

# Player state and diagnostics in adaptive serious games. Suggestions for modelling the adversarial contradiction

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**Abstract.** The premises of theories about Adaptive Serious Games are analyzed. Monistic approaches, which assume a determinacy of humans, and dualistic approaches, in which the ability of humans to self-determine is central, are contrasted. With reference to the concept of Digital Humanism, approaches that focus on the human's ability to self-determine are given preference. With this perspective, existing approaches to Adaptive Serious Games are discussed and suggestions for further development are made. The focus is on the adaptability of adaptive systems. This can be achieved in particular by suitable configuration options and an editor, with which players can determine the adaptivity of an adaptive serious game themselves.

**Keywords:** Adaptive Serious Games · Digital Humanism · Bildung

## 1 Introduction

Adaptation is a serious challenge in the design of serious games. Measuring learners state, automatically diagnosing it for adaptation purposes and concluding adaptations is an obvious answer to the challenge (Serbin et al. 2019). An assumption of this answer is that learners are stateful systems. This assumption can be made if data collected about the learner are considered as adequately modeled representations of the learner, since these data can be considered as a stateful system. In this case, the adaption is concluded for the data represented in the stateful system. Fortunately, the correlation between the learner and the data in the learner model is most probably low, since learners are hardly stateful systems. They may act as stateful systems if they wish – but being able to occasionally act like a stateful system and being a stateful system that always acts as a stateful system is not the same.

In order to substantiate this thesis, theories of adaptive serious games will be taken up first. The assumptions underlying these considerations are elaborated. The assumptions are then reflected upon with theories of digital humanism and a positioning of the argumentation presented here in the segment of dualistic theories. Against this background, suggestions for a humanistic design of adaptive digital games are finally developed.

## 2 Premises in Theories of Adaptive Serious Games

The narrative of the history of Adaptive Serious Games is usually started with Abt's (1970) publication on Serious Games. Abt opens his argument with the remark: "As civilizations evolve toward highly technological societies, the ability to use abstractions becomes more and more necessary for people to function effectively" (Abt 1970, 3). There are two surprising twists in this remark: First, the development to highly technological societies is described as an evolutionary process. This implies that the evolutionary process has a goal, namely the development of highly technological societies. Darwin (1859), however, had described evolution as a process that has no goal. According to Darwin's theory, evolution is a non-teleological process.

Contrary to the theory of Darwin, Abt assumes a goal for history. Such a theory is not a description of natural processes, but an ideology. The premise of this ideology is that history (which is the usual word for what Abbot mistakenly calls evolution) has a will that directs the path of humanity. This allows Abbot to seamlessly add the second surprising twist.

Abbot demands that humans should function well. He is able to set this premise because, due to the assumption of humanity's control through history, he believes he knows that it is good for humans to function effectively. The idea that humans may not always want to function well is something Abbot can accommodate in the context of his ideology, as is the fact that it is he who sets the premises - not evolution or history.

Implicitly, Abt does consider people who do not function well - as a disturbance variable. It follows for Abt that it makes sense to regulate people who do not function well in such a way that they function well. This is the motive Abt wants to express in Serious Games: It is about controlling people so that they function well.

This motive also became the basis of the theory of intelligent tutorial systems, which have been extensively researched for decades, mostly without results (Swertz et al. 2017). Both approaches, adaptive serious games and intelligent tutorial systems, are based on the same motive. In both cases, the premises on which this motive is based connect to Wiener's (1965) cybernetic ideology (Barberi 2017), but mostly without explicitly stating this. The connection to cybernetic ideology leads to the fact that the models for Adaptive Serious Games, formulated for instance by Charles and Black (2004) or by Lopes and Bidarra (2011), are very similar to the models for Intelligent Tutorial Systems - it is enough to exchange the word "learner" for "player" to transfer the models into each other.

Players are represented in these models. Thus, learners are viewed as stateful systems. The advantage of viewing learners as stateful systems is that future behavior is assumed to be predictable. It is a mechanistic model. At the same time, it is assumed that the outcome of games, in this case of a serious game, can be calculated in advance.

### 3 Premise Analysis

Now, here we cannot pursue the understanding of play in pedagogical processes, which has been discussed at least since the influential essays of Schiller (1795). For the purpose of the argument, it is sufficient to note here that with Adaptive Systems, which are based on the motive of controlling people with predictable games in such a way that they function well, these systems are clearly connected to behaviorist learning theories (Skinner 1958). This is particularly evident in Skinner’s influential science fiction ”Walden II” (Skinner 1948), which describes a society based on controlling people to function well (behavioral engineering).

The premise of humanity’s destiny through history and the resulting task of managing people to function well is in direct opposition to humanistic theories.

Humanistic theories have been developed at least since the Renaissance. Accordingly, the theories are diverse in detail. What these theories have in common is that the question of the *Conditio Humana*, of the essence of man, and thus of man himself, is set as the central question. The premise here is that it is necessary for humans to enlighten themselves about what is special about humans (Schmölz 2020). By enlightening themselves about their humanity, people can reflect on themselves and determine themselves as human beings. The ability to do this is possessed by all human beings (Swertz 2021). In this respect, all human beings are equal. And in this respect humans differ from animals and machines (Schmölz 2020).

With this premise it is possible to criticize social developments and to look at them from one’s own point of view. Examples include analyzing digitization as a modern form of colonization (Bon et al. 2022) or reflecting on the notions of agents and intelligence on which artificial intelligence technology is based (Russell 2022). The goal here is to develop policies to ensure that ”technologies are designed in accordance with human values and needs” (Werther et al. 2019).

The contrast of digital humanism to cybernetic ideology is obvious: While theorists of cybernetic ideology demand the functioning of humans and the necessary adaptation of humans to technology, digital humanism is about the self-determination of humans and the design of technology according to the needs of humans. The essential difference can be marked with the understanding of history: While for supporters of cybernetic ideology it is history that determines the fate of people and it is therefore necessary to follow the will of history, for supporters of digital humanism it is people who determine history. Thus it becomes necessary to determine history responsibly.

### 4 Performative Retorsion

The logical basis for this difference, which has been discussed for millennia, is the understanding of performative retorsion. A performative retorsion is a figure of argumentation for which it must be presupposed that, first, logic is possible, second,

$$\neg(A \wedge \neg A)$$

(the theorem of contradiction) holds, third, judgments have a propositional content, and fourth, judgments are expressions of performative acts.

An illustrative argument based on retorsion is that "one cannot not communicate, because all communication (not just with words) is behavior, and just as one cannot not behave, one cannot not communicate" (Watzlawick, Beavin, and Jackson 1967, 53). The argument can be justified by saying that the assertion I am behaving now is not a behavior. By making this assertion, the assertor is contradicting himself or herself because he or she is behaving in the act of articulating. In contrast, the assertion that one can communicate cannot be refuted with a performative retorsion.

This does not prove that it is possible to communicate. It is proven that it cannot be meaningfully denied that one communicates. This marks a limit of what can be proven: It can be meaningfully disputed that it is precisely with this proposition that one has to start - other approaches are always possible with self-limitation of one's own approach. But it cannot be denied that it is possible to start in this way. Likewise it is true for the proposition: There are no true propositions, that with the articulation of the proposition the recognition of the proposition as truth is demanded, but at the same time it is demanded not to recognize exactly that. Therefore the proposition is false. This does not prove that there are true propositions, but it does prove that the existence of true propositions cannot be denied: It is not possible "to deny validity at all [transl. C. S.]" (Hönigswald 1927, 148).

What is required then is to make a beginning: "No theory, not even a philosophical theory, can begin without a basic assumption, without an axiom, because a beginning from nothing is not possible [transl. C. S.]" (Meder 2016, 179). Theories, if one accepts this premise, are always incomplete (Gödel 1931, 174). Because this assumes that there is always something outside the theories, such theories are called dualistic theories. The alternative is to assume that it is possible to fully comprehend the world with a theory. Such theories are therefore called monistic theories (Schaffer 2018). People who adhere to a monistic theory assume that the world can be fully known and is therefore determined. What happens is therefore not dependent on the will of humans, but on the will of nature, history or, in the case of the monotheistic variant, a God. Since this will itself cannot be analyzed and shaped, but can only be taken note of through observation, humans have no choice but to follow this will. In contrast, people who adhere to a dualistic theory have the possibility to choose and thus to shape their own future. The future is thus not thought of as predetermined, determined and calculable, but as open.

People with an open future cannot now be meaningfully modeled as stateful systems. Interestingly, people cannot be modeled as stateless systems either. The reason for this is simple: humans ultimately cannot be modeled at all. It is only possible to design models that people can use for their purposes. For this reason, probabilistic models are too simple, in addition to mechanistic models such as the behavioristic model. With the cybernetic concept of information (Shannon and Weaver 1964), which is based on the concept of entropy, it is assumed that

the prediction of the probability of the occurrence of an information is possible. This works well if averages are measured, which is very useful in dice or card games, for example. But even the prediction of a single case is not possible: Even if six sixes have already been rolled in a row, the probability of a six on the next roll is  $1/6$ . In the case of adaptation in learning processes, case-by-case decisions for individual learners are necessary. These decisions cannot be predicted in individual cases.

In the case of players, there is also the fact that - unlike a die - they can change their behavior in an incalculable way. Therefore, behavior can only be predicted if players choose to behave predictably. People can do that - but it is not legitimate to force them to do so and thus treat them as a mechanical or probabilistic system.

The problem of uncertainty is well known and is described by the uncertainty principle. The uncertainty principle shows that the state of a system can not be predicted precisely from initial conditions (that is: the learner model). However, the uncertainty principle assumes that in the case of electrons, for example, there is a list of properties such as location, trajectory, velocity and energy (Heisenberg 1927), which must be taken into account in the model. Humans, however, are capable of changing this list of properties. Speaking in the vocabulary of game theory, people can make the rules of the game the subject of negotiation. This can be seen even in young children, who often creatively invent the rules of the game as they play. Formulated from the point of view of modeling theory, learners thereby change the model. From a dualistic point of view, this cannot be modeled.

Since this difference has been discussed for many millennia in many cultures, it makes empirical sense to work with the thesis that there is exactly the monistic and the dualistic alternative and no others. There are only two basic axioms: The monistic axiom and the dualistic axiom. Because theorists who set the monistic axiom must understand man as determined and thus externally determined (and therefore reject, for example, human rights), and theorists who set the dualistic axiom must understand man as free and thus self-determined (and therefore can justify, for example, human rights), the dualistic axiom is set here.

## 5 Adaptivity

This has consequences for the understanding of learning: While for theorists who adhere to a monistic theory, pedagogy must be about the insertion of human beings into existing, known and modelable conditions, for theorists who adhere to a dualistic theory, it is about human beings being able to determine and model the conditions in which they live and, in doing so, also determine themselves. In the German-speaking world, the latter is referred to as *bildung* rather than learning, while the former is referred to as education. The word *bildung* is not translatable and is therefore used in the following.

It must be the goal of the design of Adaptive Serious Games to create an occasion for human *bildung*. The challenge here is that there is no underlying

notion of what proper *bildung* is. The challenge can be seen in behaviorist theories, in which it is claimed that the learner is central and that learner-centered instruction is used. By this is meant that learning behavior is analyzed (this is what learner-centeredness means) and then learners are taught in such a way that goals are achieved efficiently and effectively. This does not mean that learners can determine their own goals and choose and design their own paths to those goals. To determine goals, contents, methods and media by oneself characterizes a person who has *bildung*.

That is precisely what it must be about: People must have the opportunity to determine their own goals and choose their own paths in order to create - by all means themselves - an invitation to educate themselves. So adaptive systems must not be about people being adapted by adaptive systems. It must be about people being able to determine themselves and adapt algorithmic systems for this purpose.

One consequence of this is that it is meaningless to measure whether people have achieved pre-determined goals - that is not a relevant criterion. What is relevant, on the other hand, is to measure whether people have experienced the learning experience as an occasion to educate themselves. In terms of adaptivity, one goal may thus be that people can adapt systems like serious games for their purposes. For this purpose, assistance systems that make it casually easy for people to adapt systems to their purposes, and that they can then use as long as they do not wish to change their behavior, make perfect sense. It is obvious that modeling such systems is a complex challenge because the model parameters cannot be fully known.

## 6 Adaptive Serious Games

Consequences from the previous considerations will be discussed below on the basis of the excellent overview by Streicher and Smeddinck (2016). First, attention must be drawn to a difference: While Streicher and Smeddinck state as one goal to replicate teaching by a personal trainer with an adaptive system, this is not possible from the perspective developed here. This is because replicating the behavior of humans with machines is only possible if one adheres to a monistic worldview. Elsewhere in the same paper, however, Streicher and Smeddinck suggest that adaptive systems should be understood as assistance systems - a reasonable and responsible perspective.

An option to deal with this perspective can be derived from the fact that in contrast to physical elements, learners are able to actively configure the model. This can be made possible through HCI. The principle is to make adaptations only with learner consent and to allow learners to change the configuration. This takes into account another difference between physical elements and learners: Learners occasionally change their minds. These changes are not predictable, but can be actively expressed by learners if learners are allowed to configure the model.

Even with this, the limits of Turing-powerful machines cannot be exceeded. However, it is possible for learners to analyze the limits of the media they are using at any given time and then choose which medium to use now. Thus, when learners choose Adaptive Serious Games, they must also choose to act within the limits of Turing-powerful machines.

This makes it clear at first that Adaptive Serious Games cannot be the universal solution for media in learning processes. It is an option. And this option is already valuable because the change between different media is an important occasion for processes of *Bildung*. Therefore, increasing the media ensemble is good because it allows more switching between media.

For Adaptive Serious Games, the focus then needs to be on adaptation by learners. For this, it is helpful to understand the use of an Adaptive Serious Game as communication. If adaptive serious games are understood as communication models that describes the communication between developer and player, a limitation becomes visible. The limitation is the fact that it is a unidirectional asynchronous communication. To model this communication situation appropriately, learners can be supported in modeling adaptations themselves. In this case, learners communicate with themselves. This turns the unidirectional asynchronous communication into a bidirectional synchronous communication. This can be achieved by offering an adaptation editor.

A first proposal for an adaptation editor can be developed with the considerations presented here, based on the development model presented by Streicher and Smeddick. This model contains a step in which the scope of adjustment automation, adjustment frequency, adjustment extent, adjustment visibility, and adjustment control is to be defined. In each case, a scale from "high" to "low" is provided on which developers must decide how to design the system. It is quite conceivable to design this not as a decision for the developers, but to offer it to the players as a setting. For this, a set of a few sliders would suffice, allowing players to parameterize the system. The same goes for accessibility, for example, which is best parameterized by the players themselves. It is obvious to also offer the players to automatically adjust these parameters in the course of the game.

This suggestion can be supplemented with a second suggestion. To also offer players the possibility to modify the parameter set, an adaptation editor is needed. The usability of such an editor could be improved by a visual adaptation language (Gómez et al. 2012), which could be used to link the available data and the adaptable elements with different algorithms. Incidentally, this does not only apply to players - it would also be helpful for developers and researchers to have such a system, which would facilitate rapid prototyping, at their disposal.

A third suggestion can be developed from the cold start problem. To deal with the cold start problem, there are several possibilities: First, it is possible to ask the player for an initial parameterization (Streicher and Smeddinck 2016). To do this, the player must be given the opportunity to enter parameters. A possibility not discussed so far is to suggest that the player generates the initial parameters by using the system. This allows the learner to decide what behavior the game should be adapted to, then demonstrate it, and thus parameterize the system.

Third, it is possible to offer the learner to try out the system first and then enter the parameters or generate them by demonstration when he has decided how to train the adaptive system. Fourth, it is possible to offer to work with default parameters that are generated from existing data of other players (Streicher and Smeddinck 2016) or can be set by the developers. These four options should not be fixed, but should be available at any time, because otherwise players will be restricted in their decision to change their behavior. Thus, if learners choose to turn off the adaptation system and leave it turned off, this should be possible as well as keeping default parameters, turning off the adaptation system later, or resetting parameters generated by demonstration or later recordings followed by a new demonstration, manual configuration, or training phase.

This makes it possible not only to give players a sense of autonomy while they are determined by being controlled by giving them a sense of autonomy, but to actually support them in acting autonomously. And it also becomes possible to view learner motivation not as a means of controlling players, but as an expression of the purposes set by the players themselves. People who have *Bildung* can determine their own learning. Automatic changes to the parameters should never be made - the player's consent must always be sought (Streicher and Smeddinck 2016). This is necessary because collected data often cannot be interpreted reliably. A simple example is a learner's response delayed by 180 seconds compared to the average. The cause may be a comprehension problem - or the trip to the coffee machine. If players are made aware that there were delays and then asked if they should be taken into account, they can determine this by a simple input.

A fourth suggestion relates to the goals pursued by the game. Streicher and Smeddick write, "The ultimate goal of an adaptive educational game is to support players in achieving progress toward individual learning goals" (Streicher and Smeddinck 2016). One consequence of this sensible perspective is that players must be able to set the goals themselves. To this end, at the beginning of a game, the player must be offered a choice list of goals that can be achieved with the game, so that the player can first decide whether the game is appropriate for his or her goals and, if so, specify which goals he or she wants to achieve. According to Streicher and Smeddick, the explicit specification of goals falls within the domain of adaptability. It is important to note that players can decide not to play at any time. After all, if a game has to be played within an imposed framework, it is not a game but work (Huizinga 2019). The contradiction between work and play is implicitly taken into account by Streicher and Smeddick by emphasizing the relevance of the player's life. For a serious game is formally work when it is serious, and becomes a game only when it is experienced as a game.

In Streicher and Smeddick's terminology, the proposals boil down to focusing on the adaptability of adaptive systems. To endow adaptive systems with adaptability is to allow players to adapt the adaptive system to their needs. It is clear that when players take advantage of the adaptability of an Adaptive System, they themselves become experts in the field of Adaptive Serious Games. And



this is exactly the goal: the transfer of knowledge. In this case, this passing on of knowledge about Adaptive Serious Games is done through the learning method: the method is the message. And that is certainly not the worst way.

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