senÉLudens©

A Research project initiated by Mihai Nadin

Aging, along with the associated costs (not just in dollars), is a major health problem (cf. *United Nations Programme on Ageing*[1]). Many resources are utilized for fighting aging and its effects at its core (genetic, molecular, neuronal), but few for attenuating the consequences of the basic aging process. The fact that the post-World War II baby boom generation will be reaching elderly status in the coming years adds urgency to the need to address foreseeable problems before they occur. This situation is tantamount to a "Sputnik" for research in aging, similar to what became the impetus for the American space program (cf. Kennedy[2]).

Rationale

Aware and respectful of the research in progress, especially in the area defined as brain plasticity or "rewiring", we are looking for ways to integrate its results with a new approach: combine the will of the aging to remake themselves, to live in a dignified manner, to enjoy quality of life, with available means other than medication for maintaining characteristics that make life worth living. In particular, with means that engage the individual, such as interactive games—understood in a very broad sense—that stimulate an active path of maintaining anticipatory characteristics. Games are open-ended, nonlinear stories with an embedded wager (reward mechanism). Involvement in games can be physical, cognitive, emotional, and/or social. It always entails learning, which is why games are adopted for all kinds of training. Documented through research[3] is the impact of game involvement in

- active recall of information
- coordination skills, especially eye-hand coordination
- reaction time
- predictive thinking
- decision making
- collision avoidance

Furthermore, these are all the result of the human being's anticipatory characteristics.

Why do we put an emphasis on anticipatory characteristics? Let us start at the end: Senescence is the stage at which anticipation degrades to such an extent that the body is practically reduced to its physical-chemical reality (cf. Rosen[4], Nadin[5]). Anticipatory characteristics of the living—human beings, as well as other life forms—are fundamental to the preservation of life, moreover, to the performance of rewarding activities (learning, sports, creative acts in general, orientation in one's immediate environment and beyond, etc.). We understand anticipation as "the sense of context." This translates into the ability to successfully operate in a world in which knowledge of the order and repetitive nature of physical phenomena is insufficient for coping with life's unexpected aspects. The anticipation of danger as well as a successful course of action is part and parcel of our existence. We negotiate steep slopes of downhill skiing not through reaction only, but also through anticipation. We learn how to use tools (including the new "virtual" machines) with the aid of our anticipatory characteristics. We define goals and methods for small tasks or for an entire life in anticipation of ever faster changing contexts.

Behavioral Therapy (Games, Play, VR Training)

In the unfolding of anticipatory characteristics, games of all kind—from simple interaction (hide-and-go-seek) to elaborate machine-supported performance (e.g., interactive games)—play an important role. Each game is a physical entity—described by the physics of the respective game (different in basketball, golf, football, chess, etc.)—and an anticipatory process: the outcome (future) defines the current state of those playing (tennis, pinball machines, cards, or some other game). Aging affects not only high performance (in athletics, chess, monopoly, backgammon, etc.) and learning, but even the willingness to play and

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to continue acquiring knowledge. Limitations brought on by aging—limited vision, deteriorated hearing, limited tactility, reduced agility and strength, reduced sense of balance, impaired cognition and a sense of alienation or even exclusion—make games difficult to handle and even to accept (the "What for?" syndrome). Thus games, and play in general, are progressively eliminated; the physical and cognitive challenge they pose, as well as the social attitudes encountered, transcend the abilities of the majority of the older people to overcome. This process of eliminating games and play from their lives takes place at the time when the elderly actually need them most.

Appropriately conceived games could fill the void of increasingly isolated men and women, by maintaining physical and cognitive characteristics and social interconnectedness.

Seneludens is a project focused on designing games and other therapeutic behavioral environments with the specific aim of maintaining anticipatory characteristics during the aging process. The title is derived from two words: *senescence* (from the Latin *sene*, "old age"), that is, changes that take place in a living organism as time advances; and *ludens* (as in *homo ludens*, playful human, playfulness being a characteristic of humankind[6]). It is known, and amply documented in scientific literature, that play, as an active form of involvement in a rewarding activity, fulfills necessary functions. It is practice for real-life actions. Play develops physical, mental, and social skills, just as it relaxes the mind and body without the deleterious effects of extended televiewing and other forms of passive distraction.

Based on the cognitive and psycho-physiological mapping of human characteristics at the stage of life when aging is noticeable, the future team of researchers will define the structure and nature of a new category of games and other play-conducive environments pertinent to this phase. Based on results from current advanced research in the cognitive neurosciences (accumulated in clinical observations and other experiments, especially in brain research), we will design games and interactive behavioral therapy environments that support the *active* maintenance of anticipatory characteristics of the aging. Such games will, of course, have an important learning (and reward) component.

The metaphor of mirror-neurons, i.e. neuronal configurations are generated as we attempt to imitate an action (mimetic procedure), was repeatedly confirmed in game situations.

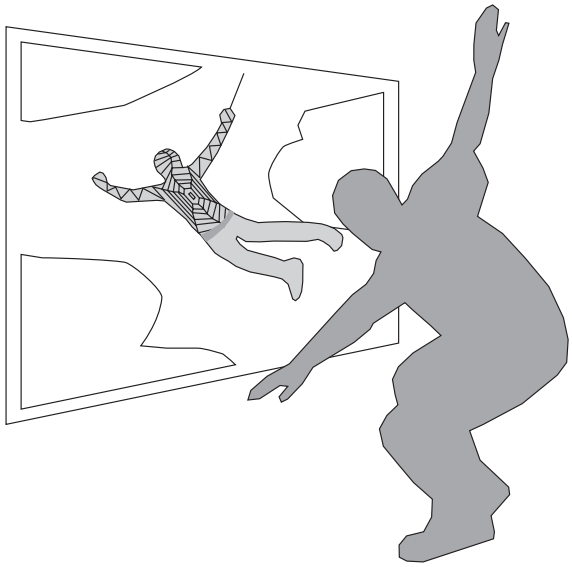

Fig. 1: Some of the games developed will require coordination skills and "mind control."

Many neuroscientists believed that the capacity of brains to reorganize was restricted to early development. Only recently has it been recognized that both young and adult brains can be modified by experience. Research in progress at UT Dallas and at many other centers in the USA and abroad focusing on cognition and the brain resulted in experimental evidence (some only in regard to animals, others including the human being) that reveals the following:

- Environmental enrichment and behavioral training increase brain responses
- In order for plasticity to occur, the triggered sensory experiences should be behaviorally relevant (i.e., the nature of the task is important).
- Task difficulty plays an important role in inducing brain plasticity.

These findings are not yet sufficient for specifying the type of activities we want to make available through games, but they are a methodological premise in the attempt to define the individual nature of the behavioral therapy we intend to make possible through the medium called game. These findings also fully confirm the anticipatory perspective, i.e., the proactive nature of the wellness model that this project pursues. Games and behavioral therapy are not a cure, but rather a method of prevention whose precise object is the maintenance of the human being's anticipatory characteristics and the delay of the onset of cognitive decline.

Foreseeable Benefits

Individuals—old and young—and society at large will benefit from this endeavor. For each lifespan that an individual gains, his/her younger family members will be able to provide affectionate support, unburdened by expensive and time-consuming care and physical assistance. Society would save the money currently spent on addressing the needs of the aging (drugs, therapy, assisted living). As we know too well, some of the aged end up abandoned by family members. Others, for reasons beyond their control, have no recourse to family support. Society would also benefit from the behavioral therapy implicit in game-supported maintenance of skills and the learning it entails. Both basic and clinical research unequivocally proved[7] that the brain is plastic throughout ones lifetime and that learning is possible until late in life. This suggests that we can enable the aging to remain independent, self-sufficient, and useful in many ways. The knowledge accumulated through games can only add to the lives of individuals who are rich in experience, but getting poorer, as they get older, in respect to their physical and cognitive faculties. This late-in-life knowledge will reward in many ways a society that makes life-long learning a priority across generations.

Very important is the creativity intrinsic in the project's goal. To conceive of games, that is, of play structures, that translate into behavioral therapy is to invent a category of artifacts that

- can be individualized
- are engaging
- display adaptive properties (i.e. reflect the dynamics of aging)
- support brain plasticity

These games will have to offer multi-sensory environments in order to stimulate the interplay between sensory driven actions and mind-initiated actions. Since with age sensory performance is affected, we will need to provide ways to compensate for lower performance by providing cognitive cues (an image can suggest the sound no longer perceived due to deafness; movement, as animation or realistic rendition, can carry haptic and temporal information, etc.). This is a challenge but also an opportunity.

In studying various processes accounting for human memory, scientists have advanced the complementary model of an action and drug-based cure (cf. Tully, 2005). In Seneludens, the goal is broader than memory maintenance (although memory is an implicit theme). Replace experience as a generic term by the variety of interactions that games and play afford: associations,

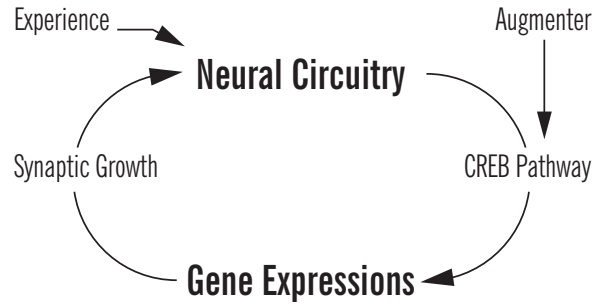

Fig. 2: Taking a cue from memory research

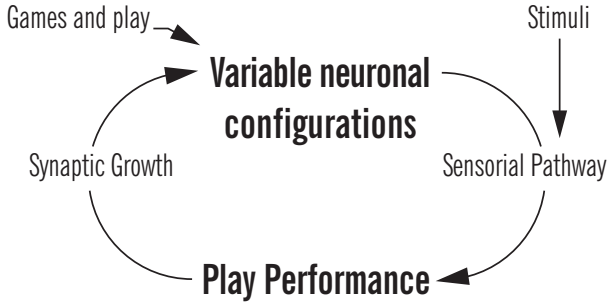

Fig. 3: Games and play as part of a rich cognitive environment

mind-driven actions (cf. Nicolelis, et al, 2005); mirror neuron generation; and heuristics (the discovery of new possibilities). Neural circuitry becomes neuronal configuration, and expressions become performance level in the game. We do not exclude the possibility of using appropriate medication (cf. Dinse, 2005) although this aspect is not a specific goal of the Seneludens project.

The current science and technology that will eventually be embodied in new products to aid the aging were not conceived from the anticipatory perspective. They are, as we know from the games developed to help train the military, rather the expression of the science of the physics, but not of the art of living. The new generation of creative designers and artists, who also acquired expertise in the computational, will have to express their creativity in a class of products that defies the industrial model of one (product, respectively game) for all. The alternative is the customized, individual product that specifically targets the cognitive dysfunction of the individual we want to help. The metaphor of mirror neurons (cf. Fig. 1) suggests that we can conceive of games that can "teach" their players how to improve their motoric performance as well. We have the science and technology for achieving this. But we do not have the knowledge and art necessary in creating variable products with adaptive characteristics.

Last but not least, games that "turn back the clock" of aging through maintenance and possible enhancement of anticipatory characteristics will add a new field of broad social and commercial significance to the economy. Based on market estimates (cf. Kaiser Permanente Foundation), by 2025 the share of the population age 65 and above will reach 22%, up from 12% in 2000. This translates into a dollar amount requested for addressing the needs of the aging population in the range of 8 trillion dollars (included here are Social Security, Medicare, additional medical insurance costs, drugs, various forms of therapy, medical care, homes for the aged, etc.).

The Researchers

Seneludens builds on the competence base acquired at the University of Texas at Dallas (UTD): an impressive amount of research in brain science and cognitive science—a great deal of which is dedicated to various aspects of aging. It also builds on the competence of faculty and Ph.D. candidates in computer science, engineering, and humanities. The new Institute for Interactive Arts and Engineering, which is attracting fresh talent (undergraduate and graduate students, faculty, and researchers) beyond the initial expectations of its founders, will be involved in many aspects of this project. Seneludens will also benefit from the study of anticipation—a multidisciplinary endeavor involving mathematicians, computer scientists, cognitive scientists, neuroscientists, among others—that the new Institute for Research in Anticipatory Systems (antÉ, for short) is conducting.

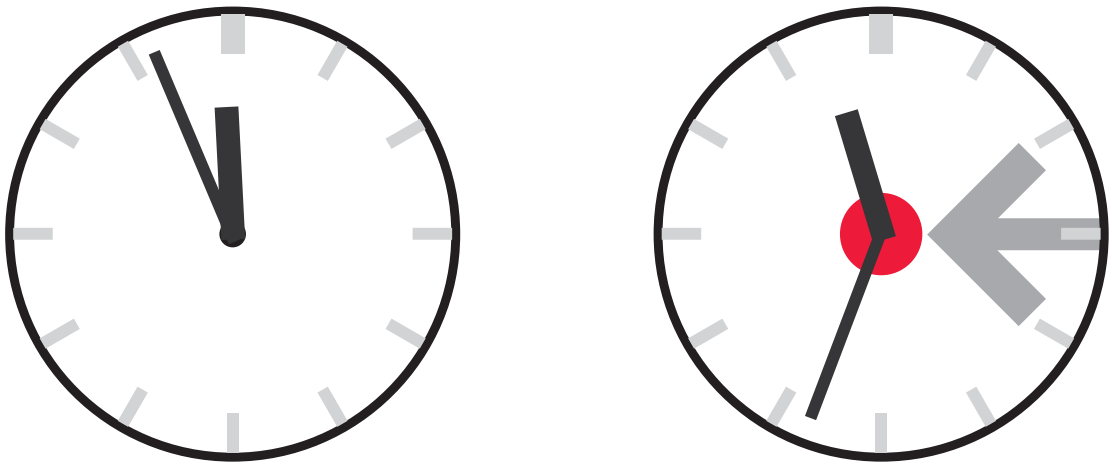

Fig. 4: "Turning back the clock" is a metaphor that illustrates the intentions of the *Seneludens* project

To date, the following Schools and Institutes have expressed the desire to become part of the *Seneludens* project: School of Behavioral and Brain Sciences, in particular the Center for BrainHealth™; the Institute of Biomedical Sciences and Technology; the Institute for Interactive Arts and Engineering; the Erik Jonsson School of Engineering and Computer Science. In addition, the Presbyterian Hospitals have expressed interest, and several physicians in Dallas are already providing data and additional material. We are trying to build bridges to colleagues at UT-Southwestern, as well as to other UT programs. We are working with Human Emulation Robotics, LLC (HER) and interact with Ritual Entertainment concerning the game industry. The Center for LifeLong Learning and Design (L^3D), University of Colorado at Boulder; the Masters in Immersive Media Environments (MIME) at Indiana University-Bloomington; the Interdisciplinary Center for Complex Systems, Bonn University (Germany); and the Institute for Neurocomputing, Bochum University (Germany) have recently joined this research effort.

In view of the complexity of the endeavor, and of the need to coordinate many activities—including a two-day seminar of all participants, which will eventually lead to grant applications (or to a comprehensive long term initiative)—this project requires start-up support in the form of seed funding.

Seed funding for the *Seneludens* project will allow for the following:

i. Further identification of persons at the UTD campus, UT-Southwestern, and other universities in the area who can and want to contribute to defining the many aspects of the project (cognitive map, the locomotorics of aging, networking, etc.)

ii. Further identification of medical professionals (independent or part of the hospital systems in the area) who can provide clinical data and qualitative assessments and also assist in the quantification of observations pertinent to anticipation (how it decreases with age, and how it might be affected by active involvement in the games developed), as well as in other behavioral therapy environments resulting from *Seneludens*

iii. Identification of the forms of interaction conducive to motivating and engaging the aging: alone (self-motivation), with friends, with family, with direct relatives, with younger persons, including grandchildren of different ages

iv. Identification of the various characteristics of particular groups (the role of social, psychological, and cultural factors, gender, religious belief, sexual orientation, etc.) to be addressed in the game model

v. Networking effort to identify various centers for the study of aging, in the USA and abroad, with the aim of sharing knowledge pertinent to the project

vi. Initial data acquisition at the new Motion Capture Lab at the Institute for Interactive Arts and Engineering, and data processing aimed at providing evidence of anticipatory characteristics at the antÉ Graduate Laboratory

vii. Virtuality and virtual compensation of physical degradation. Addressing the feasibility of constructing virtual environments with intelligent features that help individuals to maintain physical condition, that is, to improve coordination, reaction time, predictive modalities, etc.; the study of therapeutic applications of virtual reality; virtual games and virtual sports applications (e.g., tennis, swimming, table tennis, biking, hiking)

viii. Network playing of games and learning: local and remote (over networks) project-based cooperation, various new forms of competition (focused on attention skills, pattern recognition, and even artistic,

scientific, and technological creativity)

ix. Expert system identification of individual characteristics and appropriate games corresponding to individual characteristics. Expert system evaluation of data resulting from active behavioral therapy involving games. Optimization of therapy.

x. Identification of specific funding sources

Web-based Integration and Interaction

Everyone expressing an interest in the project will participate in a Seminar (maximum two days) focused on the social, medical, economic, and political aspects of aging, as well as on games, playing, and learning. The participation of representatives of public institutions (national, state, local) is desired for assessing the goals, methods, necessary means, and funding possibilities. The open exchange of knowledge within the Seminar will provide occasion for refining the goals of the *Seneludens* project and for evaluation of intended methods. Although antÉ will coordinate the project, each research group will work autonomously. This requires a very good understanding of common goals and procedures for the integration of research results. Therefore, after the Seminar, guidelines for carrying out the project's various segments will be distributed. A website dedicated to the project will serve as a repository and provide tools for interaction among participants. The website will also serve as a Preliminary Report publication medium. It should be possible to maintain a website with internal communication functions and with a clearly defined public access facility.

Based on preliminary findings (i - x) and on the concrete results of the proposed Seminar, research proposals to the National Institute of Aging (NIA), the National Institutes for Health (NIH), the American Federation for Aging Research (AFAR), the Gerontological Society of America (GSA), the National Institute for Mental Health (NIMH), the National Science Foundation (NSF), The Administration on Aging, the American Academy of Physical Medicine and Rehabilitation, the Alzheimer's Association, and other private foundations. As the preliminary data come in, proposals for collaboration with industry (computer, gaming, sports and gymnastics equipment, etc.) will be elaborated and submitted. Unless subject to private information protection, each submittal will be posted on the *Seneludens* website. In the spirit of openness characteristic of research today, the website will carry feedback from grant applications, as well as audit information pertinent to the project. We will extend a specific invitation to the aging to be active in the project and make their input through the website, just as we will stimulate researchers to maintain research diaries of public interest.

Structure of the Endeavor

The project relies on the expertise of many disciplines and involves nine basic phases. (See also Attachment A, "Timeline.")

A. Preliminary phases
   1) Information and knowledge acquisition
   2) Knowledge evaluation and preliminary synthesis
   3) Knowledge sharing and transposition from the object domain (study of the aging) to the application domain. Specification for new games and other related applications

B. Intermediary phases
   4) Conception, design, prototyping, testing, and refining of new games and other related applications
   5) Validation phase: feedback to game developers and therapy practitioners
   6) Refinement. Blind evaluation of the hypotheses set forth, the conclusions, and the specification procedure

C. Final phases
   7) Global evaluations of all results. Experts in the field from all over the world will be invited to attend
   8) Dissemination of knowledge (through peer-reviewed publications, web publishing, conference and congress communications, etc.)
   9) Technology transfer to industry sponsors, to

businesses, to start-up companies, to health providers willing to adopt the methods and means developed

It is quite possible that some form of adequacy examination (similar to the FDA approval procedure, but hopefully less costly and less time consuming) will be adopted. *Seneludens* might be invited to play a role in defining the procedure.

A proposal for funding of preliminary phases 1 and 2 has been submitted to the National Science Foundation (2/23/05). Partners in the proposed project are the Center for BrainHealth™, the Institute of Biomedical Sciences and Technology, the Institute for Interactive Arts and Engineering, the Erik Jonsson School of Engineering and Computer Science, the Masters in Immersive Mediated Environments – Digital Information Systems (Indiana University-Bloomington), and the Interdisciplinary Center for Complex Systems (Germany). antÉ is in the process of applying for additional grant support.

For phases 1, 2, and 3, the project will accomplish the following:

- It will challenge cognitive scientists to
  a) report findings pertinent to the subject
  b) continue studying specific developments of the aging process, including perceptual, cognitive, linguistic, emotional, social, and physiological processes, as well as individual variations in these processes
  c) express the acquired knowledge as specifications for new forms of activity that could eventually lead to games and to virtual environments for maintaining physical condition
- It will challenge brain researchers, who have access to very sophisticated imaging technology (such as fMRI), to specifically address issues of
  a) "rewiring" or "recharging" the brain (various aspects of plasticity) through learning and involvement in interactive environments
  b) focusing on brain plasticity and playing
  c) brain remodeling and regeneration as the individual and groups get involved in new forms of interaction
  d) measuring brain plasticity at the level of neurotransmitters at a global level through functional brain imaging.
- It will challenge partners active in the medical field (practitioners, faculty members at various universities in the area, etc.) to address particular age-related symptoms of decline in the functional integrity of the human being and to translate these into the language of the changes envisioned in game-based therapy. In particular, we will have to measure what it means that anticipatory characteristics decline (as related to high incidence of falling, difficulties in orientation, diminished predictive functions, diminished hand-eye coordination, diminished sense of rhythm, etc.).
- It will challenge age-focused healthcare providers to prepare for a shift in the perspective of their valuable activity. In parallel to the well established healthcare methods currently practiced, providers will have to adapt to the need of giving the individual aging person the chance to pursue (pro)active behavioral therapy. What for the aging should appear as playing (the game being the carefully conceived and tested medium) will be a new challenge for the healthcare professional. *Seneludens* pleads for a new dimension in healthcare for the aging by making it possible for them to remain active and healthy as they advance in their degree of seniority.
- It will challenge researchers in the social sciences to focus on the specific aspects of communication and interaction of the aging and elderly, and to address how being active in a social context translates into requirements for new games and behavioral therapy based on emotional and cultural rewards.

Of utmost significance is the realization that the data documenting the decline of anticipatory characteristics can come only from the researchers in the specialized fields mentioned above. This will lend to the endeavor the scientific foundation without which the next

step—conception, design, and implementation of new forms of active involvement through games and related environments—cannot be conceived. Moreover, this is also where the process will be validated. Science defines the specifications; science measures the results and provides feedback for further refinement. For this purpose, using AI techniques will allow for

a) individualized solutions (which interactions reflect the individual aging process, that is, what kind of games are appropriate to the individual)
b) quantification of results

In the implementation phase, *Seneludens* will address the community of computer scientists, software designers, game designers, communication experts, therapists and healthcare providers. For phases 4, 5, and 6:

- It will challenge computer experts to provide interfaces behind which the computer will disappear for the elderly, yet still offer rich possibilities to network and interact.
- It will challenge game developers and designers to address an important—and growing—segment of society that they have ignored.
- It will challenge healthcare providers to consider alternatives to medication and surgery.
- It will stimulate the elderly to actively support the attempt to make available alternative solutions to some of the limitations they experience in daily life.

A major endeavor is the conception, design, programming, prototyping, and testing of a game engine dedicated to the aims of the *Seneludens* project. A game engine is the non-game specific technology that makes the game possible (just like the engine in a car makes locomotion possible). An engine is the "generative" core of all the future games that will eventually be conceived and built (like various care models driven by a good, reliable engine). The specific game part (models, animations, sound, AI procedures) consists of assets; the engine will reflect the particular profile of the users considered and will integrate components (such as network connections for on-line guidance and assistance, and even professional monitoring). The renderer, 3D world, culling overview, pipeline flow, lighting, textures, mapping, anti-aliasing, inverse kinematics, game control mechanisms, etc. will have to be conceived after detailed consideration is given to the perceptual and motoric characteristics of the aging player. Moreover, since the various game platforms are proprietary, we would need to assess the possibility of advancing a game engine that is, to the extent feasible, portable, in order to avoid "locking in" the users and exposing them to the risks of being "owned" by one company or another. We cannot adopt commercially available game engines because our purpose is fundamentally different: to individualize the play experience as to reflect the individual needs of those we address.

Therefore, such a game engine would have to be adaptive, with a dynamic configuration. There is very little expertise available for meeting such a goal. But once the goal is reached, we might expect that the category of artifacts we call games will eventually be fundamentally changed. Computer science expertise and advanced AI models, in addition to anticipatory computing, will contribute to the game engine that this project revolves around.

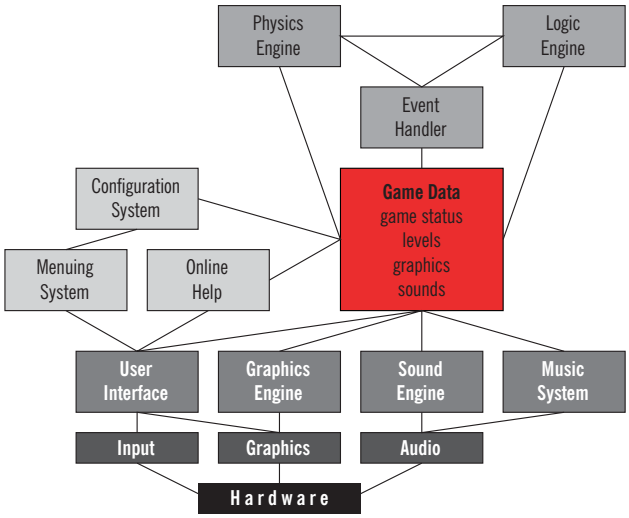

Fig. 4: Global Game Software Architecture

The final phases (7, 8, and 9) include testing, validation, refinement, and preparation for knowledge transfer to the economy. This part will again address the professionals mentioned in A, but this time the interaction cycle with the

professionals included in B will be reduced. Expert system validation (matching individuals to appropriate games and of evaluating appropriateness based on the knowledge acquired) will be made available. Finally, the knowledge, probably in the form of public domain resources, as well as patented solutions, will be made ready for transfer to industry and to healthcare professionals. We include in this phase the dissemination of knowledge through a sequence of colloquia, seminars, open forum discussions, as well as peer-reviewed publications (not the least among which might be a book entitled *Seneludens*). Multimedia material to support the dissemination of results will also be generated.

The Preliminary Phases (A)—outline, project initiation, preliminary planning, documentation, initiation of web presence and the like—is in progress. The estimated budget for this phase is ca. $1,000,000 and is partially provided by UTD (through salaries, facilities, auxiliary services). The difference, ca. $500,000 is subject to fund-raising. Members of the Seneludens team will apply for research grants. Seed-funding can insure the project's the momentum and signal to funding agencies the backing of the project through the University and other local initiatives.

During the Preliminary Phases, a Pilot Project will be carried out.

PLAY – A human-face robot that will fuse art (especially facial expression), game design, cutting-edge artificial intelligence, and social robotic hardware. The expected result is a therapeutic game whose main function is cognitive stimulation and emotional response. antÉ cooperates in this Pilot Project with Human Emulation Robotics, LLC (HER, for short). This project's two phases are as follows:

1. Combine the expertise of antÉ in anticipatory studies with HER human-like robotics technology. For this phase, $50,000, with matching funds supplied by HER, will support the design and manufacture of custom sculpted robot hardware and the development of software (language processing and animation). The outcome of this phase will be a biped robot with a human face, expression, interactive behavior, and game facility.
2. The product will have to be tested. Given the many implications of testing in real-time environments with aging persons, this second phase is more delicate and intensive. The costs associated with this testing are $250,000 (more than one functioning SeneLudens [sic!] will have to be made available for monitored deployment). It is the intention of all those involved to use some of the knowledge acquired in this phase for the general project. Therefore a record of data generated during the test phase will be carefully kept and analyzed by all those partaking in the project.

The results of this Pilot Project will eventually be made available to the public at large on DVD and on the web. A detailed description of the entire Pilot Project is given in Attachment B.

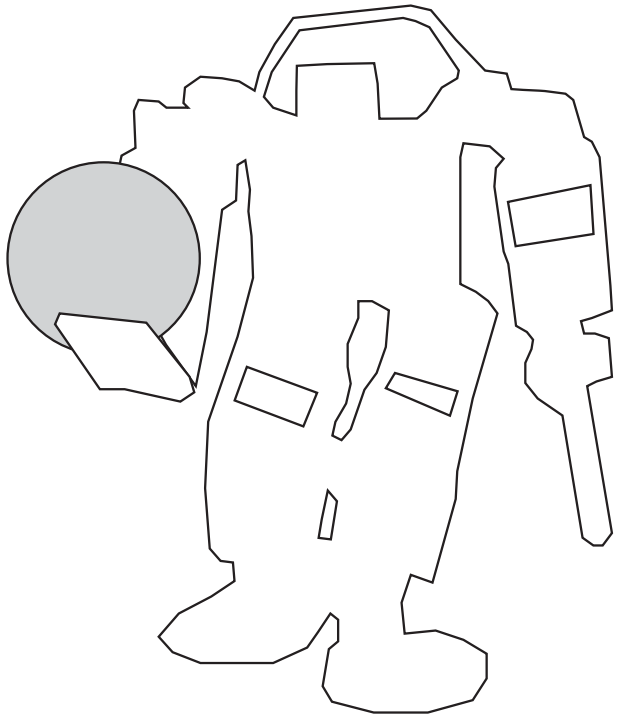

Fig. 5: The *Seneludens Robot* can play ball

Funding

A. Preliminary Phases. The estimated budget for these phases is ca. one million dollars. UTD currently covers more than one half of this sum.

During this phase, we will carry out a Pilot Project (as described above and in Attachment B). We will prepare the website and the knowledge repository (a data-mining engine). We will conceive, script, design, and produce a short documentary. During these phases, we will have to fund grant application development for at least seven proposals.

Total necessary funding	$1,000,000.00
Provided by UTD (salaries, facilities, equipment, etc.)	($500,000.00)
Remainder to be funded	$500,000.00

Phase 1: Participants come mainly from the fields of cognitive science, brain research, medical research. Knowledge acquisition involves the use of available facilities (brain imaging, motion capture, antÉ Graduate Lab, etc.).

6 researchers, for 2 years	$900,000.00
Data acquisition and processing costs in the antÉ Lab (modeling, simulation, data-mining)	300,000.00
Data acquisition at the Motion Capture Lab (MoCa)	300,000.00
Data acquisition from brain imaging, cognitive science, neuroscience, geriatric facilities	500,000.00
Total	$2,000,000.00

Phase 2: Interdisciplinary work (in part, parallel to Phase 1)

9 researchers, for 2 years for data acquisition, evaluation, synthesis	$750,000.00
Data processing and software development costs in the antÉ Graduate Lab	700,000.00
Data acquisition and processing at MoCa	550,000.00
Total	$2,000,000.00

Phase 3: Knowledge of biomedical relevance will be transferred from the object domain (study of aging) to the application domain. Interdisciplinary effort involving 1 cognitive scientist, 1 brain imaging scientist, 1 medical scientist, 1 computer science researcher, 1 game developer.

5 professionals for 1 year each	$375,000.00
5 design/computer graphics researchers	375,000.00
Game engine development, 3-year effort	1,000.000.00
Individualization through AI-based techniques	300,000.00
Total	$2,050,000.00

B. Intermediary Phases.

Phase 4: Conception, design, prototyping, testing, refining new games and other related applications.

6 graduate students and Ph.D. candidates (2 years each)	600,000.00
4 game designers 4 animation designers 3 music programmers (2 years each)	1,650,000.00
2 HCI professionals (2 years each)	300,000.00
4 virtual reality researchers (2 years each)	600,000.00
8 programmers (2 years each)	800,000.00
Total	3,950,000.00

Phase 5. Validation. Partially in tandem with Phase 4, once prototypes are developed

Costs of consultations with cognitive scientists, gerontologists, therapists, and the aging, etc.	250,000.00
Conception and maintenance of website for global knowledge dissemination and sharing	25,000.00
Total	$275,000.00

Phase 6: Refinement, also in tandem with Phases 4 and 5.

C. Final Phases: Implementation

Phase 7: Global evaluation of results

Costs of invited experts from the USA and abroad (includes, travel, board, honoraria for 20)	400,000.00
Costs of seminars and conferences	400,000.00
Total	800,000.00

Phase 8: Dissemination of knowledge via web publications, CD-ROM, conference and seminar communications

Phase 9: Technology transfer to industry sponsors, manufacturers, medical centers, health providers, etc.

Although it is too early to precisely assess the amount of funding needed for Phases 6 - 9, we estimate it to be $2,000.000.00.

Total projected costs for *Seneludens*	$13,585,000.00

A detailed cost vs. return analysis will be provided once the seed funding will allow for professional assessment. But before this happens, one should consider the following:

Eight trillion dollars corresponding to the aging population of the USA and their needs! The possibility to reduce this amount by even 1 percent while simultaneously increasing the quality of life of very many people, is only a *suggestive* measure of what *Seneludens* might effect. Moreover,

- new fields of creative endeavor
- new products
- the possibility to generalize from this experience to other fields (training, performance maintenance, etc.)

are indicative of the project's impact. Last but not least: the knowledge to be acquired in respect to a process we are aware of but will never be able to escape. "Happy aging!" to all those hereby invited to become part of *Seneludens*.

Remarks:

1. Seed funding for the purposes mentioned (in i-ix), for the seminar, and for the Preliminary Phases could be provided by corporate sponsors and/or philanthropic sources. From the funds to be obtained, we could support some Ph.D. candidates with demonstrated interest in this particular field. The total goal for seed funding is ca. $6 million, which should entirely cover the Preliminary Phases and the Pilot Project.

2. Sponsors and venture capital funding: Although it is too early to suggest specific benefits, one can imagine that some concepts, ideas, and specific games could enrich UTD's portfolio of intellectual property, as well as of the portfolios of the institutions participating in the project. Moreover, there is a good chance of sharing in the outcome of new games to be produced by local developers, outside companies, or of initiating a start-up company. Expected funding from sponsors and venture capital is ca. $3 million.

3. Research grants and grants from private foundations: the target is $5 million over 5 years.

4. Product development funding: An estimate at this moment would be premature.

An overall evaluation of the scope, methods, possible participants, evaluation procedures, product development, and initial deployment, as provided above, can be only indicative of the overall investment. Precise figures will have to be derived by all those directly involved. Even though in some cases we will refer back to results accumulated (locally or at other institutions in Texas or elsewhere), what is not at had is a methodology for "translating" medical, cognitive, and brain research data into specifications for the applications pursued in the *Seneludens* project. This is a real challenge. And given the fact that our subjects are human beings, especially individuals in an already less than optimal condition, we will have to develop simulation methods and other techniques in order to avoid harm. This will add to the general costs, but will also generate applications of interest to areas such as training (civil and military), and to developing new learning methods.

The project is inter- and transdisciplinary. Its many components make it a good candidate for long-term initiatives by the many entities it will integrate. *Seneludens* is expected to take 5 to 8 years, when products will be ready to enter the economy.

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Notes

[1] Refer to the website www.un.org/esa/socdev/ageing

[2] John Kennedy, in his speech announcing the Apollo Space Program on May 25, 1961. "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth. No single space program in this period will be more impressive to mankind, or more important in the long-range exploration of space; and none will be so difficult or expensive to accomplish."

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[4] Robert Rosen. *Anticipatory Systems: Philosophical, Mathematical and Methodological Foundations*. Oxford/New York: Pergamon Press, 1985.

[5]Mihai Nadin. Mind: Intelligence is Process, graduate lecture at the Ohio State University, 1/1987; *Mind – Anticipation and Chaos*. Zurich/Stuttgart: Belser Verlag, 1991*; Anticipation-The end is where we start from*. Basel: Muller Verlag, 2003.

[6] Huizinga, Johan. *Homo ludens. Proeve eener bepaling van het spelelement der cultuur*, 1938. See *Homo Ludens: A Study of the Play Element in Culture* (trans. by R.F.C. Hull). Boston: Beacon Press, 1971.

[7] Older Americans and the Internet. Pew Internet and American Life Project. www.pewinternet.org
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