Is There an Uncanny Valley for Virtual Objects ?

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ABSTRACT

The uncanny valley describes the effect, of virtual representations of real world characters not matching with reality and create cold and eerie feelings, when observed. This state is caused by the uncertainty if the depicted character is real or fake. Currently the causation and origin is strongly debated. Previous studies results argue, that the effect is only portrayed for humans and anthropomorphic characters. This paper switches the perspective onto non-living objects and enlightens a neglected part of the current research. We tested 50 participants, with 45 different stimuli deriving from 9 real world objects. Using Noise Pattern blending those stimuli borders are blurred in different gradients. Our findings show against valid opinions, that non-living objects also induce an effect with similar effects to the classic uncanny valley.

KEYWORDS

uncanny valley, 3D, real

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1 INTRODUCTION

Per definition the uncanny valley phenomenon describes a nonlinear relationship between the degree of an object's human likeness and the assessment and emotional reaction of the observer to the affected object.[4] Because of an unbalanced relationship between these two aspects, virtual representations might be very realistic in theory but can still convey an unpleasant and negative impression. Previous studies have already proven this theory[2]. That is the reason, why human-like robots can cause an immense decrease in the observer's acceptance when they approach a nearly human look. Apart from human beings, this effect can also be observed for portrayals of animals. Moore[5] adds more depth to this theory by blending stimuli between target and background categories. His approach evolves around increasing cue conflicts, or the inconsistencies in stimuli, to generate perceptual tension and causing hereby the uncanny valley. He also adds a psychological layer for the emerging circumstance, rendering the effect itself a highly personal and individual incident, that strongly depends on the observer as a person. Nonetheless regarding non-anthropomorphic objects, for example food, plants, stone, metal etc., the effect has not been specifically observed yet.This leads us to our main question about the topic. Does the uncanny valley hypothesis, which is usually based on "human" likeness, also apply to objects besides humans or animals. We base our researches on the study of Chattopadhyay and MacDorman (2016), in which they investigated the occurrence of the uncanny, depending on feature set manipulation.While on one hand it deals with the inconsistent degree of realism and the following phenomenon, it also includes non-anthropomorphic objects. But it could not be confirmed that these had an Uncanny Valley effect on the observer. The goal of our study is, to basically redo this study, but with a higher emphasis on non-anthropomorphic objects. We want to compare our results to the work of MacDorman and Chattopadhyay and find new aspects, that can answer the question if the Uncanny Valley is actually linked to the human likeness of observed stimuli or rather a result of varying inconsistencies in realism. We expect similar results as the original study. Since the previous studies results did not show any appearances of the Uncanny Valley in this specific category, we expect our results to confirm these findings.

2 RELATED WORK

As mentioned in the introduction, the existence of the Uncanny Valley is not a new scientific topic, so there is already a lot of related work that deals with this kind of problems. However, besides the work of Chattopadhyay and MacDorman, there aren't many related studies to be found, which also focus on anthropomorphic Objects, as it is a matter

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which isn't researched very much until now. But the numeral other sources, that revolve around the Uncanny Valley topic build an important foundation for our study. Therefore it's important look at some of those works to reach a better understanding of the main issue of inconsistent realism and also show the present state of knowledge, which is necessary to answer the questions we ask.

Increased realism not necessarily implying acceptance[1]

That a bigger acceptance of the observer is not always a consequence of an increased realism of an object is the main hypothesis behind the Uncanny Valley effect. The many previous studies, that dealt with the effects and the explanations behind the phenomenon, often used human like Robots as a central component in the studies to prove this assumption. In 1970 Mori was the first put forth this kind of experiment. The hypothesis here was that when a robot gets more and more similar to a human in form, our affinity towards this robot will not, as one would expect, steadily increase . While at first, the expected increase of acceptability would be occurring, there would be an immense decrease in acceptance when the robot approaches the nearly human state. This abrupt dip in the relationship between affinity and realism is what the Uncanny Valley term stands for today.

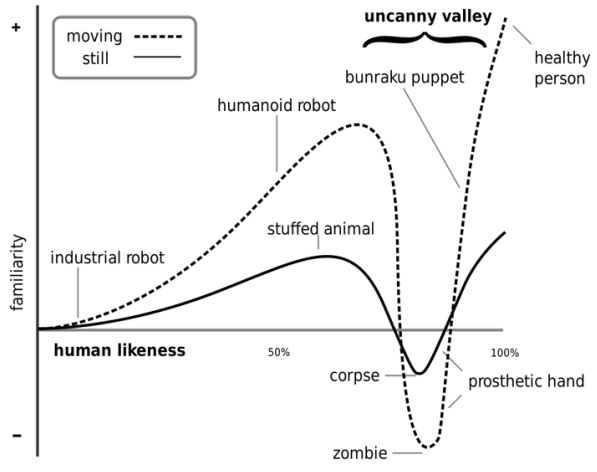

Figure 1: Simplified diagram showing the hypothesized relationship between affinity and realism with the uncanny valley appearing as a negative response as one approaches a high degree of realism.

Overcoming the Uncanny Valley[1, 3]

Throughout many of the previous works like the study of Chattopadhyay and MacDorman it has been made clear that the two aspects increased realism and greater acceptance by audiences are not coherent. There is a lot of anecdotal evidence to the phenomenon, but we still don't know if the Uncanny valley is part of natural human actions. Finding specific ways to navigate in and out of the Uncanny Valley and which properties have to be manipulated to do so remains difficult. Also is finding clear standardized definitions. So today, preventing the negative effects and therefore trying to overcome the Uncanny Valley is still a big challenge in computer technology . However, there already are approaches in how to 'control' the uncanniness of an object. For example in the study of Koschate et al. it is shown that the display of emotions can reduce the uncanniness of humanoid robots. Here, a highly human like robotic head that either showed appropriate basic emotions or reacted by blinking was used. This approach leads to the consequence that the human likeness does not necessarily have to be reduced to decrease our negative perception of objects (in this case the robot). Through this addition of displaying appropriate human emotions when briefly interacting with participants of this experiment, the same goal (decreasing the negative effects) could be reached. The "mismatch between expectation and perception" is declared to be the main reason for a decreased acceptance here, as robots can be capable of emotional experience but can not react back with fitting emotional responses.

The Uncanny Valley effect on humans, animals and objects[2]

Since previous studies mainly focus on humanoid objects, as a last point in our related work section our main source should be mentioned. Familiar faces rendered strange: Why inconsistent realism drives characters into the uncanny valley from Chattopadhyay and MacDorman deals with the Uncanny Valley effect based on all 3 mentioned above aspects (humans, animals, objects). While the conclusion shows, that the inconsistent realism significantly affects the observer when it comes to humans or animals but less when they compare real and artificially generated objects. We will get a deeper insight on the results of the study (and a comparison with our conclusions) in the following sections of our paper, since our goal is to redo the main aspects of this work and get our own answers.

Summary

Previous work mostly emphasizes on the different definitions and approaches on the effects of inconsistent realism, and how to possibly overcome the resulting problems of an Uncanny Valley effect. We, on the other hand focus on the question if those kinds of impacts even exist for anthropomorphic objects and how those would show in comparison to the perception of humans or animals.

3 METHOD

Design

This study strongly orients itself on the original study, executed by MacDorman and Chattopadhyay[2]. Hence the focus is shifted on non-anthropomorphic objects instead of a broader display of possible 3D representations the stages of this experiment are simplified. The study adopted a within group design with only one round of testing, that contains all 45 stimuli derivations. Used stimuli are combinations of the real world objects and their computer generated counterpart. The experiment consisted of a two-choice categorization task and score ratings of the task stimuli.

Participants

Participants were recruited by social media, the mail distributor of the University of Regensburg and personal acquisition. All Participants have been asked, if they have a previous knowledge or work with computer generated imagery, design or photography on a regular basis. Participants received no compensation. A total of 48 participants took part in the study. The test group consisted of 52% female participants. 56% of the participants had specific media design fields. The distribution is as follows: 44% photography and image editing, 19% film or animation, 44% graphic design, 44% CGI&3D and 33% illustration. Multiple answers were possible for this question. The age distribution is as follows: 58% 18-24 years, 19% 25-39 years, 17% 40-59 years, 4% 0-17 years and 2% between the age of 60-79.

Apparatus

The used Stimuli consisted of seven basic entities, three can be categorized as living while the other four are objects. The three living objects (Clint, Emilie and dog) were already used in the original study by MacDorman and Chattopadhyay[2]. The four non-living stimuli have been generated for this study with photography and the use of photogrammetry software. Created stimuli were moldy bread, normal bread, cake, shoe, stone and pinecone. Instead of the original use of feature set manipulation the fraction of real was altered in 1/5 steps via noise pattern blending, so every entity of used stimuli has five representations varying in 0%, 25%, 50%, 75% and 100% section of real.

Generated stimuli were implemented into an online survey, consisting of 49 pages in total. To reduce user fatigue, categorical stimuli rating and ratings of the stimuli were placed together on one page. A introduction section was set before the actual test to gather additional information of a participant's background.

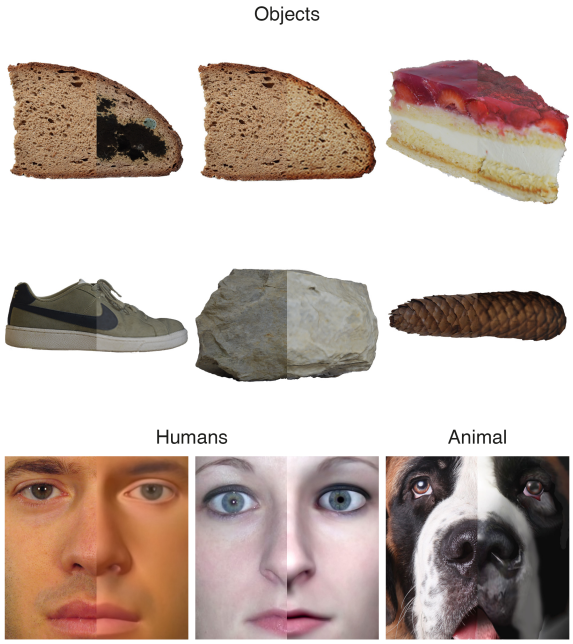

Figure 2: Used stimuli for the study consisted of three categories: objects, humans and animal. The latter two were used as orientation categories.

Figure 3: Used noise pattern for creating the five derivations of created stimuli

Procedure

For every created stimuli entity participants had to rate whether it is computer generated or a photograph. On each

entity's page users were required to rate the stimuli on 4 different topics: warmth, familiarity, eeriness and realism. Before starting the survey participants got informed, that their rating speed is tracked and important for the overall outcome for the survey itself.

Figure 4: Example for realness of the stone stimulus

Variables

The independent variables in this experiment is the fraction of real of every single stimuli representation. This results in 5 varying degrees of realism, 0%, 25%, 50%, 75% and 100%, that had been altered and are influencing the results. As dependent variables the time for the task of every stimuli rating, the categorization as real or computer generated and the overall rating of the stimuli with 4 different categories, warmth, familiarity, eeriness and realism and are being observed. For every category participants have a rating range from 0 to 6, whilst 0 denotes a very low perception of the proposed category and 6 being a high interpretation.

4 RESULTS

To verify if the uncanny valley effect was transferable from anthropomorphic to non-anthropomorphic objects we tested following hypothesis:
H1: Reducing consistency in feature realism reduces perceived familiarity, realism, warmth and increases eeriness (from now on referred to as f, r, w and e) for non-anthropomorphic entities.

Testing H1

Most important for the results of our study were the results of the rating of our stimuli. While the results of processing time and categorization will be mentioned if they show something extraordinary, they are not in the main focus of this evaluation, and they often do not show relevant information, but still remain dependent variables, together with the four main categories. The level of CGI the stimulus has been altered with was our independent variable, used to test our hypothesis. To make sure there can be observed any effect at all, of which we already where convinced and mainly to have results to compare our non-anthropomorphic models to we implemented two human and one animal models, which were mentioned before. All values will be displayed in steps of 0.5.

Anthropomorphic models

. While "Dog" and "Male Face" are at level 0 at high values, >4.5, at all categories, "Female Face" starts a bit lower, r>4.5, f>3, e>2.5, w>2.5. All models show a rapid increase of eeriness and decrease of the other values at different levels of CGI usage, for "Female Face" it is 1, for "Male Face" it is 4 and for "Dog" it is 3. Also, even if in case of "Dog" very slightly, the mean processing time for every of the three models is rising at some point, indicating the appearance of a sensory mismatch. So as expected there is an uncanny valley effect happening at these stages, which gives us the possibility to compare these three models to our non-anthropomorphic ones.

Non-Anthropomorphic models

. Our non-anthropomorphic models can basically be divided in two groups, food and no food. As described before we wanted to test if the bond people may have to, for example appetizing cake, would influence their perception, on different CGI levels, in any direction. Also we wanted to test the possible influence of negative feelings, like disgust or similar, with our "Moldy Bread" model. "Bread" and "Cake" at CGI-level 3 both show a similar increase of eeriness and processing time, while the other three factors decrease. The "Moldy Bread" model, which feature realism is not reduced, instead we added more Mould for every level, showed similar results at level 1 and 2 but the values very much stabilized after level 3. The other three models "Pinecone", "Shoe" and "Stone" show as well a drastic change of their values between the levels 2 and 4. "Shoe" and "Stone" both also show an increased average processing time at the critical points. Compared to the three anthropomorphic models the non-anthropomorphic ones too, show a similar effect of a rapid decrease of perceived familiarity, warmth and realism and an increase of perceived eeriness and sometimes processing time, too. The most drastic change happens with the values of "Moldy Bread", while the results of the other food models don't differ significantly from the rest of the non-anthropomorphic stimuli. All plots containing error bars for standard deviation can be found in Appendix A.
Over all, every stimulus showed an downward trend in experienced warmth, familiarity, and realism and an upward trend for perceived eeriness and in some cases rising processing time, with rising use of CGI, just as it can be expected, looking at the results of MacDorman and Chattopadhyay[2]. But also every model's results had at least one critical point at which its values changed drastically and which lets us conclude that an effect like the uncanny valley is occurring. H1 was tested using a paired t-test for variance analysis. Its mean results for every stimulus are displayed in Figure 7.

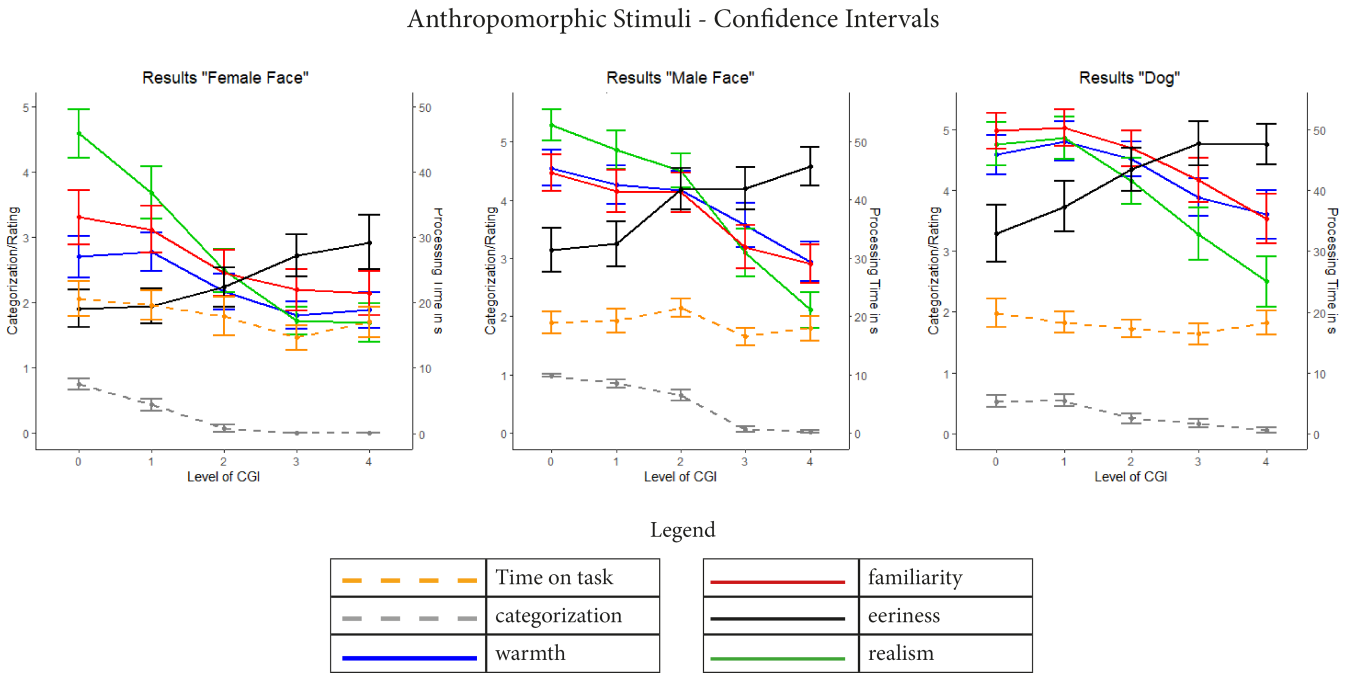

Figure 5: Plots for the anthropomorphic categories, containing errorbars for confidence intervals

5 DISCUSSION

Summary of findings

After evaluating the results of our experiment, with 48 people fully participating, we were able to draw firm conclusions about the effect of inconsistent realism and a resulting uncanny valley phenomenon. With heavy focus on stimuli of virtual objects, we got answers to the main questions behind our study.

To summarize our results, we got an expected increase in uncanniness and an occasional rise in decision times with a decreasing degree of realism, which was simulated throughout the use of higher levels of CGI. An Uncanny valley like effect could in fact be observed in our study, as a critical drop in familiarity at a certain realism level, which defines the Uncanny valley, occurred in every used stimuli. This also includes the stimuli of non anthropomorphic objects, which represented the main focus in our study.

Implications

These results lead us to the conclusion that the fact of inconsistent realism not only affects human like objects but indeed also non anthropomorphic virtual objects. While our findings and conclusions in relation to representations of humans or animals essentially don't differ from the findings in the study of Chattopadhyay and MacDorman, there were deviations for the other stimuli. With higher focus on objects than in the previous study, a more precise insight of the human impressions while observing the stimuli was possible. This deeper look on the stimuli itself can explain the differing results from the other study.

Critical reflections /limitations

To critically reflect on our own approach on the topic, there are some points that could have triggered a less precise outcome of our study. For example, as Chattopadhyay and MacDorman used more complex feature manipulation to manipulate the degree of realism in the study, we relied on simply using different noise patterns. This could have also lead to to other factors, as the edited stimuli (through noise patterns) generally lean towards being more realistic.

Despite the information we could draw from our study, we are still far away from answering the question of why the Uncanny valley phenomenon appears. For example, like already addressed in previous work (see related work section), we still don't exactly know why something like the Uncanny valley lies in the nature of a human being.

But after the results we got from our work, it might be a serious consideration, not to solely concentrate on the aspect of human likeness in future definition approaches of the uncanny valley, but more on the central topic of inconsistent realism and what it triggers in our perception of virtual objects. Regardless of the nature of used stimuli (living being/ non anthropomorphic).

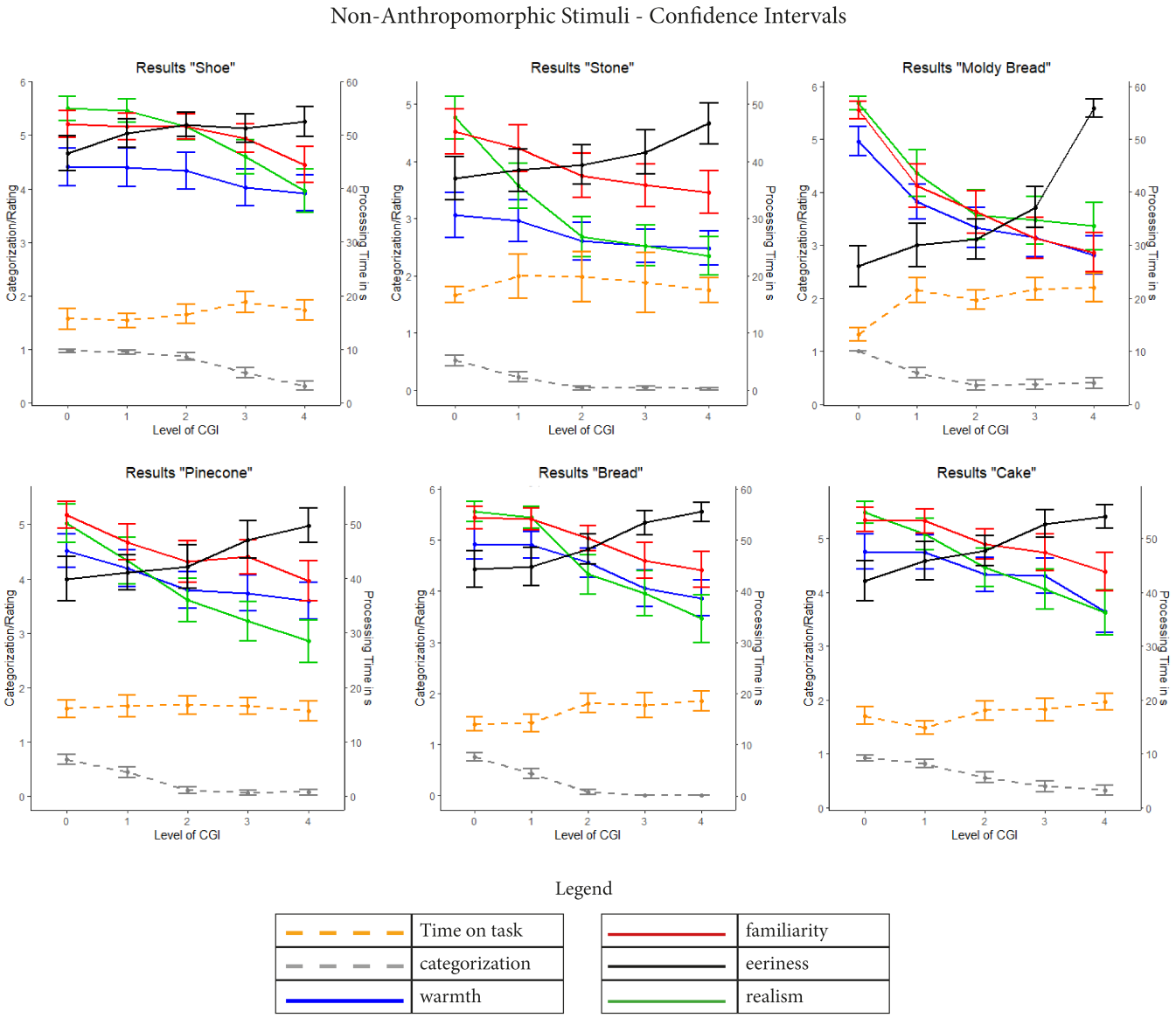

Figure 6: Plots for the non-anthropomorphic categories, containing errorbars for confidence intervals

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	Warmth				Familiarity			
Stimulus	t	df	p	d	t	df	p	d
Moldy Bread	2,92	47,5	0,078	0,51	3,44	47,5	0,04	0,67
Cake	1,66	48,75	0,408	0,26	1,59	48,75	0,315	0,23
Male Face	2,07	48,25	0,076	0,39	2,26	48,25	0,232	0,41
Dog	0,18	49	0,024	0,06	2,1	49	0,13	0,39
Female Face	1,24	50,5	0,362	0,2	1,92	50,5	0,178	0,29
Bread	1,87	48,25	0,29	0,3	1,97	48,25	0,081	0,29
Shoe	1,21	47,5	0,347	0,15	1,28	47,5	0,436	0,2
Stone	0,8	48	0,588	0,15	1,28	48	0,274	0,24
Pineconde	1,5	48,5	0,218	0,24	1,66	48,5	0,281	0,27

	Eeriness				Realism			
Stimulus	t	df	p	d	t	df	p	d
Moldy Bread	-4,22	47,5	0,121	0,76	2,58	47,5	0,288	0,58
Cake	-1,78	48,75	0,176	0,26	2,81	48,75	0,013	0,44
Male Face	-1,96	48,25	0,386	0,35	4,42	48,25	0,007	0,82
Dog	-2,01	49	0,231	0,37	2,76	49	0,071	0,53
Female Face	-0,62	50,5	0,15	0,24	3,78	50,5	0,176	0,71
Bread	-2,4	48,25	0,069	0,33	3,02	48,25	0,039	0,56
Shoe	-1,11	47,5	0,363	0,18	2,25	47,5	0,198	0,4
Stone	-1,64	48	0,288	0,23	3,24	48	0,21	0,58
Pineconde	-1,53	48,5	0,257	0,25	3,21	48,5	0,121	0,57

Figure 7: Mean results of pairwise t-test for every stimulus