Games therapy, system insights and dementia, a first analysis

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Abstract

This study is exploring how to use systems analysis to explore the functionality needed in software using virtual reality and gamification technologies. The system of a person having dementia and its interaction with the support system and surrounding relatives. This was mapped using causal loop diagrams. The conclusion is that such a task would be possible. It will be discussed how this can be simulated and the simulation entered into a game engine, using soft-ware like UNREAL.

1. Introduction

This is a description of an innovation process focused on the use of tools and methods in gamification, animation and virtual reality. We have used systems analytical methods in the innovation process itself to map and understand causal relationships, find intervention points and to create a common understanding of what the need for innovation really is and how this should be solved. At the time of writing this joint document was Harald U. Sverdrup, on behalf of the group. If anyone sees something that needs to be completed, corrected or added, please write this directly into the document, tracking changes is not needed. This text continuously documents what goes on in the group modelling and workshops we have. Currently, this is arranged in chronological order. This will be reorganized continuously into logical arrangement. The image sequence below gives an impression of how the development of dementia manifests itself from the patient's perspective. This is a series of self-portraits painted by the British artist William Utermohlen, where the last five images describe his development towards a severe cognitive impairment over a period of four years. As can be seen from the images, the changes are about something far more than just a reduction of memory.

1967 1996 1997 1998 1999 2000

This series of images is an example of the type of symptoms and changes we believe can be presented in a more clarifying and fundamental way through simulations in VR.

2. Objectives and scope

The project has several parts that come in order. The overall task was to investigate what it would take to use game technology for developing a tool based on a combination of Virtual Reality (VR), Augmented Reality (AR), Game Technologies and systems analysis insights. The tool would be intended for training health care personnel and supporting relatives of people with dementia. Work to understand what the audio-visual tool should do, we need to understand the dynamics of dementia, what its progression looks like, and how the environment around the patient perceives what is happening. After that, we need to define the learning needs of the family and those involved in the immediate daily care of people with dementia.

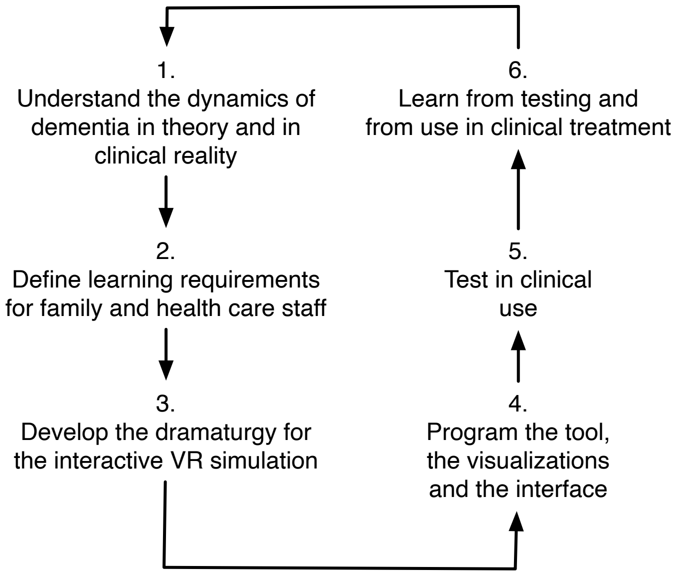

Figure 1. The project's workflow is iterative, to the point that the tool works well enough for practical use.

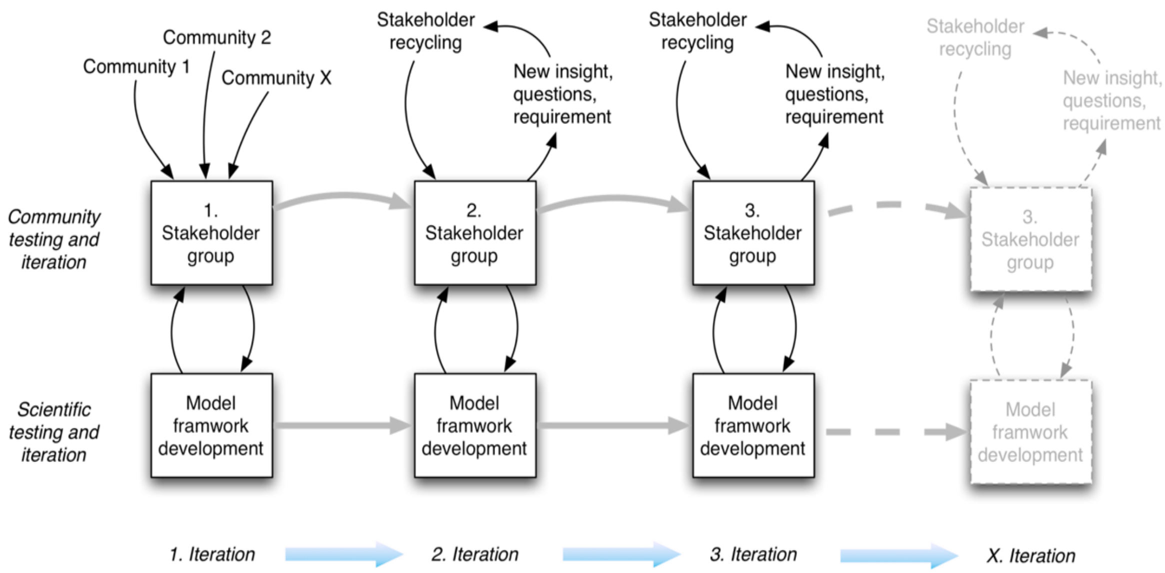

Figure 2. General overview of group modelling (Haraldsson 2004, Sverdrup et al., 2020, 2022)

3. Methodology

The standard tools of systems analysis, interactive learning workshops, causal loop diagrams and flow charts. Meetings arranged as group modelling in the form of workshops were held in the DemEX project on 3 October. June, June 28, 12. August 2020 and the 31. August 2020. with meeting at Spillskolen, Inland Norway University of Applied Sciences, Hamar (INN). The participants were: Marit Christine Berg Strandvik (Head of Department of Game School, INN), Bård Gunnerud-Åhlen (Head of Game School Studies, INN), Ståle Fredriksen (Senior Consultant, Geriatric Psychiatry, Innlandet Hospital), Elin Johnsen Liljehovde (Geriatric Psychiatry, Innlandet Hospital), Geir Kristian Lund (Researcher, Innlandet Hospital) and Harald Sverdrup (Professor of Systems Thinking, Game School, INN).

With the two pieces of knowledge in the baggage, then comes the development of the tool, the form of interaction, the dramaturgy (Figure 1). We need to plan how empathy and insights will be taught with the help of the tool. It will include elements of gamification, virtual reality (virtual reality, VR), augmented reality (AR), and computer-animated images computer animated graphics (CAG). Once that is done, we can program up tools and test it in a number of situations that we have to create. This is shown in Figure 1. There was a number of group modelling meetings to work out all the elements as shown in Figure 2. The method has been developed in previous projects and documented in Haraldsson (2004) and further explained in Sverdrup et al., (2022). Typical patterns of events in the treatment of dementia patients occur. One example is shown in Figure 3. We will retrieve a number of such chain of events from clinical activities. Daily functioning requires a chain of events to work, in dementia patients there are violations in one or more places. The group will map a number of such sequences of events.

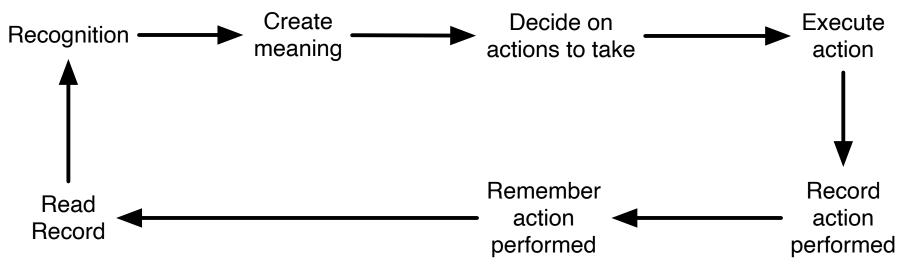

Figure 3. Chain of events for the cognitive process involved in a common event, where a problem arises for dementia patients. It shows what happens over time, but not why. The cause-and-effect diagrams should explain why.

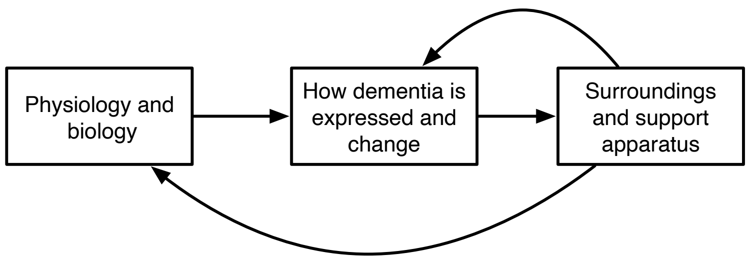

Figure 4. Physiology is involved in the inner causes of dementia. The dynamics and expression are what the outside world reacts to, relatives and caregivers react back against the expression, medical expertise against both expression and physiology.

4. Very short in dementia

There are have different types of dementia:

1. Vascular dementia
2. Neurodegenerative dementia (Alzheimer's etc.)
3. Frontal-lobe dementia
4. Trauma-derived dementia (Physical injury, overexertion, psychological overload)

All of these can occur simultaneously, and add up to erode the patents cognitive capability. Over time, the world may appear very different to the demented person, as compared to the unaffected. The outside world can (1) eliminate underlying or contributing disease, (2) generally strengthen health by enhancing healthy lifestyles, or (3) provide care to the person with dementia if we interpret Figure 5. Of the different types of dementia, some of them are reversible, while many are caused by irreversible damage. The brain can deal with damage in two basic ways, with three different outcomes.

1. There are physiological repair mechanisms, and the damage can be repaired. Possibly with some medical assistance. Exercise and treatment help Then the damage is reversible.

2. The damage is irreversible, but the damage can be compensated for by functional relocation in the brain or by retraining in a healthy centre in the brain. Exercise and treatment help. The damage can be compensated as long as there is sufficient available capacity and learning ability.
3. The damage is irreversible, but the learning ability is not sufficient or there is no available brain capacity. The damage cannot be improved.

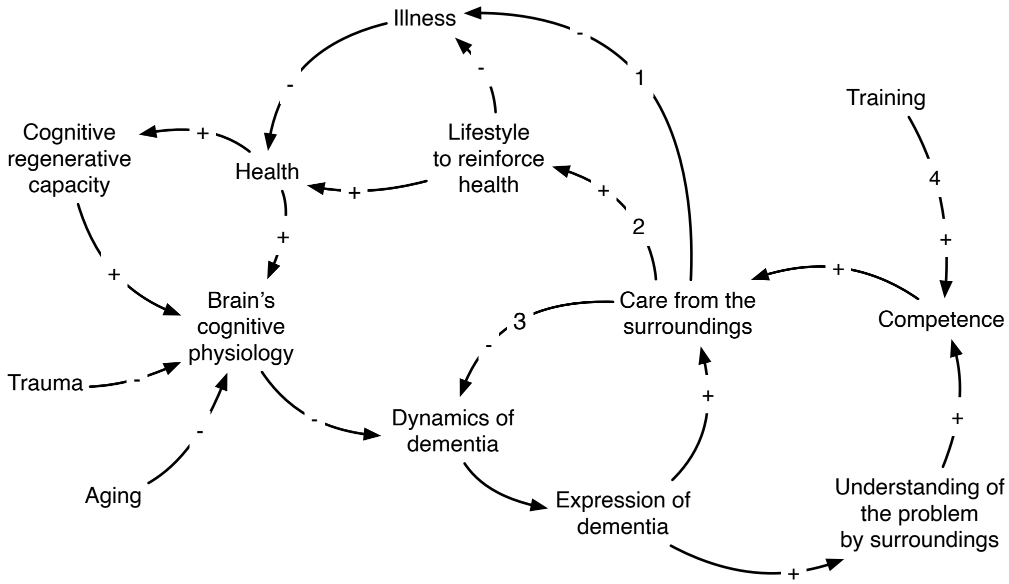

Figure 5. The whole health treatment and care system is a feedback system. The project is about strengthening competence and understanding. Care have several pathways to affect the system, marked with 1-2-3.

5. Results

5.1. Conclusion from the workshops

We held an initial brainstorming session on some of the reasons in the dynamics of dementia, and to train simple systems analytical methods. Sverdrup worked at the blackboard and drew input from the participants. This was mapped based on the group's understanding of cause-and-effect.

The first workshop brought together the group, who made an initial storming of ideas. The first meeting, began the process of creating our way of working, based on frequent work meetings. As a result, we have seen that we need more workshops. At later meetings, there were group modelling sessions where the initial system analysis was started.

The first workshop was held in the DemEX project on 28 September. June 2020, meeting at The Gameschool, Inland Norway University of Applied Sciences, Hamar. The participants were: Berg Strandvik (INN), Bård Gunnerud-Åhlen (INN), Ståle Fredriksen (Innlandet Hospital), and Harald Sverdrup (INN). We drew an overview picture in the session that identifies 3 main components of our research question. The cause-effect diagram after the first workshop in the DemEX project is shown in Figures 6 and 7 (Senge 1990, Sterman 2000).

The causal loop diagram shows relationships between cause and effect. The character + means that a change in the cause leads to a change in the same path of the effect. An increase in cause gives an increase in effect and a decrease in cause gives a decrease in effect. The sign - on the arrow means that an increase in cause gives a decrease in effect, and that a decrease in cause an increase in effect. A causal ring (causal loop, feedback loop) means that we have cause and effect running in circles. R means that the causal ring self-reinforces. We can start anywhere in the ring with an increase and if it comes back as an increase we have self-reinforcement (reinforcing loop). These are marked with R1, R2, ... and with arrows in red. When a causal ring allows an increase to return as a decrease, we have a self-braking ring (balancing loop). You can read more about this in the textbook by Sverdrup et al., (2022) and the booklet written by Haraldsson (2004). These diagrams are the carrier of our shared understanding of the problem, putting what we know in context. These diagrams are used when we need to program the content of the simulations and the functions inside the GAME/VR/AR tool we are going to create.

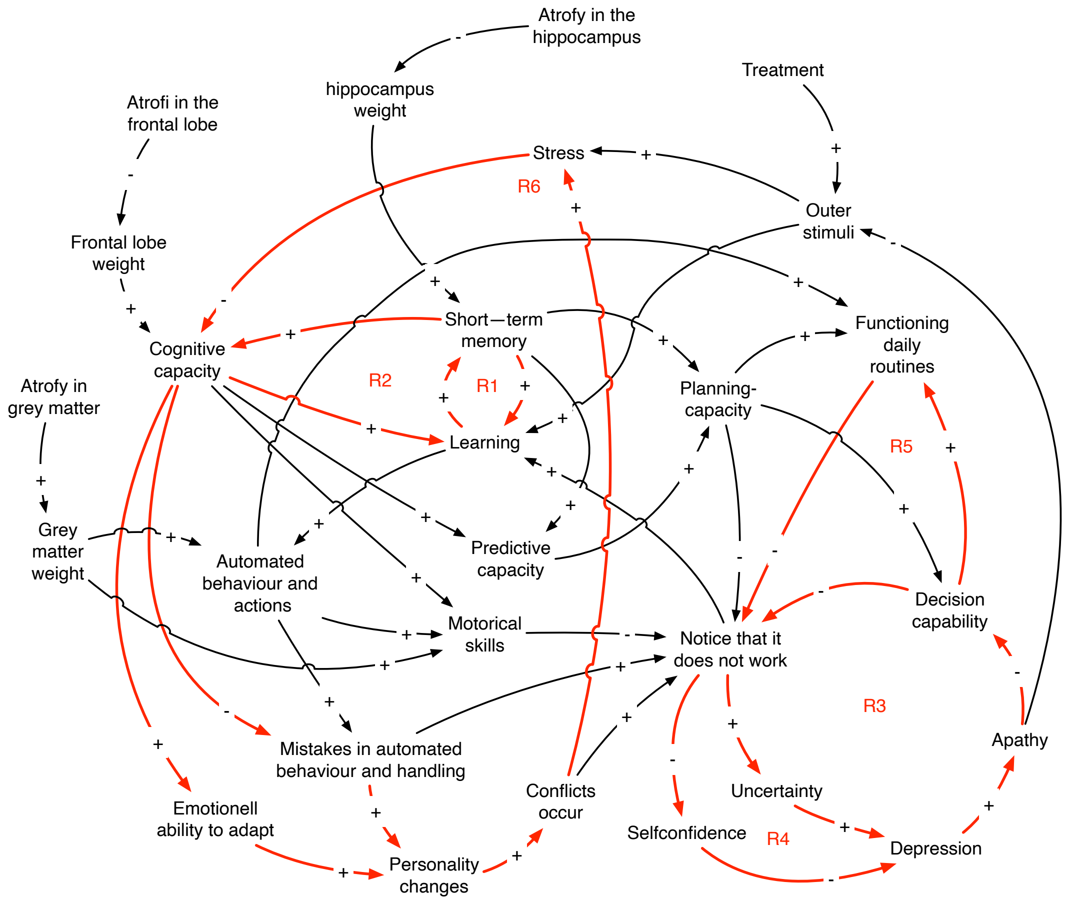

Figure 6. Cause-effect diagram (Causal loop diagram) of dementia dynamics developed in the first workshop. The diagram will be critically assessed or further developed in the next workshop.

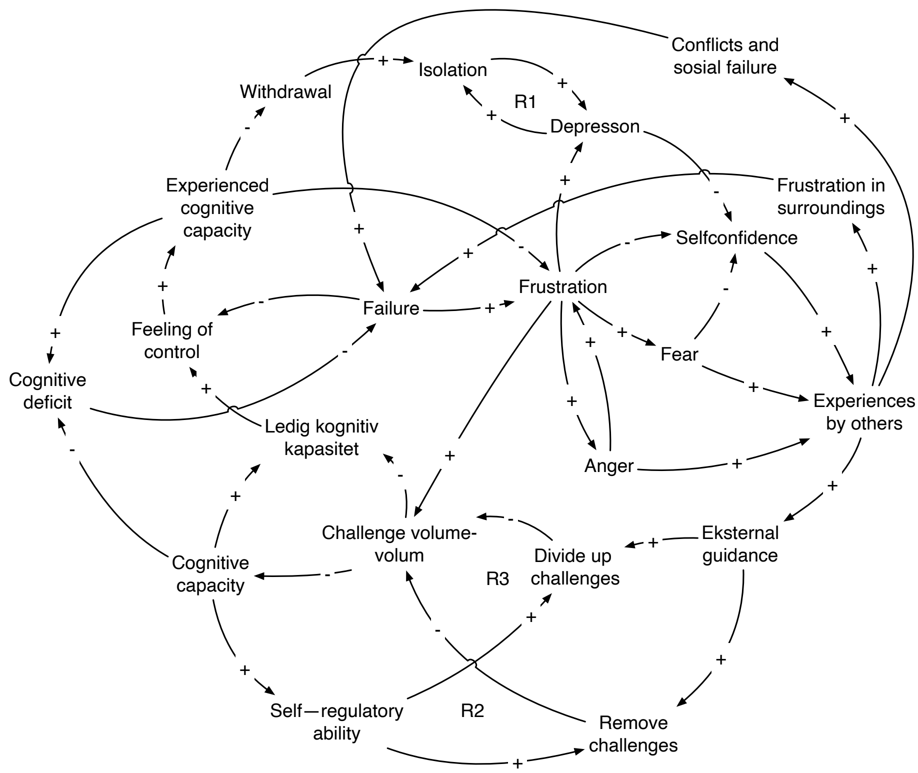

Figure 7. Cause-and-effect map of how the dementia expresses itself to the person and how this is perceived by the outside world from the second work session. Note some overlap with Figure 3.

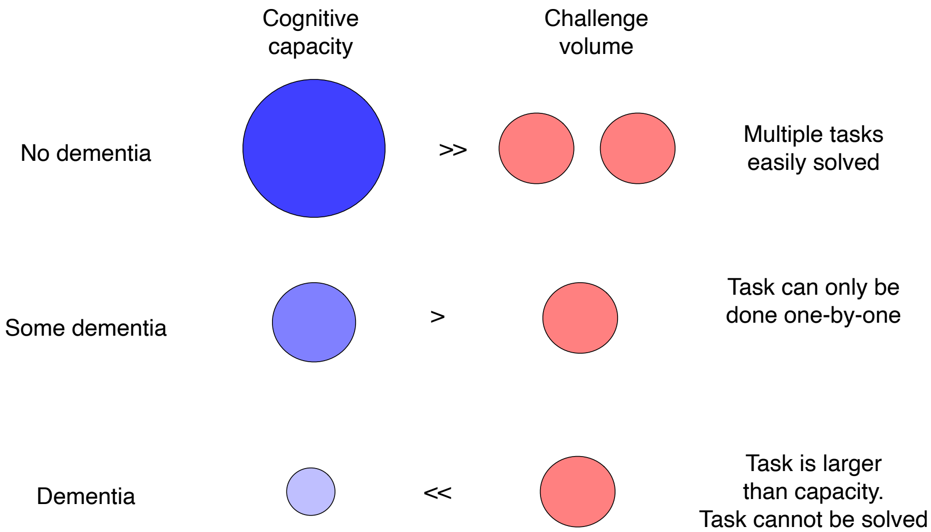

Figure 8. Visualizing how people have ability to handle challenges, depending on what cognitive capacity is available to them. This is to illustrate how dementia works. One solution is to reduce a too large challenge down to a series of smaller challenges that can be taken on sequentially.

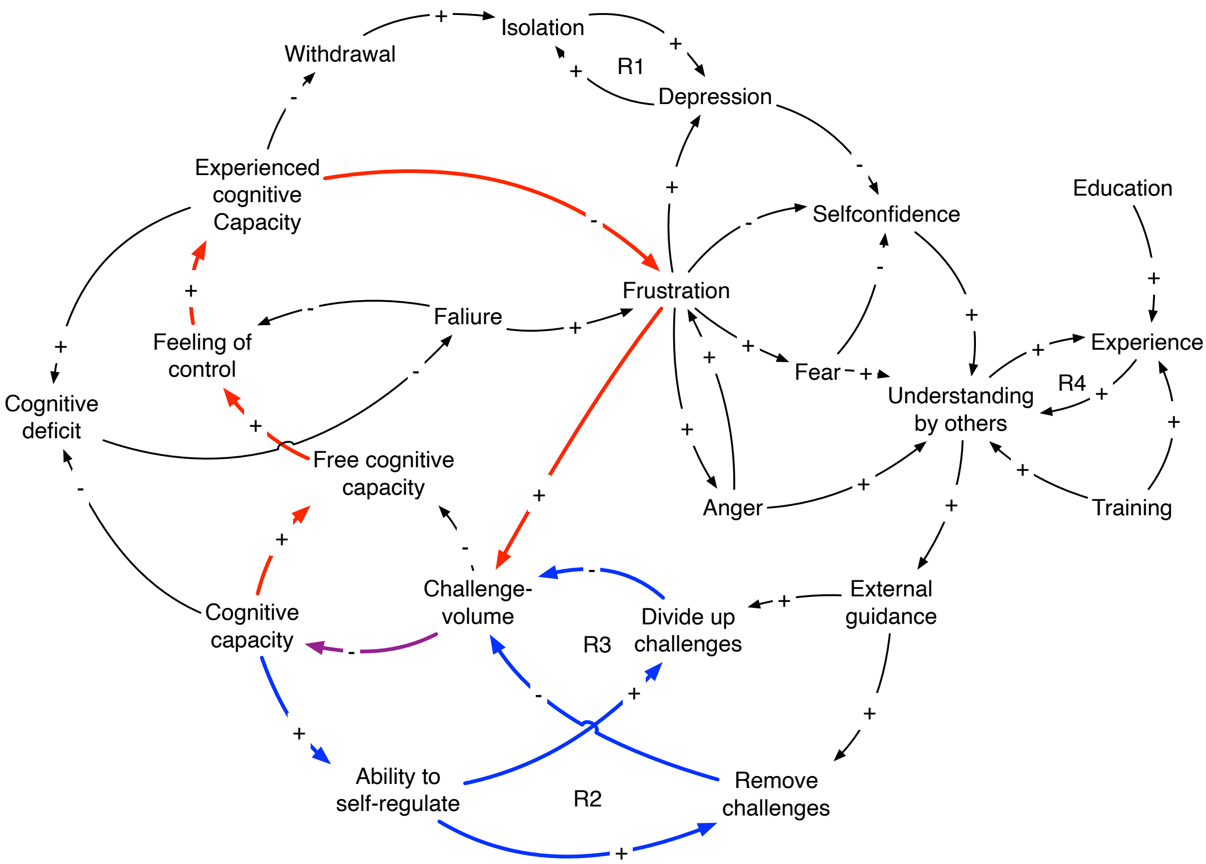

Figure 9. Dementia presents challenges in performing tasks. A modification of Figure 7. As long as the self-limitation ability is present, the person can divide up the challenges themselves or remove the challenges themselves and thus manage the situation. When the self-demarcation ability no longer works well enough, this self-compensating mechanism stops working.

5.2. Visualization of how dementia works.

A healthy person who faces challenges solves them quickly and efficiently as long as their cognitive capacity exceeds the challenge problem. Multiple problems at once are not a problem in daily life. In extreme situations, a healthy person can be overwhelmed by too many challenges (in crises or overwhelming situations). In the case of incipient dementia, capacity decreases and this can be felt by the fact that the challenges are solved more slowly and only one at a time. In more severe dementia, the challenge may exceed cognitive capacity. The challenge cannot be solved. Figures 7 and 8 illustrates what we mean. Figure 8 shows a visualizing how people have ability to handle challenges, depending on what cognitive capacity is available to them. This is to illustrate how dementia works. One solution is to reduce a too large challenge down to a series of smaller challenges that can be taken on sequentially.

Analogous to what unfolds in dementia is when people "hit the wall", become totally overworked and stop functioning. This leads to similar situations where cognitive capacity is reduced, challenges exceed ability and dementia-like situations can occur, where the person stops functioning. To be overworked is normally a reversible condition, although treatment can take a long time and create situations with the outside world very similar to what happens in dementia. A cause-and-effect map of how dementia expresses itself to the person and how this is perceived by the outside world from the second working session is shown in Figure 7. Note that there is a significant overlap with Figure 3. Figure 9 shows how early dementia presents challenges in performing tasks. As long as the self-demarcation ability is present, the person can divide up the challenges themselves (do only a small part now and do a next part afterwards, and continue like this until it is ready...) or remove (get someone else to deliver) the challenges themselves and thus manage the situation. This requires that the person understands what is happening and has the ability to react to this. When the self-demarcation ability no longer works well enough, this self-compensating mechanism stops working. It requires that the person understands the situation, can interpret it, can plan what is to be done and start acting on the plan. The situation may be that the ability to initiate is impaired. Or that understanding has disappeared.

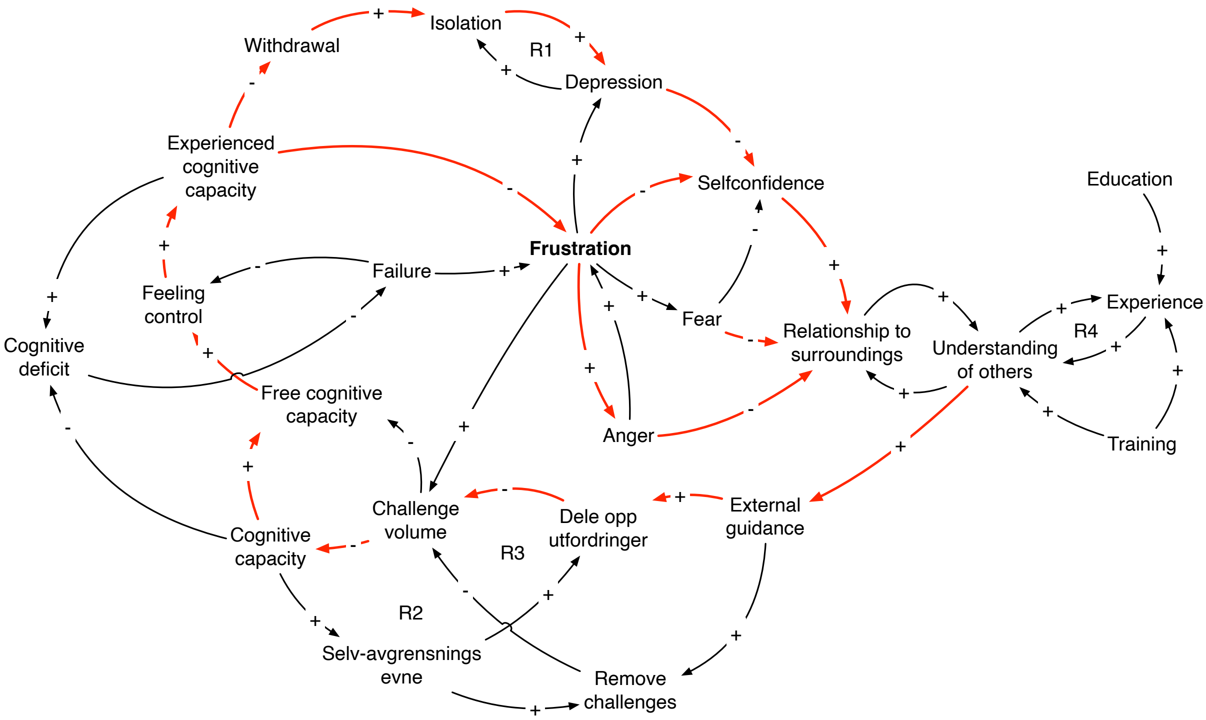

Figure 10. The figure shows how next of kin and health personnel can influence the situation. This is marked by the red arrows. This is done by intervening from the outside and either removing challenges (support takes over) or dividing up the challenges so that they are smaller than the available cognitive capacity.

Figure 10 shows how next of kin and health personnel can influence the situation. This is marked by the red arrows. This is done by intervening from the outside and either removing challenges (support takes over) or dividing up the challenges so that they are smaller than the available cognitive capacity. This can be read from the diagrams we made. When one's own ability to handle the challenges is severely reduced, the entire care falls on the surroundings (next of kin or the care system, (see Figure 11).

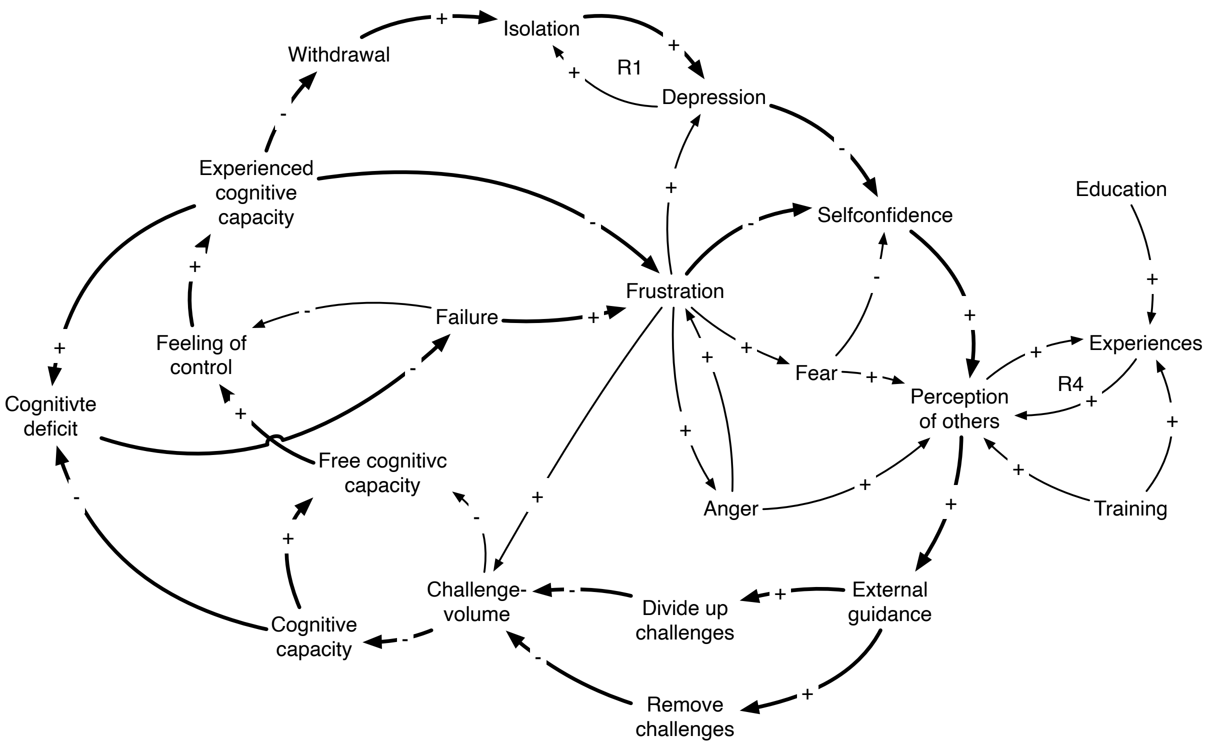

Figure 11. When one's own ability to deal with challenges is severely diminished, the entire care falls on the surroundings (next of kin or caregiver). Then conflicts and communication problems may arise.

5.3 About the tool's function and objectives

From the system analysis of the causes of dementia, the expression and dynamics of dementia and how this affects next of kin and the support system, the picture of what a digital training tool based on system dynamics (SD), virtual reality (VR) or augmented reality (AR) should look like and what it should do. We identified different categories of people who are users of the system:

1. Relatives of people with dementia and brain damage
2. Health professionals in training for the care of dementia and brain-damaged people
3. People with early mild dementia
4. Researchers working on issues related to dementia and brain damage

The group discussed what situations we should create for the person who will use the experience tool. Types of situations that can be played up in an application:

1. **Driving**, handling driving in a roundabout, finding the car in the parking lot or among many back streets in the city, geographical navigation in urban environments and on roads with changed driving patterns.
2. **Manage everyday routines**. Get up in the morning and ready breakfast. Arrange their private hygiene, remember their medications, make breakfast, and clean up afterwards.
3. **The Graduation party**. Dealing with masses of impressions, many people at once, simultaneous conversations, many distractions, avoiding feelings of chaos or cognitive overload. mastery of social impressions, expectations of the environment. The conversation where you can't remember the thread or the names. Who is recognized and who is not...
4. **An easy shopping trip** to the store. Be able to go into the mall, perform simple things, pick up the shopping list, identify and find the goods, and find the way out. Getting home.

Here we intend to compose the situations and create the dramaturgy of the episodes and the virtual environment. The playwrights and VR/AR specialists of the game school will develop these parts. The specialists in gamification will then create the animatic outline and create the virtual reality elements and assesetts.

5.4 Serious Games and Gamification.

The situations described above can be implemented as apps on a phone or as complete virtual interactive simulations. Apps can be augmented by AR glasses or similar, while the simulations would use VR tools. The ideas and development of these apps or interactive simulations will be based on the CLD's described in fig 6 to 10 above, the team doing the implementation will also use System Analysis to describe the applications. Game elements such as aesthetics, storytelling, goal description, flow and interactivity and feedback will be important in the development phase of both apps and rooms. Other game elements such as replay /do over, abstraction, time compressing and expansion, different kind of feedback etc. will be discussed and matched to learning pedagogics and psychology. Further, some applications can be Gamified using elements such as conflict, competition and cooperation and different reward structures to make the play more fun. The gamifications should also be connected to well proven psychological motivation theories such as the ARCS or the Self Determination Theory shown in fig 12 below. All in all, the serious games and gamification should:

- be as fun and immersive as entertainment games and follow the flow
- have clear objectives and align with organizational or educational goals
- allow social integration through collaboration, competition and social recognition
- progress tracking and give immediate and constructive user feedback
- give challenges and variety to maintain interest and prevent boredom
- give onboarding education and training so users understand how to participate and benefit from the experience
- give meaningful rewards and incentives and consider both intrinsic and extrinsic motivators
- use game mechanics with purpose for education/learning
- simulations must have high quality art, animations and technology must be as fast / good as possible to be as immersive as possible
- have easy and user-friendly design, well-designed interface, easy navigation, and intuitive interactions
- real world gamifications must be consistent and in no way dangerous
- Be adaptive to the individual players and allow autonomy, but at the same time gather feedback to tailor the Gamification to individual users

After apps and rooms are designed, they will be simulated using System Dynamics to tune the apps to give the best results. In INN this is usually done in Stella Architect, but any simulation application can be used. When the simulations are optimised, the developers can either use the numbers directly in the final app or export the simulation code to the game engine (Unity, Unreal etc) so that the simulations can be run in the apps or rooms during execution (Nordby et al, 2023):. The latter gives greater flexibility and allow adjustment of the apps during play to adapt the apps to the individual players.

The complete development cycle for the serious games and gamifications is shown in fig 13. It has 3 learning loops: R1 is the System Analysis loop, R2 is the System Dynamics loop, while B3 is the implementation loop. The main learning methodology used in this example is Problem Based Learning (Barrows & Tamblyn, 1980) but learning also takes in a community of practise (situated learning) (Lave & Wenger, 1991).

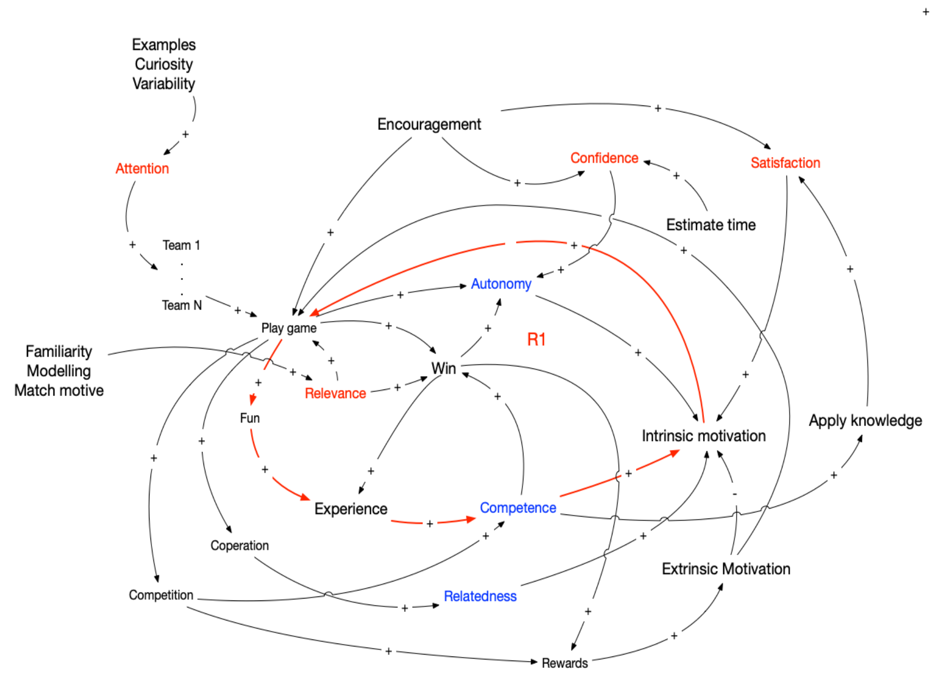

Figure 12. The game elements can trigger elements in the ARCS and SDT motivational models. Here the ARCS elements is shown red and the SDT elements in blue.

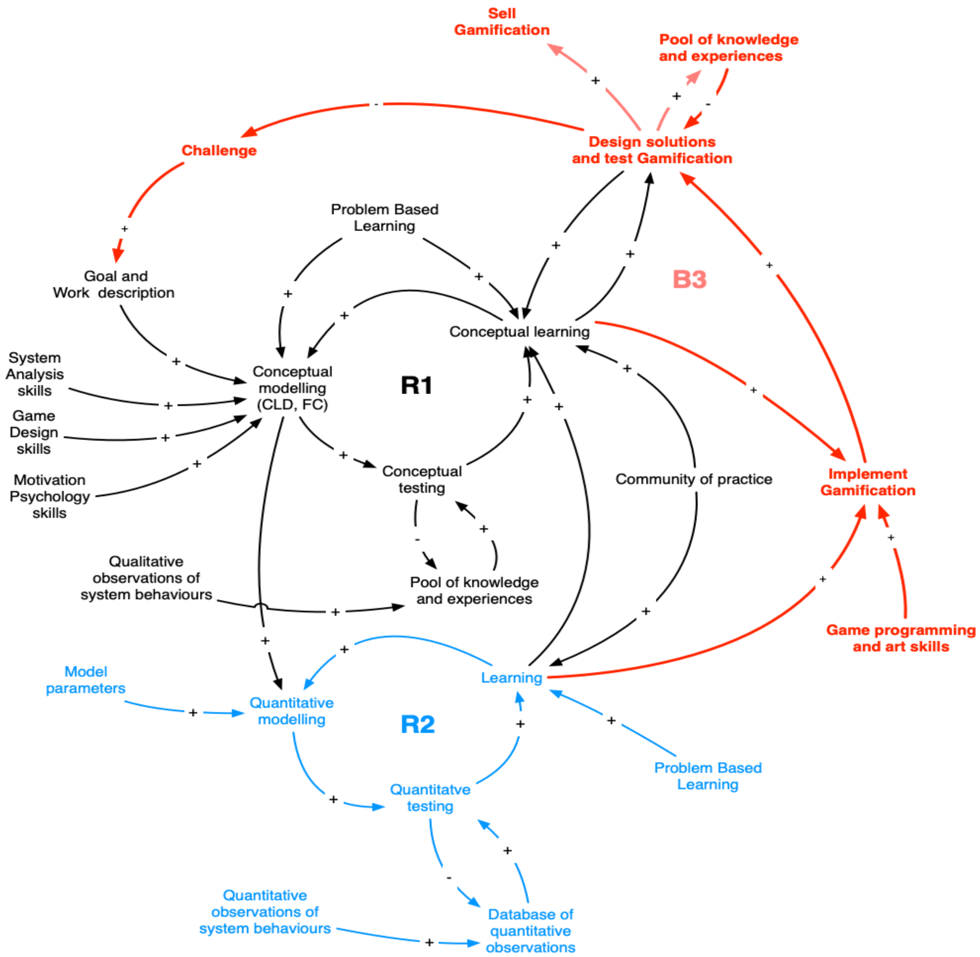

Figure 13. The serious game and gamification development cycle. R1 is the System Analysis loop, R2 is the System Dynamics look, while B3 is the implementation loop.

6. Discussion

There is a lot of work remaining to be done, but our short incursion into the subject has shown the necessity of analysing the system properly with systems analysis, and that this can be used as the basis for building a gamified training tool. The training tool would probably utilize VR-googles and make a simulated world the user can enter into. These can be shaped as a number of episodes as outlined earlier

7. Conclusions

It is fully possible to map the system of dementia patient, health care system and supporting relatives in a way that this can be modelled in a simulation model. By using Virtual Reality combined with game technology, it will be possible to use the simulations to simulate the dementated person experience of the world as a way to train people supporting the demented person.

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