# AAU Semesterproject M.Sc Medialogy WS 17/18 Creating an interactive experience to teach teenagers about Dementia

**Sebastian Hansbauer**
Aalborg, Denmark
sehans17@student.aau.dk

**Artúr Barnabás Kovács**
Aalborg, Denmark
akovac17@student.aau.dk

**Jorge Villa**
Aalborg, Denmark
jvilla17@student.aau.dk

**Sorin Stefan Perlea**
Aalborg, Denmark
sperle14@student.aau.dk

## ABSTRACT
The condition Dementia is a growing healthcare problem in today's society, that not only affects the people living with it, but also their social circle. Children and teenagers often have problems understanding the behavioural changes that this condition entails. Therefore the aim is to disseminate knowledge about Dementia to young people and teenagers. This paper outlines and evaluates a new educational approach that enables teenagers to experience the symptoms of Dementia first-hand in an engaging, interactive and approachable way. The quantitative results indicate a distinct increase in identifying specific symptoms of Dementia as well as a raised awareness for the problems people with Dementia have to face, although the qualitative measurements yielded somewhat ambiguous results. However the user experience was perceived positively. The findings were discussed subsequently in terms of limitations and measuring difficulties, and possible further improvements to the application were given. In the end we contrast the game to other solutions, summarize the paper and address the applicability of our approach in educational environments.

### Author Keywords
Dementia, educational game, teaching teenagers

## INTRODUCTION
Groups like the *Alzheimer Association* and the *World Health Organization (WHO)* are providing valuable data on Dementia [16] [11]. At the time of writing, the number of people with Dementia is raising significantly. The estimated amount of Dementia cases in 2015 were 46.78 million which was around 0.63% of the total population. [20] By 2030 the percentage of Dementia cases will increase to 0.87%, and the same number in 2050 will be 1.34%. This means that by 2050 every 75$^{\text{th}}$ person will have a form of Dementia based on the referred estimations. [15] [20]

According to the Alzheimer's Association, Dementia is a degenerative brain disease that causes different symptoms during its progression.[15] Common symptoms are memoryloss *(Amnesia)*, communication issues caused by *(Anomia), (Aphasia), (Agnosia)*, coordination loss *(Apraxia)*, loss of motivation *(Aphaty)* and visual and auditory alterations in perception. [16] Impairments in these basic abilities have apparently a severe impact on the persons capability to manage their everyday life. [15]

### Teenagers and Dementia
The Mental Health Foundation (MHF) points out that teenagers who have close relatives with Dementia often experience feelings like "confusion", "frustration" and "embarrassment", because they do not understand what happens to their loved ones and what causes the changes in their behaviour. [18]

As the number of people with Dementia is increasing considerably, the chances teenagers meet elderly, diagnosed with a form of Dementia, will raise too [17]. Therefore teaching them about the implications of this condition is important in order to enable them to interact more naturally with people with Dementia.

In order to provide insight on how the different physiological and psychological symptoms affect the lives of people with Dementia, we decided to simulate the symptoms and emotional implications in the form of an interactive experience.

### Related solutions
The question at hand is; How to teach children and teenagers about Dementia through an engaging experience?

Therefore a number of akin games and experiences are introduced in this section to give an overview about recent related implementations in this topic.

*"Into D'mentia"* [3] is a project done by a research and advisory bureau called Minase, which developed the concept at the end of 2012. The project was received positively and by the year 2013 more than 1000 completed the training. In this project the user can experience the life of a person with Dementia during some fragments of

their daily life. *"Into D'mentia"* provides caregivers with a better understanding of how persons with Dementia experience the world around them.

Another mentionable project is *"Forget-Me-Knot"* [23] a first-person, narrative-driven computer game that lets the player immerse into the perspective of an elder person with Alzheimer. During the game the symptoms are partially revealed through the environment and the avatar's audible thoughts.

*"Alz"* [4] is a short, online, side-scrolling game that features an artistic representation of Alzheimer's. The game focuses on giving an impression of the confusion that accompanies Alzheimer's rather than presenting specific symptoms.

Furthermore *"Depression Quest"* [14] is a valuable inspiration for this project. The text-based game feels like an "interactive book" with detailed descriptions of events and the player's mental state. It takes the players choices into account which affect the story line of the game.

In the following this paper explains the steps from developing and executing the main experiment in section 2 to displaying the obtained results in section 3 followed by their discussion, interpretation and further improvements for the developed solution in section 4. Last but not least, section 5 highlights the differences of the game to other solutions, rounds up the paper and looks into its appliance to educational environments.

## EXPERIMENT

The goal of this experiment is to develop and analyze an interactive and engaging teaching experience in order to disseminate knowledge about Dementia to young people and teenagers.

This chapter describes the main experiment starting with the user study that was conducted in section 2.1, the choices that were taken into account for designing the experience 2.2, and the evaluation procedure in section 2.2.

### User Study

First a user study was conducted in order to gather information about the target group, composed of teenagers aged from ten to eighteen.

Therefore twenty pupils from an international high school were asked to participate. Their age ranged from fifteen to eighteen years.

Unfortunately the participants age range is a small limitation to the user study, as it is situated at the upper age boundary of the target group and therefore does not represent the whole age range.

The participants received a link to the online questionnaire which they had to complete on their own media devices.

The user study started with a section about the housing environment and daily tasks of the target group. This information was required to better relate to the users and design the level and game elements accordingly, to make it easier for them to familiarize with the game world. It was revealed that ninety percent of the participants have a room for their own in their homes. However, the number of rooms in their homes were widely spread, with four as the most common result. Further the participants stated, that they either go out to meet friends or stay at home in their freetime. The most common everyday task among the participants was cleaning at home and studying. These tasks were also present in the description of their typical days. The common recurring pattern contained "waking up", "breakfast", "school", "home" and afterwards "homework" and or "friends".

The next section of the questionnaire was about the existing knowledge about Dementia. Interesting was how the participants gauged their own knowledge about the disease. Fifty percent choose "very bad knowledge" which shows that Dementia is not a big topic at this age. This impression is affirmed by the follow up question, where they should state something, they know about this condition. The majority of the answers where "nothing".

Last but not least the participants gaming experiences and preferences where assessed, in order to extract features that make a game more appealing to the target group. Forty-five percent stated, that they play less than fifteen minutes a day, which means the game controls should be designed in way that is also suitable for non gamers. As favorite games, a variety of different genres were mentioned, for example First Person Shooter (FPS), Multiplayer Online Battle Arena (MOBA), Adventure and Smartphonegames. The participants stated that they have access to laptops (86%), Iphones (70%) and Smartphones (40%). Further the questionnaire revealed that freedom was the most valued trait in games with twenty-five percent, followed by the storyline with twenty percent.

The gained information from the user study will be used in the next section to back up decisions in order to design the experience.

### Design of the experience

The events of the game take place inside a house in which the avatar lives. The house has one bigger sized area where the living room is located with an open-plan kitchen. There are four other rooms which are all separated through walls from each other and other parts of the house. These rooms can be accessed from a hallway. Figure 1 was taken looking from the living room towards the hallway.

The game is structured in a way that lets the player experience a gradual decline in cognitive abilities in order to replicate the progression of Dementia. To successfully simulate this, it was needed to make sure that the player knows what is considered to be normal in the realm of the game. In this regard the main structuring element in the game is a day. Table 1 gives a quick overview of

**Figure 1. Screenshot exhibiting the house structure**

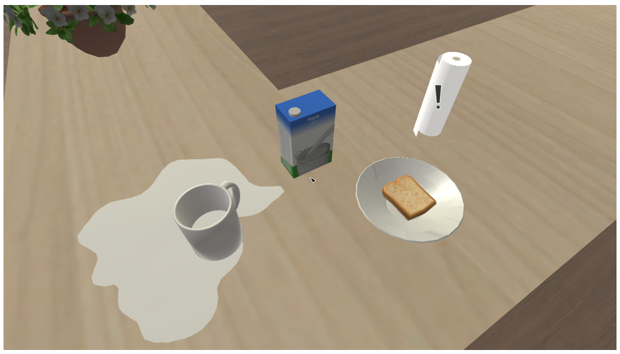

**Figure 2. An image from the game showing the spilled milk, and the highlighted paper towel.**

| *Day* | *New symptom (event)* |
|---|---|
| 1) | — |
| 2) | apraxia (pouring milk) |
| 3) | agnosia (mistake a lent object for an other) |
| 4) | — |
| 5) | amnesia (cabinets shuffled) |
| 6) | — |
| 7) | anxiety (rooms shuffled),<br>altered perception (tunnel vision) |
| 8) | altered perception (voices),<br>anomia (unable to name backpack) |
| 9) | apathy (has no motivation to go out) |
| 10) | — |

**Table 1. Overview of days indicating the symptoms which first appear at that day**

how the appearance of different symptoms is scheduled. The experienced symptoms may change from one day to another, but not during a single day. To get the player used to the environment, the symptoms are not strongly present during the first four days. Furthermore the player is presented with the same tasks that must always be executed in the same order on these days. During this time, the game guides the player carefully by highlighting the next object that should be interacted with and displaying an exclamation mark on the screen, directing the attention of the viewer towards the highlighted object. Some of these days also involve short conversations with the avatar's friends. The chatters on the first four days happen at different times providing a way to keep the player engaged while the same actions being repeated. The aim of repeating the aforementioned tasks on the first three days is to establish a sense of routine in the player. On the fourth day the tasks are still the same, and there are no changes in the environment, but starting from this day, the objects are not highlighted any longer. It is worth mentioning that there is a slight hint to one of the symptoms (agnosia) that is revealed in a conversation with the avatar's friend during the third day, but this should not disturb the procedure of creating a routine and familiarizing the player with the house.

*Apraxia* starts to become noticable with the first task of the game as pouring milk gets harder day by day. Using a vertical slider the player can affect the angle at which the avatar holds the box while pouring the milk, thereby controlling the flow rate. Although the position of the vertical slider does not directly correlate to the flow rate. We add a time-dependent Perlin noise to the value obtained from the slider to produce a value which gets translated to a flow rate. Unity's `PerlinNoise` [24] function was used for this purpose. The frequency and the amplitude of the noise is set for each day in such a way that a gradual loss of coordination can be simulated. The challenge in this task is keeping the flow rate under a certain level to prevent the milk from spilling. A minimal flow rate would not cause the milk to spill but it would greatly increase the time it takes to finish this task, motivating the player to try to pour the milk at a faster rate, risking the spill. When a certain amount of milk has been spilled, the game forces the player to stop, use the paper towel (clean spill), and carry on afterwards, as it can be seen on Figure 2. Another aspect of apraxia can be noticed by not being able to walk straight or keep balance. To achieve this, we again add a time-dependent Perlin noise to the yaw and pitch of the camera. Conveniently the aforementioned `PerlinNoise` [24] function has two-parameters so the yaw and pitch can be manipulated independently by plugging the time in the first argument and leaving the second as zero for yaw, and the same arguments swapped for pitch.

*Agnosia* is not clearly present in the game however as it was stated before, there is a slight suggestion of this symptom early in the game, on the third day. If the player encounters this piece of conversation by selecting a certain response during the conversations, this would be the first apparent sign that something unusual is happening to the avatar.

*Amnesia* is probably the most prominent characteristic of Alzheimer's disease which is the most common disease among Dementia.[16] This is why several of the phenomena experienced in the game demonstrates a type of memory failure. The first time the player encounters the effects of amnesia happens on the fifth day. The cabinets change their place. The kitchen environment presents four closed cabinets at the beginning of each day, with three of them locked. In the open cabinet, the player has


**Figure 3. A conversation in game, where the characters talk about the movie for the first time**

to put the interactive plate and mug after performing the milk pouring task. On the fifth day the game switches the cabinets around: a different cabinet is unlocked. The same principle is used with three other phenomena in the game. One is the rooms changing position in the house. This is very similar to the cabinets changing their order, but at a larger scale. As it was stated earlier, the player has to pick up the backpack before going to school. Another way how memory loss is simulated in the game is by changing the position of the backpack in between the days, as if the avatar put it to different places. The player however does not remember this, because the backpack needs to be placed at the same spot every day. The final phenomenon for demonstrating amnesia is a certain topic, that comes up twice during the game. More specifically the avatar agrees with their friends on going to cinema to watch a particular movie. When this topic comes up the second time, the conversation suggests that it actually has never been discussed before. 3

This also leads to indications of *anxiety* displayed by the avatar through their responses. The day when the player first encounters the shuffled rooms the phone is immediately taken out to reach for the avatar's mother. The player can choose between three different sentences. The first two clearly show shock and fright, while the third one is seemingly less serious. The reply of the mother for all possible messages show that she recognizes the severity of the situation.

This day is also the first time *altered perception* appears in the form of a slight tunnel vision. This symptom continuously gets worse each day of the game until the ninth day. The tenth day is the final one where the effect is reduced to have a less chaotic ending. On day eight the player starts hearing voices as another form of altered perception.

A sign of *anomia* is displayed on the eighth day. During a conversation the avatar means to write "I just have to drop off my backpack" but is unable to find the word for backpack ending up describing it to their friends.

On day nine *apathy* surfaces. The friends ask the player to go out with them on the following day but the avatar rejects the offer. The friends express all their support in the following messages, showing the player the importance of support from others towards a Dementia patient.

In order to reach a wide target audience, a strong emphasis was kept on platform independence. Although at the time of writing this paper the game was only tested with desktop operating systems (Windows, Mac), the controls and the game mechanics allow it to be ported to smartphones, and virtual reality with almost no differences in the way the game works. However the user experience (UX) might change with different input methods but that would mostly if not only be caused by the fundamental differences between these platforms. The reason why the authors think this is possible is because a decision was made to constrain the player controls to be very simplistic. The player can look around while the moving is point-and-click based. The interaction with the objects is made by aiming towards the objects of interest and pressing a button, lastly the user being able to use the in-game smartphone, which shows different conversations and messages that are valuable in the learning experience. These are all the possible actions that the player can do in the game. These functions are very few compared to an average game that is made solely for entertainment and usually assumes experience in computer gaming. This leads to the second advantage of having simple controls which could be learned easier by the player, which is especially important when taking into account that forty-five percent of the user group have less frequent experiences with games.

It might be worth noting that we faced technical difficulties with the lighting, this is why we had to resort to a much less realistic, much less polished look regarding lighting.

In the end of the development process the title *The 5 A's* was chosen for the game in order to refer to the group of symptoms that are present in the experience without immediately unveiling the topic of the experience.

## Evaluation of the experience

This section explains the evaluation process that was used to analyze the experience described in the previous section 2.2. In order to evaluate whether the experience meets the goal highlighted at the beginning of section 2, it is divided in two separate parts.

Firstly, to assess the teaching potential of the experience, we measured the actual knowledge about symptoms of Dementia that participants gained after trying *The 5 A's* experience opposed to a control group who did not. The benefit with this design is, that each participant is only tested once, therefore effects like fatigue, practice and experience that could skew the results are getting mitigated. In our case, we can assure that the participants saw the questionnaires the first time and thus did not have prior experience about the topic of the questions from another assessment. This experiment method is referred to as *independent measures design.* [22]

Secondly the perceived user experience was assessed after playing through *The 5 A's.*

More than thirty English speaking pupils and students took part in the evaluation process. They were split in an evaluation group (EG) which consists of fifteen people from an international dormitory in Denmark, who were all aged between fifteen and twenty-six. And the control group (CG), which is also made up of sixteen international pupils and students between seventeen and twenty-six from Denmark, Poland, Hungary, Germany and Romania.

The basis of the evaluation was the educational experience, *The 5 A's.*

Participants of the evaluation group had to fill out a consent declaration form in the beginning and then experienced the whole *5 A's* until the very end. Afterwards an online questionnaire was opened that the EG had to fill out. This questionnaire contained three sections.

In the first section the participants knowledge about Dementia is gathered through a series of questions that on one hand asked about specific symptoms of Dementia through binary check-boxes and on the other hand featured open questions about situations they think people with Dementia have problems with (Q1) and how they could help them in these situations (Q2).

The second section is about general feedback of the experience. How they perceived the duration of the experience, whether they think they have learned something valuable and about how likely they would recommend the experience to their friends.

Finally, in the third section, the participants perception of the experience is evaluated by utilizing the *AttrakDiff* [2] method. This can be used to measure quality aspects that exceed the fundamental usability of software. Therefore not only the pragmatic qualities (PQ) were taken into account but also the hedonic qualities (HQ).[6] For this the *AttrakDiff* uses a number of 7-point scales each featuring two contrasting adjectives, for instance "unpleasent" and "pleasent". The participants then had to select what they consider the most appropriate description for the experience of each word-pair.

The control group however had to do a shortened version of the questionnaire containing only those questions from section one that relate to their knowledge about Dementia. As they have not tested the full experience there is no need to ask the other questions.

The procedure for the evaluation group of the experiment took place in an international dormitory in Denmark. The setup consists of two workstations where the participants sit facing each other, in order to allow simultaneous evaluation to increase the evaluation efficiency. Both workstations had mouses and headphones attached and were running a version of *The 5 A's.* The facilitators were on the opposing side of the room to be available in case of problems but with enough distance to minimize distraction of the participants. The control group on the contrary only received the questionnaire as an online link, thus we can not verify their environment.

Qualitative data was obtained through analyzing the online questionnaires. Hence from section one of the questionnaire a general as well as a specific percentage per symptom for the correct answers can be computed. The user experience section provides the hedonic qualities (HQ), which is separated into the interaction part (HQ-I) and the stimulation part (HQ-S), and the pragmatic qualities (PQ) of the experience. Other quantitative data was gathered in form of logging files containing the camera direction (forward vector) for each frame, the avatar position after each movement, and any "interaction" with game-objects. The time as reported by Unity's `Time.timeSinceLevelLoad` [25] was recorded for all log entries.

From the logging files, knowledge about technical and story line problems, that negatively affect the user experience, can be conducted. The hedonic and pragmatic qualities of the experience are used to infer the users engagement and perceived practicability of the experience. Overall we reckoned that the user experience would be perceived positively. And we expected that the percentile knowledge about Dementia will be significantly higher among the evaluation group as a result of the experience compared to the control group. Additionally we supposed to find cues within the semantic phrasing and the content of open text question, that indicate a better understanding and awareness for the problems people with Dementia have.

## RESULTS

This section displays the results we obtained from the experiment described in section 2.3.

Table 2 shows a comparison between the evaluation group and the control group. The value at each specific symptom indicates the percentage of participants who *correctly* recognized if the particular symptom is related to Dementia or not. Note that some of the entries are written in bold. These are symptoms which are certainly encountered by a player in game.

Since the data was collected in a binary format and only later was transformed into continuous numbers there is no scientifically method to reliably check whether it was generated by a baseline normal distribution. However Albert and Chib [1] proposed a method that uses a Bayesian analysis in order to augment the data that caused it. This could be an approach to check for the baseline normal distribution in retrospect.

Nevertheless a paired t-test was applied to determine whether there is a statistically significant difference between the two datasets. (Matlab's `ttest` [9] function was used to obtain $p$) As shown in table 3 the calculated

| *Description* | *CG (n = 16)* | *EG (n = 15)* |
|---|---|---|
| **Apraxia** | 43.80% | 86.70% |
| **Amnesia** | 100% | 93.30% |
| **Altered perception** | 50% | 86.70% |
| **Orientation loss** | 43.80% | 86.70% |
| **Anomia** | 56.30% | 60% |
| **Communication** | 37.50% | 53.30% |
| **Limited vision** | 6.30% | 53.30% |
| **Object misplacement** | 25% | 60% |
| **Anxiety** | 37.50% | 60% |
| **Apathy** | 25% | 53.30% |
| **Forgetfulness** | 25% | 53.30% |
| Headache | 93.70% | 80% |
| Color blindness | 93.70% | 73.30% |
| Agnosia | 50% | 53.30% |
| Limited speaking | 31.30% | 33.30% |
| Heavy sweating | 93.70% | 93.70% |
| Dizzyness | 87.50% | 46.70% |
| Reading problems | 87.50% | 80% |
| Agitation | 12.50% | 40% |
| Depression | 87.50% | 43.30% |
| Diarrhea | 100% | 100% |
| Boldness | 100% | 100% |
| Sleeping problems | 81.20% | 80% |
| Altered personality | 43.80% | 40% |
| Phantom pain | 100% | 100% |
| Innapropriete behaviour | 18.80% | 33.30% |

**Table 2. Success rate in determining symptoms' relation to Dementia**

| *Description* | *CG (n = 16)* | *EG (n = 15)* |
|---|---|---|
| *All symptoms* | | |
| Mean | 60.42% | 68.28% |
| Standard Deviation | 32.50% | 22.55% |
| p-Value | -> | 0.0956 |
| *Featured symptoms* | | |
| Mean | 40.93% | 67.87% |
| Standard Deviation | 24.10% | 16.57% |
| p-Value | -> | 0.00037 |

**Table 3. Measures derived from success rate in determining symptoms' relation to Dementia**

mean of the control group is 60.42% and the standard deviation is 32.50%, while the evaluation group shows a mean of 68.28% with a standard deviation of 22.55%. After performing the paired t-test, the $p$ value is 0.0956. With $\alpha = 0.05$ as established border, it is apparent that $p > \alpha$ therefore the difference between the two conditions is not statistically significant.

After that the symptoms where narrowed down to the symptoms that were actually featured within the experience. As table 3 reveals in the last section, this decision improved the p-value. With $p = 0.00037$ it becomes true that $p < \alpha$, which indicates a statistically significant difference between the evaluation and the control group.

| *Description* | *CG (n = 16)* | *EG (n = 15)* |
|---|---|---|
| Avg. word count Q1 | 7.8 | 10.6 |
| Avg. word count Q2 | 6.0 | 17.3 |
| *Semantic text analysis (STA)* | | |
| Positive words Q1 | 0.192% | 0.113% |
| Positive words Q2 | 0.250% | 0.204% |
| Negative words Q1 | 0.032% | 0.037% |
| Negative words Q2 | 0.010% | 0.012% |
| *STA - no determiners* | | |
| Positive words Q1 | 0.261% | 0.148% |
| Positive words Q2 | 0.375% | 0.310% |
| Negative words Q1 | 0.043% | 0.050% |
| Negative words Q2 | 0.016% | 0.18% |
| Avg. Score Q1 | 1,562 | 1,933 |
| Avg. Score Q2 | 1.125 | 2.267 |

**Table 4. Results of the text analysis of the open question for the cg and the eg**

Qualitative data was collected from the open-ended questions Q1 and Q2 of section one of the questionnaire 2.3 and processed into a presentable format. In table 4 the answers show a noticeable difference in the average word count between the two groups.

Wilson wrote about subjectivity and sentiment analysis in order to recognize the intensity, polarity, and attitudes of private states. In the mentioned work, sentiments are defined as positive and negative emotions, evaluations, and stances. [26] We wanted to carry out a similar approach to analyze the used language in order to draw conclusions about the participants mindset towards people with Dementia. However due to the limited data a less complex approach was chosen. Therefore a set with over 6000 positive words [13] and over 4500 negative words [12] was used to evaluate their occurrence. This was implemented with a Python script (Appendix .2) that calculated the percentile appearance of these within the answers. In order to get more meaningful results, many of the English determiners [10] were filtered out beforehand alongside with other words that are irrelevant for the semantical analysis. (Appendix .1) These results are displayed in table 4 as well.

It is remarkable that the control group showed seemingly better results than the evaluation group, in terms of positive language (higher percentage of positive words and lower percentage of negative words).

However the authors subjective impression was that the answers of the evaluation group seemed to be more concrete and applicable. For instance one participant wrote: "By reminding them what has been told in previous conversations, not forcing them to socialise if they need to have more space and being diligent to make them comfy.

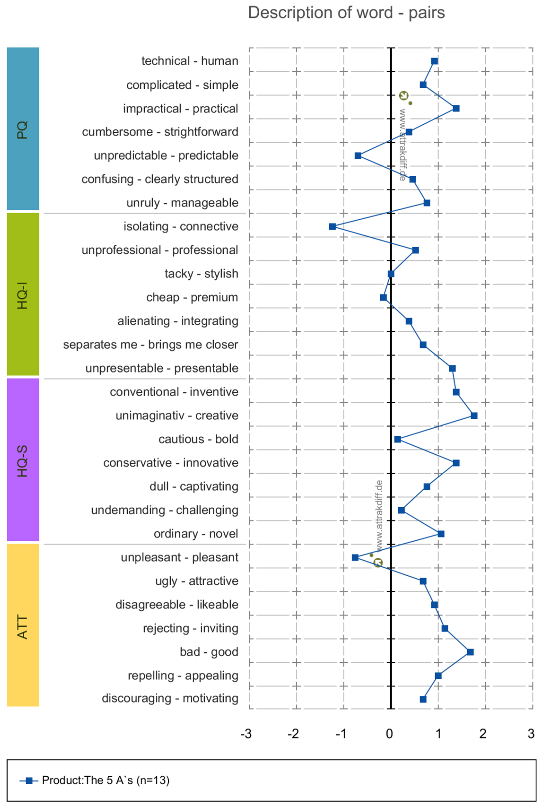


**Figure 4.** ***The 5 A's*** **AttrakDiff word-pairs**

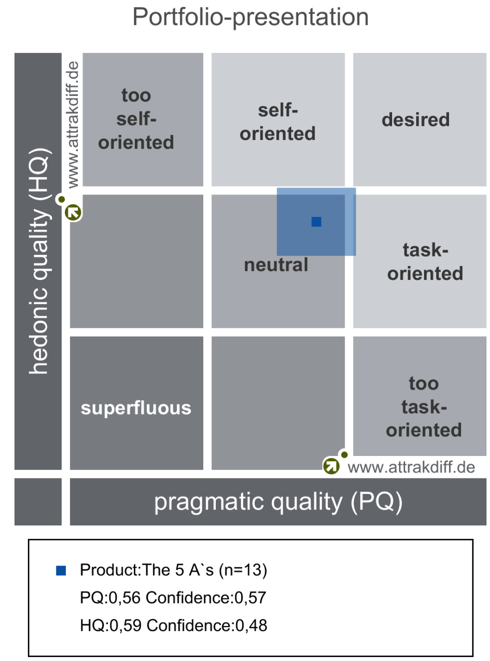


**Figure 5.** ***The 5 A's*** **AttrakDiff classification**

When taking transportation if they feel lost or do not have what to do to take a train, the workers at the airports and the train stations should have an specific procedure to deal with people with Dementia". To further evaluate this, a measurement score per answer was introduced. An answer to Q1 was given a point for each example situation whereas an answer to Q2 was given a point for each proposed solution and another point for each solution where an explanation was added. The comparison in table 4 shows that with this unit of measurement the evaluation group scores better than the control group.

Based on these results, the actual knowledge gain about Dementia and the increase in awareness will be further analyzed in the Discussion section 4.

Figure 4 shows the distribution between the AttrakDiff word pairs assessed in the user experience questionnaire. The colored boxed on the left side group the pairs to their specific domain, namely the pragmatic quality (blue), the identity (green) and the stimulation (violet) part of the hedonic quality and the interactivity (yellow). The calculated average values for these domains are 0.56 for the PQ, 0.22 for HQ-I, 0.97 for HQ-S and for the ATT 0.77. Especially relevant are the rows that notably differ from the neutral position marked with the thick grey line in the middle.

In figure 5 the experience was classified by the AttrakDiff method in terms of hedonic quality (y-Axis) and pragmatic quality (x-Axis). Thus the right top is the desired area as it indicates an enjoyable and at the same time useful product and the bottom left is the opposite, it is superfluous because it is unpleasant and not useful; thereby the center represents the neutral position in between. The dark blue box represents the center of *The 5 A's* surrounded by the light blue confidence interval.

Some of the log files got corrupted during testing, so the log analysis was done on the eleven seemingly sound logs. The first observations were made on the camera rotation. As no relevant trends or patterns were visible, the authors decided to exclude the camera rotation from further analysis. As it was stated earlier, the camera direction is recorded at each frame. This makes the log files practically impossible to be examined manually. Therefore the next step was creating a small program that removes all the camera directions from the log files. This enabled further investigations by means of merely looking at the logs through a text editor. Early in the design process the authors made the assumption that the users will learn the routine in the course of the first three or four days of the game. This is important because on the fifth day the cabinets in the kitchen get shuffled to simulate amnesia. It was assumed that maximizing player confidence towards the daily tasks results in greater surprise and confusion when the routine is artificially disrupted and thus results in greater increase of empathy towards Dementia patients. Processing the logs with another custom written program the source code of which can be found in the appendix at .3. This program reads in all the log files (one file per test subject) and counts all interactions with the cabinet doors until the dishes

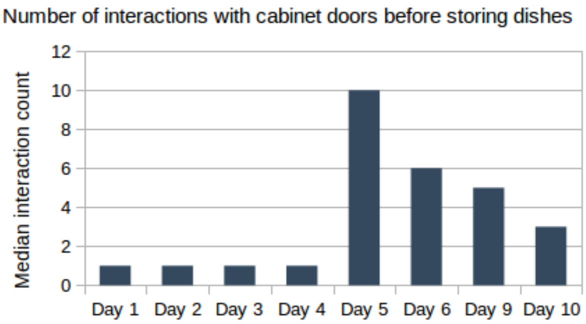


**Figure 6. Median of number of interactions (clicks) with cabinet doors before placing the dishes inside the correct cabinet.**

are put inside the appropriate cabinet. Interactions with the cabinet doors that happened after the dished were put away, are not taken into account. The program counts these for each day, and writes these numbers to the standard output. This output is then copied to Libre Office Calc, where the median is calculated using the `MEDIAN` [5] function. This is then visualized within Calc, producing Figure 6.

## DISCUSSION

One limitation of the evaluation process regards the age of the EG and CG, which does not exactly comply to the user group described in section 2.1. The users that have tested the game were between seventeen and twenty-six years old, therefore, they did not represent the same age as the pre-established target group. More important is that the age could affect the results of both of the questionnaires, as an average nineteen year old person possibly knows more about Dementia than a fifteen to eighteen year old. On the other hand, the ages were almost the same among the control group and evaluation group, supporting the validity of any positive difference in the results between the two groups.

The posed problem- “How to disseminate knowledge about Dementia to young children and teenagers?” -was addressed by creating an interactive game that would show the user what a patient diagnosed with Dementia is going through. As shown in section 3 there is no statistically significant difference between the two user groups, with all symptoms taken into account. However there is a statistically significant difference when only those symptoms were observed that are distinctly presented in the game.

It is apparent that the game is able to teach a significant amount from the symptoms that it presents. Although the intriguing question is the following: What causes the p-value to increase and the statistical significance to decrease when questions from the questionnaires that are not covered by the game are added to the t-test calculation? It is known that the other symptoms are not shown in the game therefore the players receive no additional knowledge about them. The test subjects would give identical answers on average for questions requiring knowledge that was not offered by the game. So from the viewpoint of the t-test any question that is expecting knowledge that was not offered by the game, just artificially moves the two data sets closer to each other, because the individuals from the two groups give similar answers to these questions, thereby seemingly decreasing the statistical significance.

As it was presented at the end of the section 3, some of the symptoms that occur to a diagnosed Dementia patient had a big percentage difference in the two groups: Apraxia, Altered perception, Orientation loss, Agitation, Limited vision. In this case, the interactive game played a very important role in sharing knowledge to the user group. In the CG, the above-mentioned symptoms were rated lower, because of the lack of knowledge that the CG had towards Dementia, without having the play-through of the game. The EG presented major difference within the percentages of right answers in the narrowed cases.

The results of the text analysis in table 4 show no sign that the evaluation group used a more positive language when thinking about problems and suggesting support for Dementia patients compared to the control group. Based on the used semantic language no conclusions could be drawn that the EG displays more empathy towards people with Dementia than the CG. In fact as stated in the 3 it seems to be the other way round. On possible explanation for this observation is the difference in the word count between the to two groups. As the evaluation groups tends to answer in longer and more complete sentences the evaluation group often used very short descriptions or even only words. Thus the amount of filler words required to build a sentence distorts the semantic keyword to word ratio. Even the attempt to mitigate this influence by removing the words, that were irrelevant for the semantical analysis, had only a minor effect.

For that reason the answers were compared by hand with the subjective measure of how applicable and concrete the answer was. This way the evaluation group did better than the control group. This could be an indication that as a result of experiencing how certain symptoms actually feel, the participants were able to identify the generic problem domains that go way beyond the scope of the experience and therefore easier find examples and solution that also fit to this generic problem domains. For example they experience orientation problems in their own house, which leads them to think Dementia patients generally have orientation problems, which therefore also applies to situations where orientation skills are needed, like for public transportation. However, it should be taken into consideration that the worse score of the control group, compared to the evaluation group, could be the result of less motivation to answer the questions properly, because they did not have the same context to the topic and different test conditions.

Regarding the user experience the AttrakDiff method provides a valuable indicator how the users have perceived the experience. According to Hassenzahl et. al [8], the importance of the pragmatic quality is influenced by the way, the software is used. The more taskoriented an application is utilized, the more important the pragmatic quality becomes. The hedonic quality, however, always influences the perceived appeal of the software. [7] Since *The 5 A's* features components that are taskorientated, like following the established routine 2.2 with its exact order, it is important to take both qualities into account, when the results are analyzed.

As the figure 4 shows, there are noticeable tendencies between several word-pairs. Remarkable are the three negatively rated attributes: unpredictable, isolating and unpleasant. In retrospective it is not surprising, that these attributes where chosen, for the fact, that the experience intendedly contains elements that make the user feel like that, in order to simulate the symptoms of Dementia. Focusing on the most positive ratings, the users perceived it as a practical, creative and good experience. This and the overall positive trend towards to the desired area, depicted in figure 5, leads to the conclusion that the majority rated the user experience positively. This is also reflected in the questionnaire, where 87% stated that they would recommend this experience to their friends.

However, the actual user experience seems to be not as engaging, as it was desired to be, as the calculated position within the HQ and PQ dimension is still in the upper neutral area. That could be either, because of the design or the topic of the experience, which probably leaves mixed feelings within the participants. But it is without doubt, a valuable experience that lets the user earn their knowledge about Dementia.

The results of the log file analysis in figure 6 indicate that the game was able to successfully establish a routine in the player. On the first three days the median interaction count on the cabinet doors was one, with the objective highlighting enabled. The same median interaction count was also recorded on day four, though the object highlighting was deactivated. At this point the players seem to know exactly what they have to do in order to accomplish the task. However, on day five the routine is disrupted by the first occurrence of severe Amnesia. The openable kitchen cabinet was moved so that the players could not find it anymore. Therefore they started clicking on the familiar but now locked cabinet. Upon realizing that it is not going to open, they soon began checking out the other cabinet doors, until they found the correct one. During the following days this effect was not that visible, because the players were now aware that the cabinet doors may change and therefore sooner started checking out the other doors. In the last day there was a slightly bigger drop in the median interaction count, which could be correlated to the introduction of green markers that are used to guide to the correct cabinet door. The reason that it is still not as low as on the first few days, probably lies within the curiosity of the players that opened and closed the green door and still checked out the other ones.

One thing that should be addressed in future versions of *The 5 A's*, is the design of the beginning, which should be more exciting and appealing to get the user hooked, until the message of the experience could be conveyed. This could be done through gamification of different events in the game. A good overview over gamification methods in education, is given by Seaborn and Fels [21]. Based on this one option would be, to make the tasks inside the game more transparent and check them in a visible appealing way, to signalize completion and introduce a star rating to the milk minigame, that indicates how well the player filled up the mug in order to induce motivation to do better the next time.

## CONCLUSION

There aren't enough adequate tools to teach children and teenagers about Dementia. The biggest goal of this study was, to create such a tool, a game that is not just informative but engaging at the same time. In contrast to the other solutions mentioned in section 1, this approach combines elements of narrative storytelling with the possibilities of simulations to create an experience that is directly targeted to teenagers by featuring elements, they can relate to. The game is embracive enough, to not only inform about the psychological effects of Dementia but also the psychological side and furthermore, it is able to show the progress of this condition to some extend.

As section 3 shows it is clear that our game can teach symptoms of Dementia, however, due to certain limitations, the evaluation was conducted on participants, who were not all representatives of our target group. The text analysis of the open text questions showed no indication for a changed mindset when writing about Dementia related problems, though, the subjective impression was, that the evaluation group wrote in a more applicable and concrete way about it. The user experience was measured with the AttrakDiff method that showed the pragmatic and hedonic quality of the experience in the upper neutral to desired area.

The results and the feedback provided lead us to think about additional appliance of this game in educational environments, like classroom settings or workshops. Moursund [19] writes about helping children learn, through the use of games and mentions the approach of situated and one-trial learning, which applies to our experience. This can be superior to common static teaching methods in classrooms, due to the player is immersed in the environment of the game and thus stimulating Low-Road transfer of learning.

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## APPENDIX

### STA - irrelevant word list

The full list of semantically irrelevant words that was used for the text analysis in section 3:

```
the,
a,an,
this,that,these,those,
my,your,his,her,its,our,their,
a few,a little,much,many,a lot of,most,some,any,enough,
one,ten,thirty,
all,both,half,either,neither,each,every,
other,another,
such,what,rather,quite,
I,me,my,mine,myself,
you,you,your,yours,yourself,
he,him,his,his,himself,
she,her,her,hers,herself,
it,it,its,itself,
we,us,our,ours,ourselves,
you,you,your,yours,yourselves,
they,them,their,theirs,themselves,
the other,
and,or,to,
in,is,at
```

**Listing 1. STA - irrelevant word list**

### STA - Python implementation

The implemented Python script that was used in the text analysis in section 3:

```
#!/usr/bin/python

# -----------------------------------------------------------------------
# sta.py - script to perform text analysis based on word occourrence
# -----------------------------------------------------------------------
# usage: sta.py -i <inputWordFile> -s <searchWordFile> -f <filterWordFile>
#
# inputWordFile: input text file
# searchWordFile: file containing all search words for the analysis
# filterWordFile: filter words that are removed ahead of the analysis
# -----------------------------------------------------------------------

import sys, getopt
from collections import Counter

def main(argv):
   inputWordFile = ''
   searchWordFile = ''
   filterWordFile = ''
   try:
      opts, args = getopt.getopt(argv,"hi:s:f:",["ifile=","sfile=","ffile="])
   except getopt.GetoptError:
      print 'sta.py -i <inputWordFile> -s <searchWordFile> -f <filterWordFile>'
      sys.exit(2)
   for opt, arg in opts:
      if opt == '-h':
         print 'test.py -i <inputWordFile> -s <searchWordFile> -f <filterWordFile>'
         sys.exit()
      elif opt in ("-i", "--ifile"):
         inputWordFile = arg
      elif opt in ("-s", "--sfile"):
         searchWordFile = arg
      elif opt in ("-f", "--ffile"):
         filterWordFile = arg
```

```
    print "--- STA-Files ------------------------------------------"
    print 'InputWordFile:  ', inputWordFile
    print 'SearchWordFile: ', searchWordFile
    print 'FilterWordFile: ', filterWordFile

    with open(inputWordFile, 'r') as words:
     inputWords=words.read().replace('\n', ' ')

    with open(searchWordFile, 'r') as words:
     searchWords=words.read().replace('\n', '')

    with open(filterWordFile, 'r') as words:
     filterWords=words.read().replace('\n', '')

     # make list
     searchWords = searchWords.upper().split(',')
     filterWords = filterWords.upper().split(',')
     # strip inputWords
     for ch in ['&','#', ',','.','?','/','(',')',':']:
         if ch in inputWords:
             inputWords=inputWords.replace(ch,' ')
     inputWords=inputWords.replace('\'','') # trim it's
     inputWords = inputWords.upper().split()

     # filter inputWords
     inputFilteredWords = inputWords
     inputFilteredWords = [word for word in inputFilteredWords if word not in filterWords]

     inputWordsCounter = Counter(inputWords)
     inputFilteredWordsCounter = Counter(inputFilteredWords)
     findingsCounter=0
     findingsList=[]

     # search
     for inputWord in inputFilteredWords:
         for searchWord in searchWords:
             if searchWord == inputWord:
                 findingsCounter = findingsCounter + 1
                 findingsList.append(inputWord)
                 break

     findingsListCounter = Counter(findingsList)

     # comment in for additional output
     # ------------------------------------------------------------"
     # print "InputWords: " + '[%s]' % ', '.join(map(str, inputWords))
     # print "FilterWords: " + '[%s]' % ', '.join(map(str, filterWords))
     # print "InputFilteredWords: " + '[%s]' % ', '.join(map(str, inputFilteredWords))
     # print "SearchWords: " + '[%s]' % ', '.join(map(str, searchWords))
+,         # print "Common InputFilteredWords: " + '[%s]' % ', '.join(map(str,
    ↪  inputFilteredWordsCounter.most_common(15)))
     # print "Findings: " + '[%s]' % ', '.join(map(str, findingsListCounter.items()))
     # print "Findings: " + '[%s]' % ', '.join(map(str, findingsListCounter.most_common()))

     inputWordsTotal = sum(inputWordsCounter.values())
     inputWordsTotalFindingsPercentage = float(findingsCounter) / float(inputWordsTotal)
     inputFilteredWordsTotal = sum(inputFilteredWordsCounter.values())
     inputFilteredWordsTotalFindingsPercentage = float(findingsCounter) / float(inputFilteredWordsTotal)

     flcOutput = ''
     for value, count in findingsListCounter.most_common():
         flcOutput = flcOutput + ", " + str(value) + " (" + str(count) + ")"
     flcOutput = flcOutput.strip()[2:]

     print "--- STA-Results ----------------------------------------"
     print "Findings: " + flcOutput
     print "---> Findings count: " + str(findingsCounter)
     print "Word count: " + str(inputWordsTotal)
     print "---> Ratio: " + str(inputWordsTotalFindingsPercentage) + "%"

     print "Filtered Word count: " + str(inputFilteredWordsTotal)
     print "---> Ratio: " + str(inputFilteredWordsTotalFindingsPercentage) + "%"
```

```
if __name__ == "__main__":
   main(sys.argv[1:])
```

**Listing 2. STA - Python implementation**

### Log file processor

The source code for the program that processes the log files can be seen below. This program was referenced in section 3. The program was written in the Rust language. It expects that the names of the log files are passed in as arguments. On a Unix like environment the program can be executed the following way:

```
./program_name /path/to/all/log_files/*.log
```

The source of the program is the following:

```
use std::env;
use std::fs::File;
use std::io::BufReader;
use std::io::BufRead;
use std::path::Path;
use std::error::Error;
use std::string::String;
use std::result::Result;


struct Processor {
    log_name: String,
    line_num: i32,

    curr_level: i32,
    dishes_stored: bool,
    cabinet_inter: [i32; 10],
}

impl Processor {
    fn process_line(
        &mut self,
        line_result: std::io::Result<String>,
    ) -> Result<(), Box<Error + Send + Sync>> {
        let line = line_result?;
        let mut arguments = line.split(';');
        let _time = arguments.next().unwrap();
        let event_name = arguments.next().unwrap();
        match event_name {
            "loadedLevel" => {
                // "Levelii" <- ii (one or two charcters)
                // 5 characters preceede the level number.
                let level_num_string: String =
                    arguments.next().unwrap().chars().skip(5).collect();

                self.curr_level = level_num_string.parse::<i32>()?;
                self.dishes_stored = false;
            }
            "interaction" => {
                let _object = arguments.next().unwrap();
                let component = arguments.next().unwrap();
                match component {
                    "CabinetDoor" => {
                        if self.dishes_stored == false {
                            self.cabinet_inter[(self.curr_level - 1) as usize] += 1;
                        }
                    }
                    "StoreDishes" => {
                        self.dishes_stored = true;
                    }
                    _ => {}
                }
            }
            _ => {}
        }
```

```
        Ok(())
    }


    pub fn process_file(
        input_name: &str,
    ) -> Result<Processor, Box<Error + Send + Sync>> {
        let input_file = File::open(input_name.clone())?;

        let path = Path::new(input_name);

        let mut processor = Processor {
            log_name: String::from(path.file_name().unwrap().to_str().unwrap()),
            line_num: 1,

            curr_level: 0,
            dishes_stored: false,
            cabinet_inter: [0; 10],
        };

        let input = BufReader::new(&input_file);

        for line_result in input.lines() {
            if let Err(err) = processor.process_line(line_result) {
                return Err(From::from(format!(
                    "Error occured at line {}: {}",
                    processor.line_num,
                    err
                )));
            }
            processor.line_num += 1;
        }

        Ok(processor)
    }
}


fn path_to_str(path: &std::ffi::OsStr) -> String {
    String::from(path.to_str().unwrap())
}


fn main() {
    let cabinet_interact_days = [1, 2, 3, 4, 5, 6, 9, 10];

    print!("Log Name;");
    for i in cabinet_interact_days.iter() {
        print!("Day {};", i);
    }
    println!();

    for input_name in env::args().skip(1) {
        let input_name = input_name.as_str();

        let path = Path::new(input_name);
        let mut output_filename = std::path::PathBuf::from(input_name);
        let mut filename_str = String::from("mod_");
        filename_str.push_str(path_to_str(path.file_stem().unwrap()).as_str());
        output_filename.set_file_name(filename_str);
        output_filename.set_extension(path.extension().unwrap());

        match Processor::process_file(input_name) {
            Err(err) => {
                eprintln!("Error during the processing of '{}'", input_name);
                eprintln!("Error message was: {}", err);
                eprintln!("Moving on to next file.");
            }
            Ok(processor) => {
                print!("{};", processor.log_name);
                for i in cabinet_interact_days.iter() {
```

```
                print!("{};", processor.cabinet_inter[(i - 1) as usize]);
            }
            println!();
        }
    }
  }
}
```

**Listing 3. Rust code for processing the log files**