. doi:10.1207/S15327752JPA8001_16

Lockl, K., & Schneider, W. (2002). Developmental trends in children's feeling-of-knowing judgements. *International Journal of Behavioral Development, 26*(4), 327-333. doi:10.1080/01650250143000210

Lucas, A. M., McManus, P., & Thomas, G. (1986). Investigating learning from informal sources: Listening to conversations and observing play in science museums. *European Journal of Science Education, 8*(4), 341-352. doi:10.1080/0140528860080401

Martin, A. J., Durksen, T. L., Williamson, D., Kiss, J., & Ginns, P. (2016). The role of a museum-based science education program in promoting content knowledge and science motivation. *Journal of Research in Science Teaching, 53*(9), 1364-1384. doi:10.1002/tea.21332

Maureira, M. A. G., & Kniestedt, I. (2018). Games that Make Curious: An Exploratory Survey into Digital Games that Invoke Curiosity. Paper presented at the International Conference on Entertainment Computing. Retrieved from: https://www.springerprofessional.de/en/games-that-make-curious-an-exploratory-survey-into-digital-games/16100794

McGeown, S., Goodwin, H., Henderson, N., & Wright, P. (2012). Gender differences in reading motivation: Does sex or gender identity provide a better account?. *Journal of Research in Reading, 35*(3), 328-336. doi:10.1111/j.1467-9817.2010.01481.x

Muzeiko. About us. (2019) Retrieved from: http://www.muzeiko.bg/en

Naylor, F. D. (1981). A state-trait curiosity inventory. *Australian Psychologist, 16*(2), 172-183. doi:10.1080/00050068108255893

Olson, K. R., & Camp, C. J. (1984). Factor analysis of curiosity measures in adults. *Psychological Reports, 54*(2), 491-497. doi:10.2466/pr0.1984.54.2.491

Open science framework register: Curiosity in children: do levels of uncertainty matter? (2019) Retrieved from: https://osf.io/xbg7a

Oudeyer, P. Y., & Smith, L. B. (2016). How evolution may work through curiosity-driven developmental process. *Topics in Cognitive Science, 8*(2), 492-502. doi:10.1111/tops.12196

Oudeyer, P. Y., Gottlieb, J., & Lopes, M. (2016). Intrinsic motivation, curiosity, and learning: Theory and applications in educational technologies. *Progress in brain research 229,* 257-284 Elsevier. doi:10.1016/bs.pbr.2016.05.005

Piotrowski, J. T., Litman, J. A., & Valkenburg, P. (2014). Measuring epistemic curiosity in young children. *Infant and Child Development, 23*(5), 542-553. doi:10.1002/icd.1847

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical computing, Vienna, Austria.

Rowe, J. P., Lobene, E. V., Mott, B. W., & Lester, J. C. (2017). Play in the museum: design and development of a game-based learning exhibit for informal science education. *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS), 9*(3), 96-113. doi:10.4018/IJGCMS.2017070104

Stoner, S. B., & Spencer, W. B. (1986). Age and sex differences on the state-trait personality inventory. *Psychological Reports, 59*(3), 1315-1319. doi:10.2466/pr0.1986.59.3.1315

van Schijndel, T. J. P., Jansen, B. R. J., & Raijmakers, M. E. J. (2018). Do individual differences in children's curiosity relate to their inquiry-based learning*? International Journal of Science Education, 40*(9), 996-1015. doi:10.1080/09500693.2018.1460772

Vidler, D.C. (1977). Curiosity. Motivation in Education. New York, Academic Press. Voss, H.G.

Vygotsky, L. S. (1978). Mind in Society: the Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

Walker, W. E., Harremoës, P., Rotmans, J., van der Sluijs, J. P., van Asselt, M. B., Janssen, P., & Krayer von Krauss, M. P. (2003). Defining uncertainty: a conceptual basis for uncertainty management in model-based decision support. *Integrated assessment, 4*(1), 5-17. Retrieved from: http://resolver.tudelft.nl/uuid:fdc0105c-e601-402a-8f16-ca97e9963592

Whitesides, G. M. (2018). Curiosity and science. Angew Chem *Int Ed Engl, 57*(16), 4126-4129. doi:10.1002/anie.201800684

Wouters, P., Oostendorp, H. v., Boonekamp, R., & Spek, E. v. d. (2011). The role of Game Discourse Analysis and curiosity in creating engaging and effective serious games by implementing a back story and foreshadowing. *Interacting with Computers, 23*(4), 329-336. doi:10.1016/j.intcom.2011.05.001

Wu, P. H., Kuo, C. Y., Wu, H. K., Jen, T. H., & Hsu, Y. S. (2018). Learning benefits of secondary school students' inquiry-related curiosity: A cross-grade comparison of the relationships among learning experiences, curiosity, engagement, and inquiry abilities. *Science Education, 102*(5), 917-950. doi:10.1002/sce.21456

Zhang, L. (2018). Gender differences in metacognitive and cognitive strategy use and reading test performance. *Metacognitive and Cognitive Strategy Use in Reading Comprehension*, 131-145. doi:10.1007/978-981-10-6325-1_6

Appendix A. Information.

1. What is a balanced city?

That is a city with a developed infrastructure that has plenty of roads, houses, schools, and hospitals to accommodate the citizens living in it. But at the same time, it remains in balance with nature - with enough parks, clean electricity, recycling, and purification to offset human activities. As part of the living nature, the people have the responsibility to maintain and keep nature clean, not only for themselves but also for other species.

2. What is a solar panel?

A solar panel or solar battery is turning solar energy into electricity, which people need in their everyday lives. Compared to the electrical power stations, solar panels are producing a much smaller amount of electricity, so a lot of them are needed to achieve the same level of production. Yet the energy we receive from solar panels does not pollute the nature and the air that we are breathing.

3. What is a wind turbine?

Wind energy converter or a wind turbine is a machine that converts energy from the wind into electricity. Larger turbines can be used in places with a lot of wind in order to contribute to domestic electrical power needs. However, like the solar panels, we need a lot of them to produce a significant amount of electricity and we can’t use wind turbines in places without wind. If the conditions are good, wind turbines do not pollute nature and are a great source of clean energy.

4. Destruction or repair/recycling?

Often, getting rid of something that seems unnecessary can look more appealing or easy to do. However, people need to think carefully and strategically of what they produce and build, as that exhaust natural resources and often pollutes nature. Thinking before initial production, repairmen instead of putting something in the trash and recycling of things gives the nature time to recover from human influence.

5. Automobile roads or bicycle lanes?

Cars and automobile roads are important for humans, for example, so that they can go to work, for transporting more people, for long distance journeys, for loading stores and transporting people to the hospitals. But cars pollute air and nature. Bicycles do not pollute nature and allow people to exercise, and thus to be more healthy.

6. What is an electrical power station?

Electrical power stations are producing a large amount of energy required for the everyday life of people - for work, for heating, for light, for electrical appliances and devices, and much more. To produce energy, they are burning coals which in turn is releasing a huge amount of carbon dioxide in the atmosphere. Carbon dioxide is a colorless gas which is the main air pollutant and causes the so-called greenhouse effect, related to global warming.

7. What pollutes nature?

One of the most serious polluters for nature is the modern industry. When burning millions of tons of coal, oil, huge amounts of dust, carbon dioxide, and various heavy metals are being discharged and released into the atmosphere. This process also pollutes soil and water. The pollution that goes into the air, is one of the main reasons for the so-called “smog”. The smog is severe air pollution which is a combination between the words smoke and fog. It irritates the eyes and the lungs, complicates the breathing and it is especially dangerous for people with health problems.

8. How do we make the air cleaner?

Initially, the use of cars and trucks must be reduced, and industrial production should orient towards more ecological solutions. Building as much as possible solar panels and wind turbines, instead of coal-based electric power stations can also reduce the pollution effects. Preserving natural parks and forests, and building a new one, can help nature recover. The balance between the modern life of people and their needs and wants and the needs of nature is essential, in order to preserve it, and for us to stay healthy.

9. What pollutes the waters?

There are a lot of water pollution factors, like for example the use of chemicals in industrial production, the use of pesticides in agriculture, disposal of substances and medicines in the sewage. Once those polluted waters enter back the water cycle, it could be very dangerous for both people and animal species and can cause long-term contamination of the natural water recourses and soils.

10. What is a water resource recovery facility?

The wastewater treatment plant or water resource recovery facility is an occupancy that is used to purify water. The process of cleaning the water includes removing contaminants from wastewater and sewage. The water can then enter back the water-cycle with minimal harm for the environment or used back from people.

Appendix B. Questionnaire.

I/D-type trait curiosity questionnaire (Piotrowski, Litman, & Valkenburg, 2014):

1. My child has fun learning about new topics or subjects.
2. My child is attracted to new things in his/her environment.
3. My child enjoys talking about topics that are new to him/her.
4. My child shows visible enjoyment when discovering something new.
5. When my child is learning something new, he/she asks many questions about it.
6. When presented with a tough problem, my child focuses all of his/her attention on how to solve it.
7. My child devotes considerable effort trying to figure out things that are confusing or unclear.
8. My child is bothered when he/she does not understand something and tries hard to make sense of it.
9. My child will work for a long time to solve a problem because he/she wants to know the answer.
10. My child carefully examines things by turning them around or looking at them from all sides.

Additional statements assessed by the parents regarding their child:

11. My child is interested in topics like sustainable development and ecology.
12. My child likes to play video games.
13. My child is curious.

Appendix C. Figures

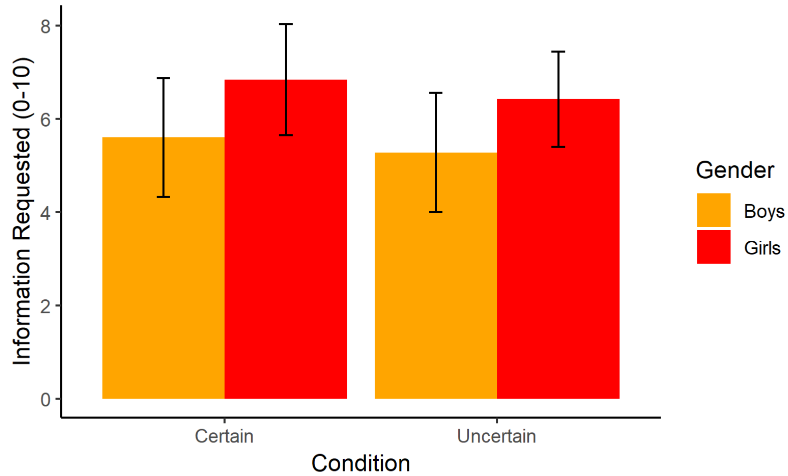


Figure 1. Gender of the child predicting information Requests per Condition

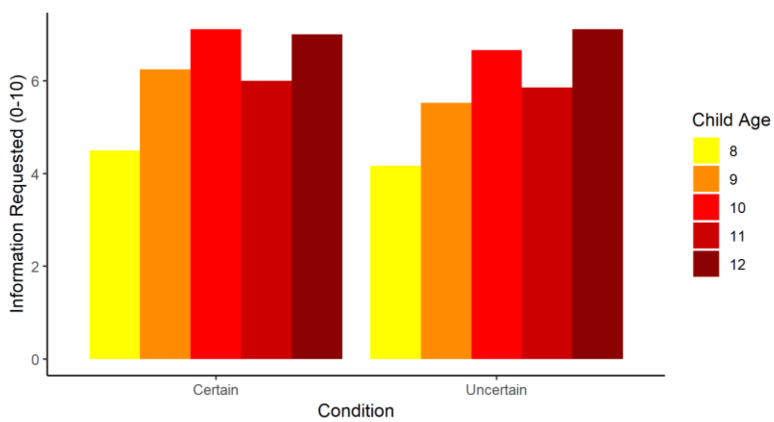


Figure 2. Age of the child predicting information Requests per Condition

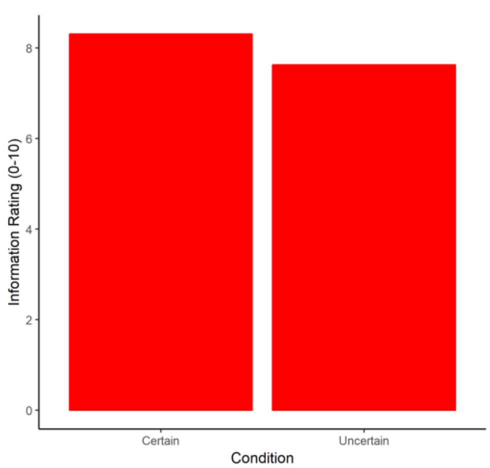


Figure 3. Children rating the information as interesting predicting *information Requests* per Condition

Appendix D. Tables.

Table 1

Descriptive Statistics for Study Measures by Condition

	Total (*N*=98)	**Low-Uncertainty Condition (*N*=45)**	**High-Uncertainty Condition (*N*=53)**
Gender			
Girls	57%	56%	58%
Boys	43%	44%	42%
Rating game: Like (positive)	99%	100%	98%
Rating game: Fun (positive)	97%	96%	98%
Mean (Standard Deviation)			
Child’s age (8-12)	9.82 (1.21)	9.73 (1.14)	9.89 (1.28)
Information requests (0-10)	6.10 (2.84)	6.29 (2.85)	5.94 (2.86)
Trait curiosity (0-10)	7.65 (1.38)	7.65 (1.47)	7.65 (1.31)
Information rating (0-10)	7.94 (1.90)	8.31 (1.76)	7.63 (1.97)
Game difficulty (0-10)	3.93 (2.16)	4.00 (2.11)	3.87 (2.21)
Performance: Starts (0-5)	3.16 (1.15)	3.18 (1.07)	3.15 (1.22)

Table 2

Correlations between Analyses Relevant Variables for Children (N = 92)

	1	2	3	4	5	6	7	8	9	10	11	12
1. Condition[a]												
2. Gender[b]	0.056											
3. Age	0.032	0.036										
4. Trait curiosity	0.026	0.195	0.015									
5. Interest in ecology	0.013	0.004	0.002	0.609***								
6. Playing games	0.180	-0.116	0.040	0.019	-0.034							
7. Information requests (DV)	-0.062	0.222*	0.219*	0.104	0.026	-0.139						
8. Performance (Stars)	0.022	-0.262**	0.212*	0.006	-0.005	0.192	0.038					
9. Game difficulty	-0.056	0.036	0.099	0.001	0.004	-0.075	0.074	-0.220*				
10. Rating: Liking game	-0.096	0.117	-0.103	0.124	-0.051	-0.059	-0.143	-0.087	0.097			
11. Rating: Game fun	0.077	0.082	0.021	0.182	-0.007	-0.039	0.052	0.073	-0.030	0.571 ***		
12. Rating Information	-0.177	-0.085	0.017	0.090	0.170	-0.053	0.215*	0.165	-0.019	0.407 ***	0.468***	

[a] 0= High-uncertainty condition; 1= Low-uncertainty condition

[b] 0= Boys; 1=Girls

**p* = <.05; ***p* = <.01; ****p* = <.001

Table 3

Summary of the Regression Analyses for Variables Predicting Information requests (N = 92)

Predictor	*Adj. R^2*	B	SE (B)	β	*t*	*p*
Model 1 (Hypothesis 1)	-.01					
Condition[a]		-0.35	0.60	-.06	-0.59	.556
Model 2 (Hypothesis 2)	-.01					
Condition[a]		-0.37	0.60	-.06	-0.62	.539
Trait curiosity		0.21	0.21	.10	1.00	.317
Model 3	.10					
Gender[b]		1.30	0.56	.23	2.24	.027*
Age		0.48	0.23	.21	2.09	.039*
Information rating		0.32	0.15	.22	2.15	.034*
Condition[a]		-0.25	0.58	-.04	-0.43	.665
Trait curiosity		0.08	0.21	.04	037	.712

[a] 0= High-uncertainty condition; 1= Low-uncertainty condition

[b] 0= Boys; 1=Girls

**p* = <.05; ***p* = <.01; ****p* = <.001