An Ontological Meta-Model for Game Research

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ABSTRACT
The subfield of game ontology has seen many models and structural hierarchies, but few that actively build on each other, or even attempt comparisons. This paper introduces a meta-model, which in addition to being an ontological model of its own, also offers a method for comparison between competing or isolated models and concepts. It does so by treating games as mechanisms (Craver 2007) with multiple levels of description, and differentiates between four main layers of the game-mechanism. In the first part of the paper we present the model in detail. In the second part of the paper we show applications of the model - we present how some of the existing approaches to game ontology can be compared within it and how it can be used to describe two case examples: the ancient Egyptian funeral game *Senet* and the difference between game mechanics and game rules.

Keywords
Game ontologies, ontology, games classification, methodology

INTRODUCTION
Game ontology is a formal tradition with a sixty-years' history, if we count Roger Caillois (1958) as the starting point. Elliott Avedon (1971), Richard Ziegfield (1989), Aarseth & al. (2003), Björk & Holopainen (2004), Zagal & al. (2007), are just a few of the more recent entries into the formal study of game components and game variation. This tradition is hampered by many problems, such as the highly diverse nature of its object, *games*; the many different purposes and motivations for making ontological descriptions (design, addiction research, hermeneutics, criticism and others); not to mention the challenging claim made by Wittgenstein (1953) that it is impossible to come up with a valid, formal definition of games. One huge area of improvement would be to have more cooperation and collaboration between its theorists, as games are studied by different disciplines using vastly different methodologies (for example, cultural studies and cognitive science).

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One way to stimulate this collaboration is to pursue a unified approach based on mechanistic explanation, which is to say, treating games as mechanisms, that is structures performing a function in virtue of its component parts, component operations, and their organization (Bechtel & Abrahamsen, 2005). It can then be argued that similarly to other known mechanisms (machines, organisms etc.), the different elements and aspects of games require different descriptions which are often provided by different disciplines.

Another challenge for the robustness of a game ontology is that it should be able to describe the changes games (especially digital) undergo over time. The recent popularity of early access (releasing games before they are fully developed), so called "games as service", the new wave of virtual-reality technologies and so-called not-games (Samyn 2010) are good examples of current trends that demand attention.

We believe that the best approach is to create frameworks which analyze the phenomenon in question in a very granular way – breaking it down to properties and categorizing them (even if it cuts across the common categorizations of larger units, for example whole games). The explanatory power of this granular approach comes from the generative, combinatory nature of the framework. The shifts of the phenomenon can then be understood as changes of covariance of combinations of properties taken from the common pool (Aarseth *& al.* 2009).

Although fruitful, this approach has its well-known difficulties. First, it is not obvious how fine grained our categorization should be. Second, games can be (and are) described by fundamentally different ontological categories – objects, processes, sets of properties, sets of relations, sets of rules. Which one should be treated as basic and fundamental and which as secondary? (Aarseth 2014).

STATUS QUO: LITERATURE REVIEW AND A BRIEF EVALUATION

Roger Caillois (1958) introduced the first structural (as opposed to empirical, e.g. Culin 1907), and still best-known categorization of games, with his four categories âgon/competition, ilinx/vertigo, mimicry/simulation and alea/chance. Proposed as different types of games, they would not qualify as a proper ontology, but Caillois posits a system of combinations, where two types form a more complex game type, say, âgon and alea taken together describes numerous card games. It should also be noted that Caillois' typology is very open and will include a wide variety of ludic phenomena from theatrical performances to gambling.

Elliott Avedon (1971) builds on Culin and also on mathematical game theory (von Neumann and Morgenstern 1944), and comes up with a list of ingredients (purpose, procedures, rules, number of participants, etc). In 1989, Richard Ziegfield creates an elaborate but very eclectic taxonomy for "interactive fiction", thus focusing on a particular subtype – that is, software-based, diegetic games. Another well-known entry is Björk and Holopainen's game design patterns (2004), inspired by Alexander *et al.*'*s A Pattern Language* (1977). With over 200 patterns, this approach has seen little use in practical analysis (a charge it shares with most if not all approaches, with the noted exception of Caillois 1958), but its descriptive power is impressive. Finally, Zagal et al.'s (2005) wiki project, though largely abandoned at this point, was another general attempt to create a top-down, component-oriented, ontological description of game structures. Their top-level categories are Interface, Rules, Entity Manipulation, and Goals.

PROBLEM: WHAT IS WRONG WITH THE STATUS QUO

Game studies is being conducted from many vastly different points of view (the humanities, social sciences, psychology, design theory, computer science, not to mention the vernacular discourses of the gamer/player communities and the game industry). There are two main reasons for this multitude of approaches:

First – the set of disciplines within which we study games is far from being agreed upon. We are still at the point where new aspects of games are discovered as possible study subjects. Every year, more and more disciplines are added to the mix (queer game studies is a recent example). Needless to say, most of these disciplines come to game studies equipped with their own conceptual tools, methods and assumptions. Note that even this obvious fact isn't free of controversy. Are there any concepts, methods or assumptions which should be shared across every discipline? Or maybe there are some that should be excluded? Can we at least count on some common ground or a starting point? Questions similar to these fueled the narrativist/ludologist controversy but they can just as easily be restated for the purposes of different disciplines.

Second – most of the disciplines which are currently engaged in game studies come already equipped with different, sometimes completely incompatible methodologies (e.g. the analytic vs continental approach in philosophy). Note that it is not the plurality itself that is the problem here but rather our inability to agree on how we should tackle it. Neither is there any consensus on whether these different approaches should be treated as complementary or competing.

This variety seems to be unavoidable as the more we learn about games and play, the more complex and ubiquitous the phenomenon seems to be. However, this situation presents a problem only if we ignore it or settle for a simplistic (i.e. reductionist) solution. But this troublesome variety could also become a great advantage, as it may give us the opportunity to employ a truly interdisciplinary perspective. There is much to gain if we do it right.

The good news is that such difficulties are not exclusive to game studies. Similar debates take place in other multidisciplinary contexts. One notable example is cognitive science, where the collaboration of such diverse disciplines as philosophy, psychology, neurobiology and computer science is crucial for the success of the project. Another, less known example is ecohydrology, which demands the cooperation of engineers, physicists, ecologists, sociologists and lawyers. It would thus be wise to observe how these disciplines cope with their respective methodological diversities and learn from their experience. Because of this, the solution we suggest in the paragraphs below draws from the experience of cognitive science (for a good rundown on how interdisciplinary ideals function in cognitive science see Eckardt 2001).

Another problem which is closely related to the overwhelming methodological diversity we discussed above is the existence of different parallel vocabularies that are used interchangeably. There are at least two major dangers associated with this fact. First of all, this polysemy often goes undetected, resulting in people talking past each other. The other danger is that some of the terms are notoriously vague and using them results in more confusion than benefit. As such, they should either be fixed or avoided in the academic discourse. Arguably, the hardest task here is coming up with a procedure of choosing the terms we should focus on. Even though scholars seem to universally agree that specific terms are notoriously vague (i.e. "game" or "mechanics") it would be too optimistic to decide *a priori* that only those terms should be dealt with.

An additional reason why the vocabulary used in game research needs to be put under scrutiny is that it often meshes with vocabularies used by developers and journalists. Both terms we pointed out above are guilty of this, but it is not hard to come up with even more examples, like "interactivity", "gameplay", "immersion" or "virtual reality". Note that even if this overlap of terminologies can lead (and often leads) to much trouble, taken in and of itself it can just as well end up being an advantage for game studies. A shared vocabulary would definitely facilitate interactions between scholars, developers and journalists.

WHY META-ONTOLOGY?

The solution we would like to propose is that we look at ontologies embedded in game studies through the perspective of different methodologies used in the field. The main idea behind this approach is that all of the disciplines in the field contain an embedded ontology – sometimes tacit or default, sometimes explicit. This assumed ontology often manifests itself in the methods a discipline uses, concepts it is formulated in, theories which it adapts for the purposes of the study of games or in a direct declaration of the author. We believe that because of the interdisciplinary nature of game studies, ontological pluralism is the only realistic attitude we could assume at the start. For this reason, a meta-ontological perspective is needed in order to identify, connect and coordinate different ontological perspectives. The reason why we prefer to characterize this new approach as "meta-ontology" is that its main task is to classify existing ontological perspectives and show how they relate to each other. There are two points we have to make upfront in order to eliminate possible misunderstandings.

Firstly, we do not want to suggest that the proposition we describe in the next section is some kind of universal, external ontological description of objects studied in the field. It is rather a picture which emerges once we look at this object through the lenses of different methodologies and their ontological assumptions. It is meant to be coherent but not homogenized.

Secondly, the model we present in the next section is intentionally more complex than is needed for most single disciplines. Its intention is to chart existing ontological perspectives. Each discipline can then pick and choose the ones that are needed or viable for it. It is nonetheless useful for every discipline to have access to a bird's eye view of all possible perspectives, and more importantly the ways they relate to each other. One of the biggest gains for particular disciplines is that different researchers could see how their work might relate to the work of others. The underlying assumption of this idea is that from a very general point of view all of these disciplines study the same phenomenon, but pinpoint it with different conceptual toolsets.

We argue that the best way to achieve these goals is to treat the object of game studies in terms of a mechanism. On the face of it this idea may seem trivial, but in practice it has some very useful methodological consequences. Most mechanisms contain multiple levels of description. It is often the case that the ontological description of the mechanism as a whole differs from the ontological description of its parts. For example – descriptions of various parts of brain differ from the description of the physical and chemical properties of neurons and these in turn differ from psychological descriptions. But the fact that we differentiate between multiple levels descriptions of an object does change the fact that we can still treat it as one object.

One of the most important advantages of successful mechanistic explanations is that they combine features from multiple levels of description. For example – if we look at the way the heart is studied (granted that we treat it as a mechanism, see Craver 2007) we can see that many explanations of its functions combine descriptions of its functional macro level (for example the role it plays in certain actions of the organism) and its chemical lower level descriptions (for example descriptions of the necessary chemical conditions of the blood needed for the function to be performed). Because of this, the perspective we advocate blocks the risk of descriptive isolationism – the risk of the multidisciplinary field becoming a bundle of disjointed disciplines united only nominally by the phenomenon they study.

But the most characteristic aspect of the mechanistic perspective is that it enables us to reconcile two seemingly contradictory approaches. It explains how one can be at the same time reductionist and anti-reductionist towards the studied phenomenon. Consider the example of a modern computer running a program and the difference between the level of its physical functions and the level of computations it performs. Note that although we are aware of the fact that the software level is reducible to the hardware level – that is, every running computer program could be, in principle, described in purely physical terms – no one thinks that it means that the software descriptions are superfluous or redundant. The reason for it is that even if such a physical redescription is possible it loses the explanatory power of the software description. This wasn't true in the early days of programming when the software and the hardware layers were very similar but nowadays, in most cases, it would have been completely counter-productive. What it means is that even if the phenomenon in question could be said to be ontologically reducible it is not reducible epistemologically.

But it would be incorrect to think that redescriptions of one level of the mechanism in terms of its other levels are useless ontological exercises. Yes – it would be unwise to want to reduce everything to one level (presumably the physical level) and replace every other description with it. But there is something to be gained from the fact that such descriptions are in principle possible. The fact that one can know for sure that everything that happens on one level has its counterparts in other levels means that the claims one is making while talking about one level may have an impact on other levels. And contrary to this – claims one believes have universal appeal may very well end up being useful only locally, on one of the levels.

Thus, to sum it up – meta-ontology sets the stage for interdisciplinary studies in the following manner: it provides a mechanistic model of games spanning over multiple layers compatible with the disciplines that study it. Apart from its obvious usefulness, this type of overall view is also important for any study which makes very broad claims (claims that apply to many or even all aspects of games). A good ontological model gives the researcher the ability to quickly check if the intended claim has the scope she intended it to have (whether it may or may not be ignoring some of the important layers of the game mechanism).

Additionally, it has to provide correlations between layers via redescriptions which help us understand how various elements of one level manifests itself on other levels. This redescription results in a non-invasive reduction of different layers of games. Even though ontology tells you how a given aspect of the game manifests itself on a different layer (for example that a given game mechanic is in reality just a physical state of the computer) it does not follow from that that everything should be studied by physics.

This gives the researchers a useful map of shortcuts connecting their specific research with the research of their peers and provokes interesting research questions - for example: how does a regularity I discovered on level x manifest itself on level y? Note that this function of ontology is especially evident in the case of assessment of the scope of terminology. Observing the usage of a given expression across different levels of game mechanism helps to detect ambiguities and other logical problems with the vocabulary. For example, it might happen that some terms which were originally defined only for selected levels of the game mechanisms are later applied universally (becoming tacit metaphors). For example – consider the notion of “shooting”. It is easy to understand this notion on the level of graphical representation but what does “shooting” mean, when we use the notion to describe game mechanics (regardless of graphical representation)? It seems that in this case it functions more as a metaphor that describes any action at a distance via indirect means (projectile) than as literal shooting. Ontology can diagnose cases like this by checking how the definition of a given term relates to the game model - the rule of thumb being - if it is used within the scope of a given level, the definition should address this level.

PRESENTATION OF THE MODEL

The model we propose consists of four main categories, all of which are subdivided further into three subcategories. It is important to point out once again that it should not be treated as a definition of a game but rather as an ontological description of the domain games are part of – it is thus, by design, over-productive. The over-productiveness or overabundance of the model comes from the fact that the models lists all layers, or property types a game *can* have and it is not a necessary condition for any given game to be describable on every layer. For example, the model can be used to describe both digital and non-digital (for example board) games. In the latter case one of the subcategories (the computational one) can simply be skipped. The other important reason why the model is over-productive is that its main aim is to function as a meta-ontology, that is, a tool for comparison of different ontological solutions. For this reason, it has to be able to fit in different existing categorizations (see Table 1 below).

As mentioned earlier the model consists of four main layers. The first of the layers – **the physical layer** should be the easiest to understand. Even if games can be argued to be abstract entities, they have a physical basis – they contain physical objects and are played by physical entities. The layer is then subdivided into three sub-layers: **platform,** which refers to the material medium used to implement a given game (which can be as varied as a console, a computer, gaming board or a football field), **physical interface**, which refers to all of the physical means used by players (for example a gamepad, a joystick or a baseball bat) and a **behavioral** layer, which describes the set of physical actions needed to play the game (for example pushing the buttons, moving a piece on a board or kicking a ball).

The next main layer – **the structural** layer – demands more explanation. It is supposed to capture several formal, abstract aspects of games, such as: their **computational** layer (in other words, their code), their **mechanical** layer (roughly, what is commonly referred to as game mechanics) and their **economic** layer. The last one is probably the least obvious one, so let us elaborate on it a bit. It refers to the economic structure of the game which is responsible for how the game is initiated, sustained and finished. A typical, historical example of such a mechanism is the coin the player has to put into an arcade machine to start a game. Discerning such a specific economic layer may initially seem to be a bit too fine grained, but it is often the case that a game changes its economic model (for example gets ported from arcade to home machines) without changes to most of the other layers. This offers an easy way to track the changes such a difference makes in terms of other layers and can therefore be very beneficial for game studies. A good example of this is free-to-play games: do monetization schemes (the economical layer) determine other aspects of games (from example its mechanics) or can they be understood as independent from them?

The third main layer – **the communicational –** consists of the following three sub-layers: the **presentational** layer (which refers to the aesthetic aspects of the game), the **semantic** layer (which should be understood broadly and refer to any communicated semantic information, from a simple command to a whole narrative) and **interface** layer which refers to non-diegetic information communicated to the player.

The final main layer of the model – **the mental –** is special in that it concerns the game as being played by an agent. It consists of three sub-layers: the **phenomenal** layer which refers to the way the game is experienced by the player, the **conceptual** layer which refers to the way the player understands (conceptualizes) the game and the **social** layer, which refers to the way players interact and perceive each other in the game.

Main layers	**Sub-layers**
Physical	Platform
	Hardware Interface
	Behavioral
Structural	Computational
	Mechanical
	Economical
Communicational	Presentational
	Semantic
	Interface
Mental	Phenomenal
	Conceptual
	Social

Table 1. The meta-ontological model.

EXAMPLE APPLICATIONS

As explained in the section "Why meta-ontology?" the reason we decided to use the prefix "meta-" is that our model is specifically designed to function as an ontological umbrella capable of covering different existing perspectives in game studies. Thus, whenever we use the model to compare different existing ontological propositions, we engage in meta-ontology. It is nonetheless possible to use the model to analyze games or to analyze some of their aspects. In this case the model functions simply as game ontology. In the following section we present a number of case studies which illustrate both usages. We start with two meta-ontological tasks: we compare several existing ontologies as well as some of the definitions of games. Then, we apply the model to the study of a single game (*Senet*) and one of the aspects of games (the notion of game mechanics).

Analysis of selected existing models

As we already pointed out, one of the most important applications of the meta-ontological model is to compare different ontologies. Table 2 below is a graphical collation of four existing ontological models. Here, the meta-ontological model functions as a framework which helps to show the differences, similarities and juxtapositions of the categories used by the compared models. As fitting the existing categories into the model is always the most controversial task, let us comment quickly on some of the interpretative decisions we took when comparing the theories.

If we look at the model proposed by Konzack (2002), we can easily see that even though he differentiates between physical (hardware) and computational (program code) in the same way our model does, he adds the notion of "functionality" which combines the two. He also does not differentiate between mechanical and representational layers (calling them both "gameplay"). As can be seen from the right side of the table, the socio-cultural aspect of Konzack's model can be correlated with Social sub-layer. Since our model does not differentiate between signifiers and signifieds, both meaning and referentiality have to be listed twice (as signs and as mental correlates of signs).

On a superficial level, the MDA model (Hunicke et al. 2004) fits our meta-ontological framework rather well (as it omits only two categories on the margins: physical and social). And yet, if we look closer, we can easily see a subtle difference as the Dynamics category seems to encompass the economic aspects of the games (since the opposites of starting and terminating the game can be understood as boundary conditions of the dynamics). Because of this, the "dynamics" category cuts across structural and communicational layers. Similarly, the category of Aesthetics cuts across our two main layers (communicational and mental), as MDA does not differentiate between the presentation and the experience of the user.

Contrary to the above, the ontological model proposed by Zagal *et al.* (2007) correlates with our meta-ontological model in a complex manner. First of all, as can be seen below, their category of "Interface" has to be split between the physical and communicational layers because the authors group graphical interfaces and game operating hardware together. In the case of the structural layer, the authors do not include the economical sub-layer and instead introduce three sub-layers, two of which (gameworld rules and rule synergies) coincide with our computational and mechanical sub-layers. The third category (gameplay rules) functions as a hybrid between the computational and mechanical. Interestingly, the notion of "goals" as mechanics observed (or inferred) by the player correlates with the rules from the meta-ontological model (understood as the conceptual sub-layer, since this is what the player does – she conceptualizes mechanics into rules). Last but not least, the difference between entities and entity manipulations seem to be compatible with the difference between presentational and interface sub-layers of the communicational layer. This results in the notion of "entities" to be situated in a similar space as graphical interface elements (but this may be due only to the fact that the notion of entities is rather vague – something that the authors acknowledge).

The last example of a theory we wish to compare with the meta-ontological model is the Aarseth & Calleja model (2015), which consists of four categories. At the more general level (counting only four main layers) these two models are fully compatible. Initially this result may not seem especially impressive, but here the main work the model does for us is that it creates a common framework in which the Aarseth & Calleja model can now be easily compared with other three competing propositions.

Testing a single concept: comparison of game definitions

Without going into too much detail about game definitions (instead, see Juul 2005, Aarseth & Calleja 2015), we can use the model to see what parts of games' ontology these definitions address. For the sake of brevity, we only include a selection of some of the central ones which we present in the publishing order. The main idea behind this comparison is that it enables us to see if a given definition addresses all layers of games or only selected ones.

Definition 1. Roger Caillois.

Even though it is not presented as a definition *per se*, Caillois' (1958) typology of games can be treated as a disjunction of properties essential for games. Once we understand it this way, the typology taken as a whole can be understood as a disjunctive definition. The first two types of games Caillois indicates (*agon* and *alea*) refer to structural properties, as they relate to rules and win conditions as well as mechanics (randomness). The two remaining categories (*mimicry* and *ilinx*) refer to mental properties of games as they relate to the act of role-playing and experiences of the player respectively. Because mimicry can be also described in a purely behavioral manner, it is possible to interpret Caillois as referring to one part of the physical layer of games (behavioral). Since this understanding of mimicry may not be compliant with Caillois intentions, we include it using a bracketed plus sign in the table below.

Definition 2. Elliott M. Avedon & Brian Sutton-Smith

An exercise of voluntary control systems in which there is an opposition between forces, confined by a procedure and rules in order to produce a disequilibrial outcome. (Avedon & Sutton-Smith, 1971)

Locating this definition within our model is not difficult as it directly relates to structural (systems, procedures and rules) and mental (voluntary control) layers.

<table>
<tr><td></td><td colspan="3">Physical</td><td colspan="3">Structural</td><td colspan="3">Communicational</td><td colspan="3">Mental</td></tr>
<tr><td>Existing models</td><td>Platform</td><td>Interface</td><td>Behavioral</td><td>Computational</td><td>Mechanical</td><td>Economical</td><td>Presentational</td><td>Semantic</td><td>Interface</td><td>Phenomenal</td><td>Conceptual</td><td>Social</td></tr>
<tr><td rowspan="2">Konzack</td><td colspan="2">Hardware</td><td></td><td>Program code</td><td colspan="2" rowspan="2">Gameplay</td><td colspan="3">Meaning</td><td rowspan="2"></td><td>Meaning</td><td rowspan="2">Socio-cultural</td></tr>
<tr><td colspan="4">Functionality</td><td></td><td colspan="2">Referentiality</td><td>Referentiality</td></tr>
<tr><td rowspan="2">MDA</td><td colspan="3" rowspan="2"></td><td colspan="2" rowspan="2">Mechanics</td><td colspan="4">Dynamics</td><td colspan="3"></td></tr>
<tr><td></td><td colspan="5">Aesthetics</td><td></td></tr>
<tr><td rowspan="3">Zagal et al.</td><td colspan="3" rowspan="3">Interface</td><td>Gameworld rules</td><td></td><td rowspan="3"></td><td rowspan="3">Entities</td><td colspan="2">Entity manipulation</td><td rowspan="3"></td><td rowspan="3">Goals</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Gameplay rules</td><td></td><td>Interface</td></tr>
<tr><td></td><td>Rule synergies</td><td colspan="2"></td></tr>
<tr><td>Aarseth & Calleja</td><td colspan="3">Materiality</td><td colspan="3">Mechanical system</td><td colspan="3">Sign</td><td colspan="3">Player/human agent</td></tr>
</table>

Table 2. Different ontologies classified by the meta-ontological model.

Definition 3. Bernard Suits.

To play a game is to attempt to achieve a specific state of affairs (prelusory goal), using only means permitted by the rules (lusory means), where the rules prohibit use of more efficient in favour of less efficient means (constitutive rules), and where the rules are accepted just because they make possible such activity (lusory attitude). [... .] [P]laying a game is the voluntary attempt to overcome unnecessary obstacles. (Suits, 1978, p. 41)

Suits' definition concerns a more complex notion of "playing a game", but it is often treated simply as a definition of games, so it is useful to include it. Similarly to the proposition of Avedon and Sutton-Smith, Suits' definition relates only to structural layer (goal, rules, constitutive rules) and the mental layer (lusory attitude, voluntary attempt).

Definition 4. Sid Meier.

The fourth definition comes from the famous slogan attributed to Sid Meier – "a game is a series of interesting choices'' (Rollings & Morris, 2004, p. 61). This short definition addresses two layers: the structural (the notion of a choice) and the mental (the idea of the choice being "interesting")

Definition 5. Katie Salen & Eric Zimmerman

A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome. (Salen & Zimmerman, 2004).

This definition clearly focuses on the structural properties of games (rules, quantifiable outcome) but expands it with the notion of "conflict" which belongs to the communicational layer.

Definition 6. Jesper Juul.

A game is a rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels emotionally attached to the outcome, and the consequences of the activity are negotiable. (Juul, 2005, p. 36)

There are no doubts that the structural layer (rules, system, quantifiable outcome, variables) and the mental layer (effort, emotional attachment) are mentioned. The idea of negotiable consequences should also be labelled as mental layer because it refers to social negotiability.

Definition 7: Espen Aarseth

Games are facilitators that structure player behavior, and whose main purpose is enjoyment (Aarseth 2007).

It is easy to see that it directly refers to three layers of our meta-model: physical (behavior), structural (structure) and mental – in both, phenomenal (enjoyment) as well as social (purpose) senses.

Definition 8. Thomas M. Malaby.

A game is a semibounded and socially legitimate domain of contrived contingency that generates interpretable outcomes. (Malaby, 2007, p. 96)

It seems that the notion of "semibounded and socially legitimate domain of contrived contingency" should be treated as a mixture of the mental layer with the structural layer, because it refers to both – the artificiality of the system (which generates outcomes) as well as to the way the system is treated in society. The notion of "interpretable outcome" locates the definition partly in the communicational layer as well.

Definition 9. Sebastian Deterding.

Gaming is sociomaterially framed (that is, materially organised to afford and socially expected, understood, normed, enacted and communicated as) the autotelic enjoyment of euphoric ease, spontaneous engrossment, and demonstration of skill in the pursuit of a problematic outcome with slight consequentiality—in a word, voluntary safe action. (Deterding, 2013, p. 237)

This definition is very interesting because it clearly refers to the physical layer (materially organized, enacted) and the mental layer (socially expected, understood, normed, autotelic enjoyment, euphoric ease, spontaneous engrossment, demonstration of skill, pursuit of a problematic outcome, voluntary safe action) as well as communicational layer (communicated) but does not refer to the structural layer. The reason for it is that it mentions "the outcome" only as something perceived by the player as problematic, and not something that is calculated, generated or even evaluated by the system of rules.

Definition	1	2	3	4	5	6	7	8	9
Physical	(+)						+		+
Structural	+	+	+	+	+	+	+	+	
Communicational					+			+	+
Mental	+	+	+	+		+	+	+	+

Table 3. The meta-ontological model applied to the comparison of game definitions.

Even a cursory glance at the results of our meta-ontological analysis of game definitions provides four interesting observations. First of all, no single definition refers to all layers (even though every layer is present in at least one of them). Second of all, hardly any of the definitions regards the physical aspects of games. Third of all, later definition tend to encompass more layers than the early ones. Fourth of all, most of the definitions depict games as combinations of mental and structural properties.

It can be argued that the differences between existing definitions are to some extent caused by two important ambiguities which have been diagnosed by several scholars (see Stenros 2017 for a good summary). The first ambiguity comes down to the difference between games as actions or processes and games as artifacts. It seems that most of the definitions focus on the process and not the artifact which explains the lack of physical layer. The second ambiguity comes from the difference between the notion of "play" and the notion of a “game”. It seems that the authors which focus mostly on the former, relate to the mental aspects (a special attitude correlated with play or a special status of the act of play in society). Contrary to this, authors which focus mostly on the notion of a “game” relate to its systemic and structural aspects.

Testing a single game: Does *Senet* still exist?

Senet, “the game of passing”, is, or perhaps was, a board game from ancient Egypt, more than 5000 years old. The board, “dice” (sticks) and tokens have been found in numerous Egyptian tombs, and also described in ancient documents and in papyrus illustrations. Therefore, it is assumed that its ritual meaning is to have been played between the recently deceased and the gods as a test of entering the afterlife. Tutankhamun, the Egyptian king who died merely 18 years old, had no less than four sets of Senet buried with him, an indication that, even 3000 years ago, teenage boys were very fond of games.

Figure 1: Senet. Queen Nerfertiti makes her move (Source: Wikimedia)

But despite all this historical evidence, the game rules are no longer known, as they are not described in any of the written accounts, which read more like bragging and superficial let’s-play sessions. So today, no one knows how to play *Senet*, although several rule reconstructions exist, the most well-known of which is found in Kendall (1978). These rulesets are by necessity speculative, and it would not be hard to make up another set of rules with equal claim to (lack of) historical accuracy. So, the question is, does the game still exist, or more precisely, in which sense does it still exist? With the help of the model, we can give an answer:

	Senet
Physical	+
Structural	
Communicational	+
Mental	

Table 4. Evaluation of Senet

If we look at each of the four levels in turn, we see that physically (materially) the game still does exist, and also the communicative structure (the tokens, board, and signs thereupon) does still exist. The structural (mechanical) level, however, is lost, as is the mental (player) level. In other words, on the levels that influential game scholars (e.g. Juul or Salen & Zimmerman) would be most interested in, *Senet* no longer exists. But from a physical and communicational perspective, it is still with us. A generalization of this conundrum is, do games exist independent of their rules? The answer may be – sometimes– with games like *Poker* and *Paintball*, the rules are not their defining element, but they do have (switchable) rulesets. *Senet*, on the other hand, only exists as a game without rules; a ludic corpse – the soul of the game has passed on.

An explanation of the difference between mechanics and rules

The model pinpoints the difference between mechanics and rules but it does not provide a full characteristic of either of them, since their definitions vary from model to model. Instead, this is a task for future game ontologies. The main difference between them is that rules, as opposed to mechanics, are situated at the mental (not structural) level. Roughly speaking we might say that rules are what the player infers from the mechanics she is presented with. Rules can be understood as mechanics that the player perceives, while mechanics are embedded in the structure independently of what the user thinks of them. Rules are either interpreted mechanics, or postulated norms. An interesting additional aspect of the model is that it also facilitates various research questions concerning the status of game mechanics. We may for example ask whether game mechanics are situated on the computational or on the physical level (Gregersen 2005). We may also wonder if some of the mechanics could be a part of a game without being implemented at the computational level at all.

CONCLUSION

As we have seen, the model we propose can be used as an ontological model in its own right (once we apply it to games and their elements), but also as a comparative tool for determining similarities and differences between existing ontological models. As we have shown in case studies in the last section, the model can be used to evaluate and verify both game definitions, ontologies, and concepts, and also to analyze specific games (*Senet*) or their elements (mechanics). We hope that in the future it will be also possible to apply the model to other domains. For example – as suggested in (Aarseth & Grabarczyk 2017) it is possible to use the model to explain the notoriously vague notions of game "versions", "ports" and "clones" which may facilitate historical studies of games (problems with these notions in the context of historical studies have been pointed out by (Newman 2012) and (Stucky 2014)).

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