Game Analysis

(a.k.a The Science of Game Design)

Prof. Perttu Hämäläinen 2024

Course learning goals

- Skills and knowledge that helps in game design
- Grounded in science and research

Course contents

- Week 1: Game design & research intro, MDA & emergence
- Week 2: Game design math, balancing, analytics
- Week 3: Understanding games and players through AI-assisted text analysis
- Week 4: Psychology of game design: Behavioral game design, behavioral economics, monetization psychology
- Week 5: Psychology of game design: Intrinsic motivation, emotion
- Week 6: Understansding the human body: Motor learning and performance, action game design, movement-based games. We end by testing some embodied games at **Valo Motion showroom**, Tuesday 26 November, at 13.15-15, https://www.valomotion.com/

Lecture slides, code & spreadsheets: https://github.com/PerttuHamalainen/GameAnalysis

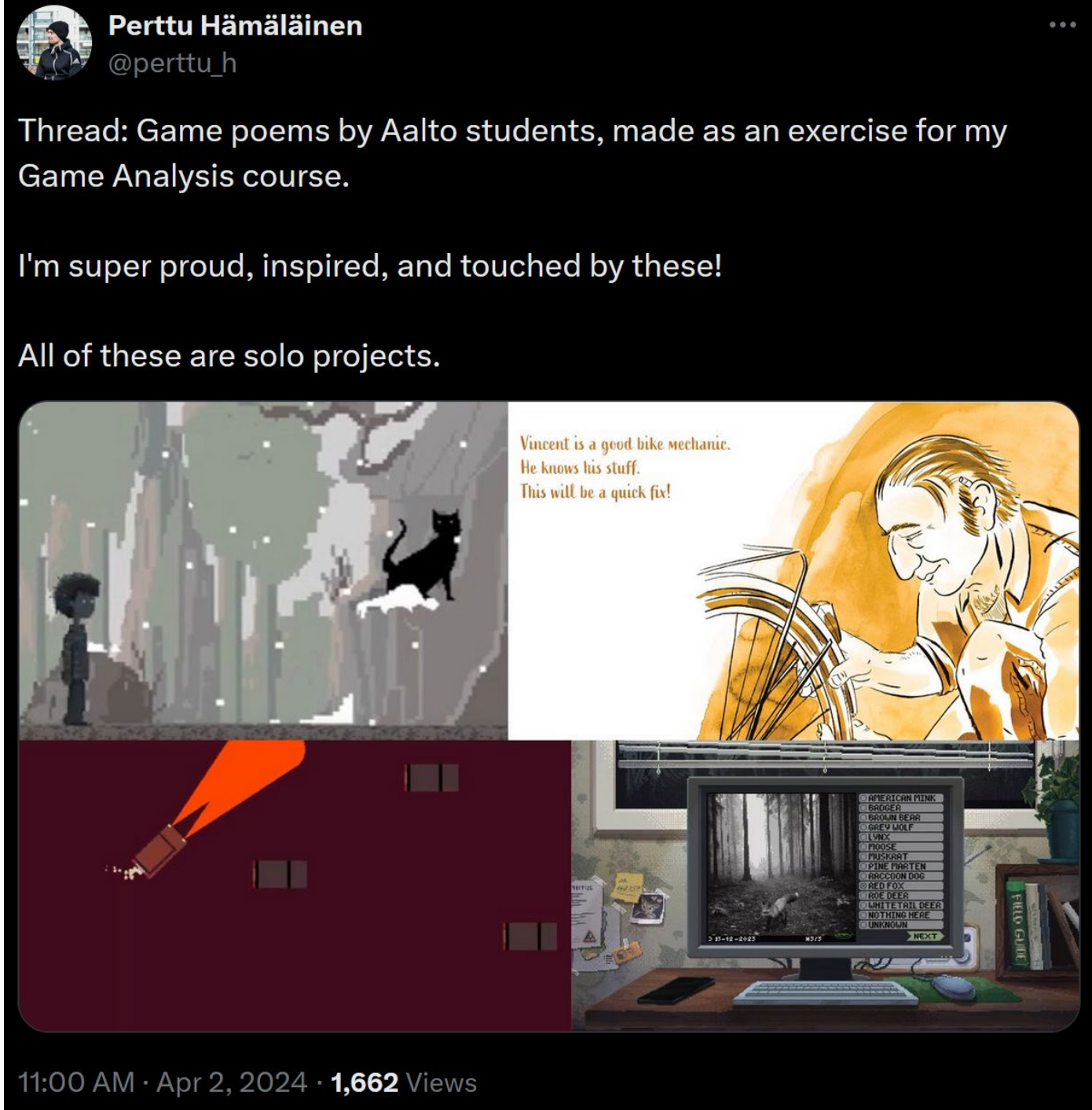
Passing the course: Final assignment

- Option 1: Make a small game or game poem that explores a theme or themes discussed on the course, e.g., how to elicit a particular emotion
- Option 2: Technical/mathematical analysis exercise, e.g., analyze the balance of a game based on data that you scrape from the game's wiki
- Option 3: Read a book, write a learning diary
- Option 4: Literature survey of a topic you're interested in

For details, see final_assignment_instructions.pdf in the course Github

Final assignment games from 2023

https://x.com/perttu_h/status/1775070670260457920



Contents (today)

- What are games?
- What is game design?
- Why research & theory?
- How to search and find research?

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- What is game design?
- Why research & theory?
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Let’s do a quick study

Go to https://presemo.aalto.fi/gameanalysis/ and answer the question:

What is your definition for a game?

The answers by others are initially hidden to avoid you biasing each other.

Vote for the best definitions

https://presemo.aalto.fi/gameanalysis/

Some common definitions

Costikyan 2002

”Interactive structure of endogenous meaning that requires players to struggle toward a goal”

Caillois 1961

”An activity which is essentially:

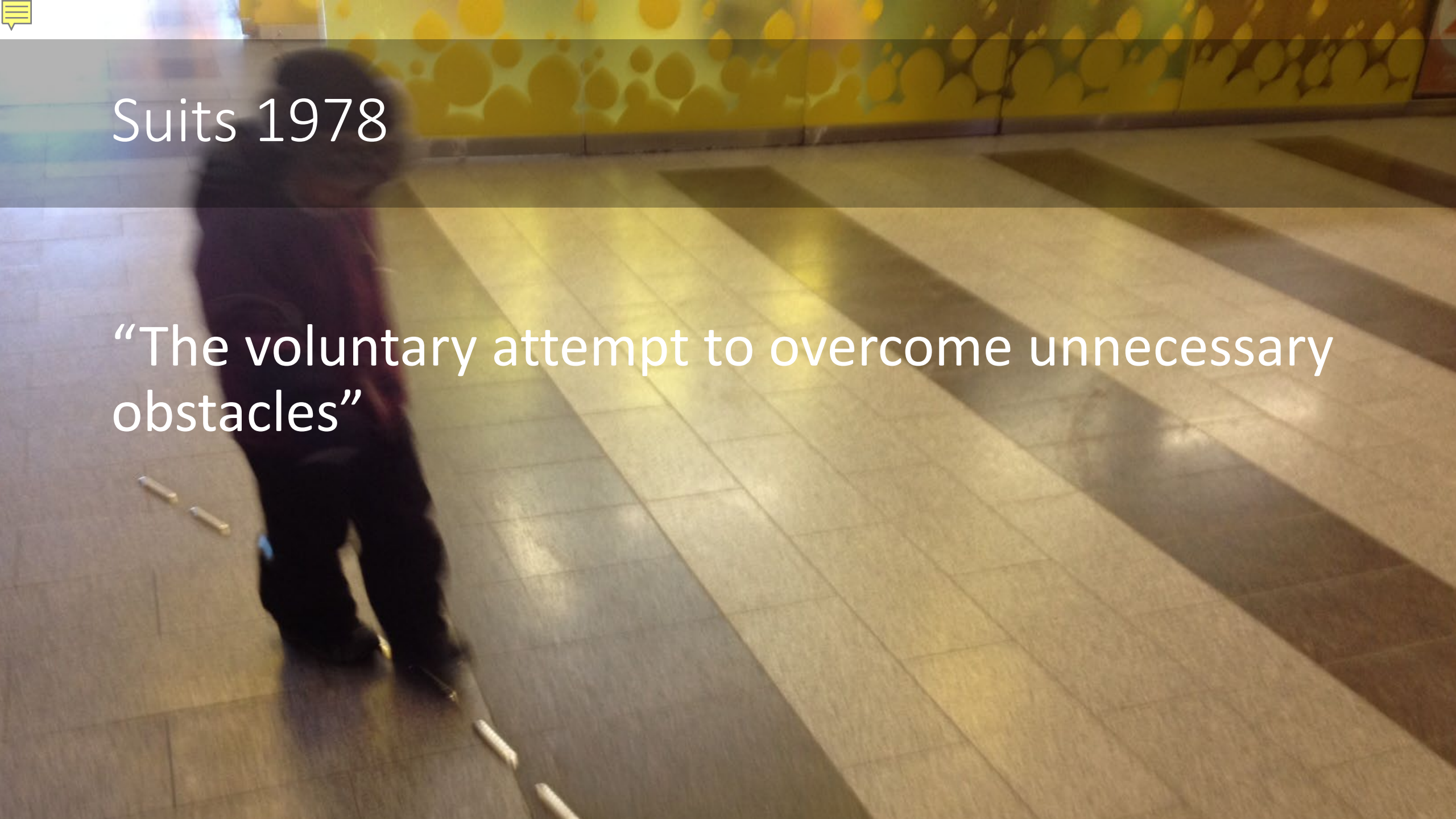
- Free (voluntary)
- Separate (in time and space)
- Uncertain
- Unproductive (as opposed to work)
- Governed by rules (different that ordinary laws)
- Make-believe (accompanied by an awareness of a second reality)

Caillois’ 4 types of play

- Agon, or competition. (Chess)
- Alea, or chance. (Slot machines)
- Mimicry, or role playing.
- Ilinx (Greek for "whirlpool"), or *vertigo*

Schell

”A problem-solving activity approached with a playful attitude”



Suits 1978

"The voluntary attempt to overcome unnecessary obstacles"

The most interesting work often stretches or breaks common definitions

https://www.gamepoemsbook.com/

TODO add a selected clip of Magnuson's talk

Jordan Magnuson: Videogames Are Poems | Games Now!

https://youtu.be/C1UepnhRFOk?si=OSsfs3BGub5WDOFO&t=556

Games Now!
1,26 t. tilaajaa
Tilaa

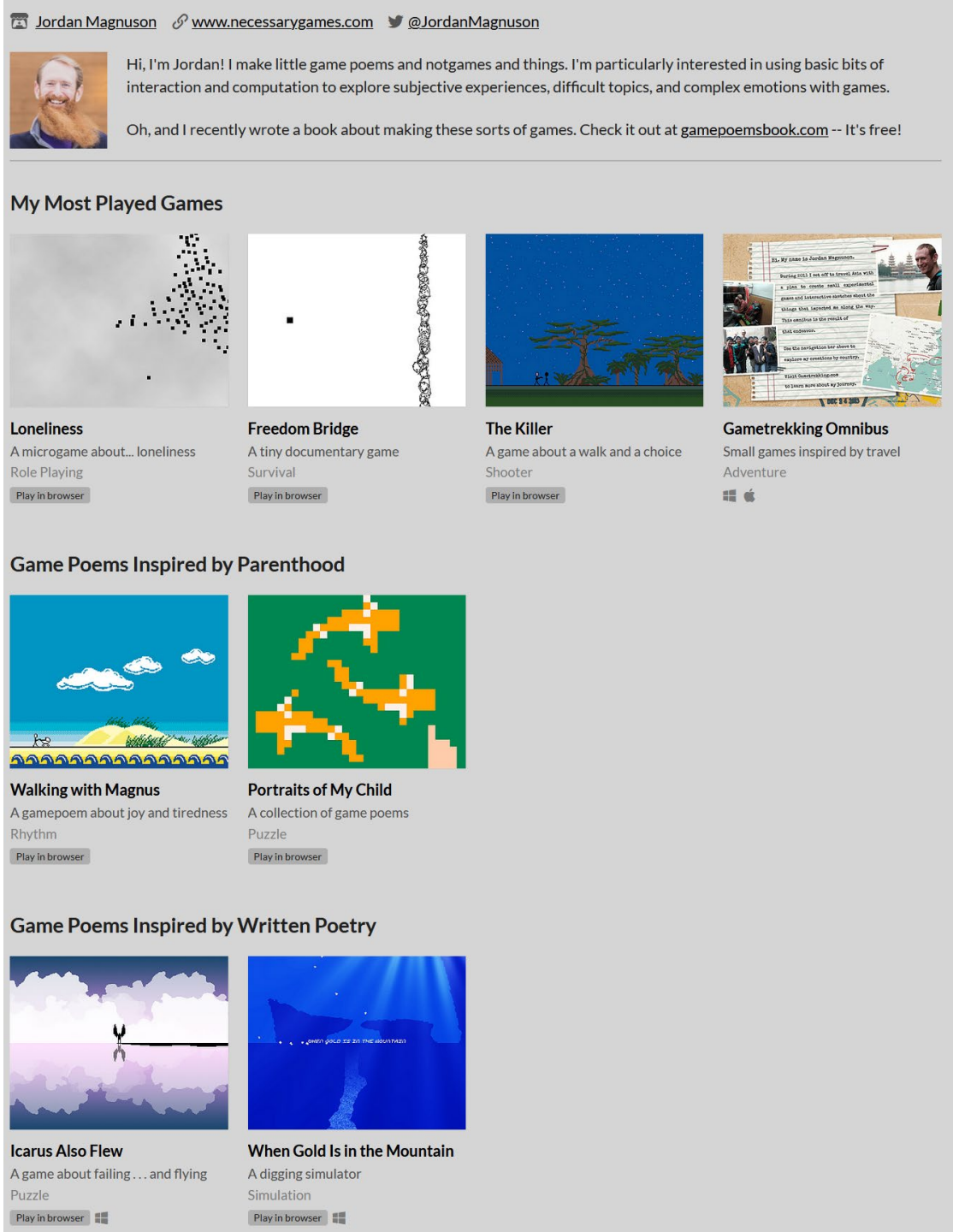
10 Jaa Klippi Tallenna ···

Let’s play some game poems

https://jordanmagnuson.itch.io/
https://www.poeticvideogames.com/

Game Analysis 2023 game poems:
https://carandache.itch.io/vincent-game-poem
https://www.youtube.com/watch?v=XzvjeZrhZKA
https://www.youtube.com/watch?v=kb6fUhg-GSY
https://www.youtube.com/watch?v=g1X1SWlcWJ8
https://tanttinator.itch.io/mort
https://soupsfactory.itch.io/looktoday
https://www.youtube.com/watch?v=rhZZ0SzMQNM
https://casino-teelicht.itch.io/hibiscus

Share any thoughts, insights or lessons learned on Presemo!
https://presemo.aalto.fi/gameanalysis/



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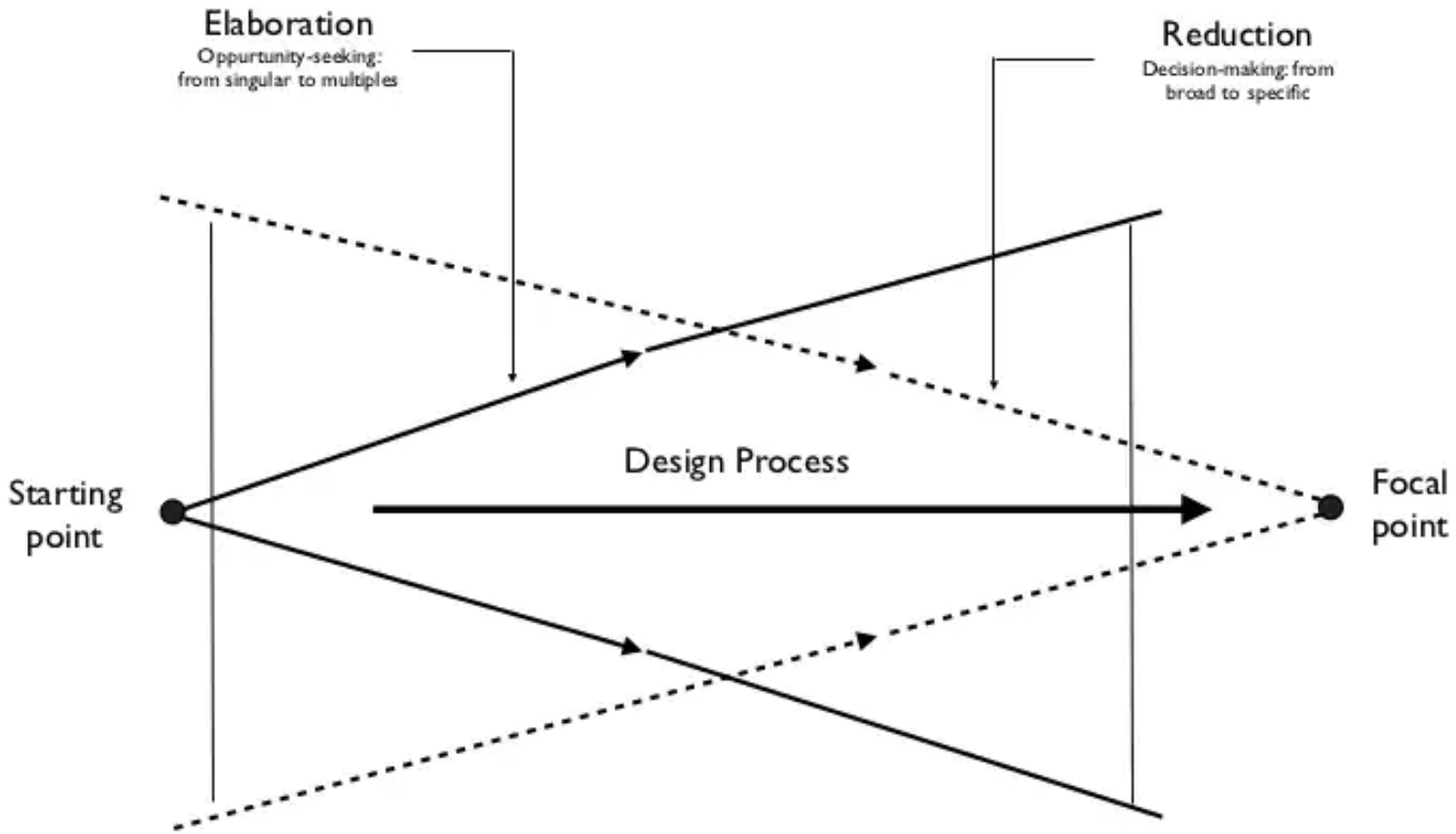
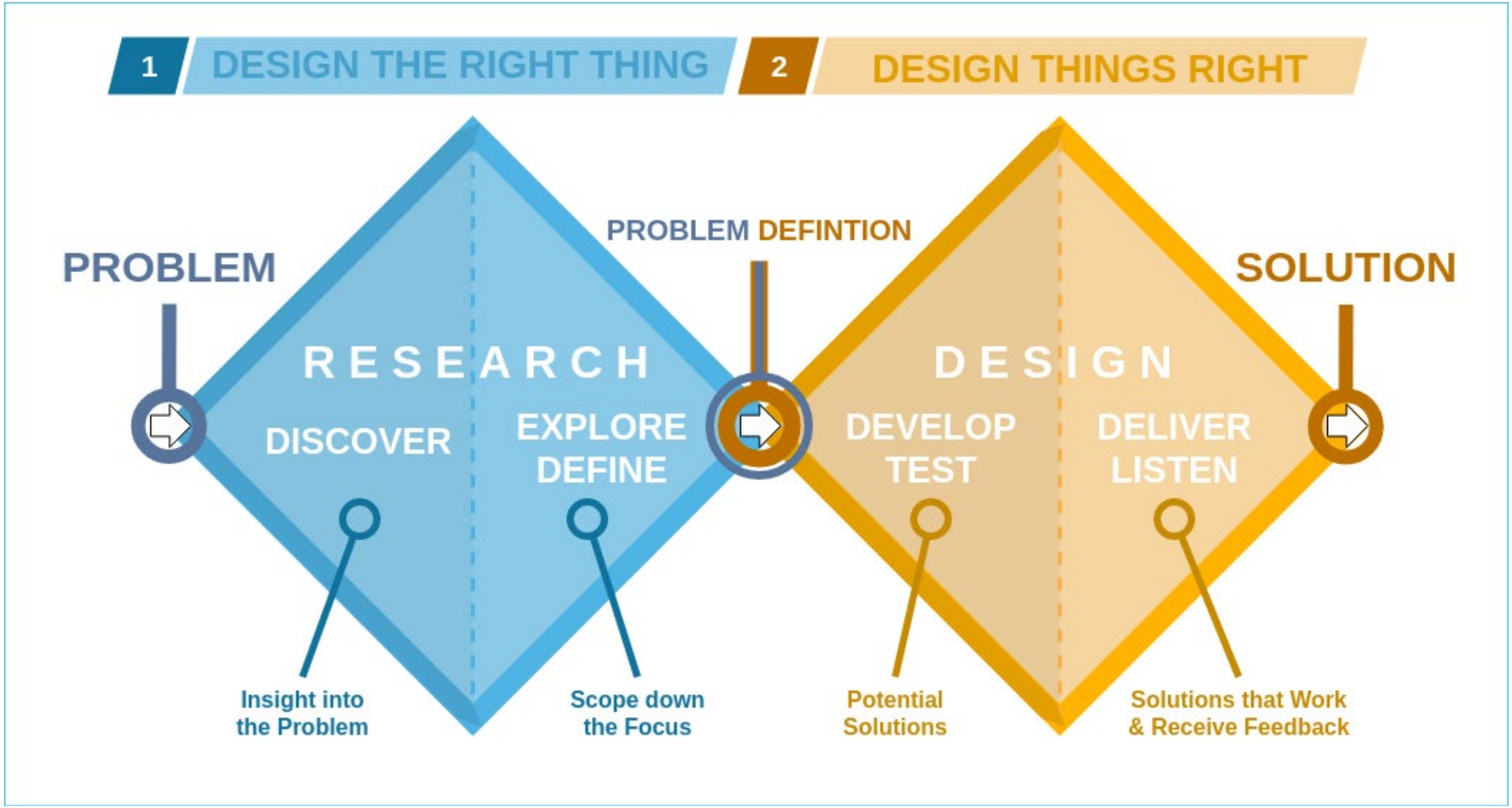
Divergent and convergent thinking

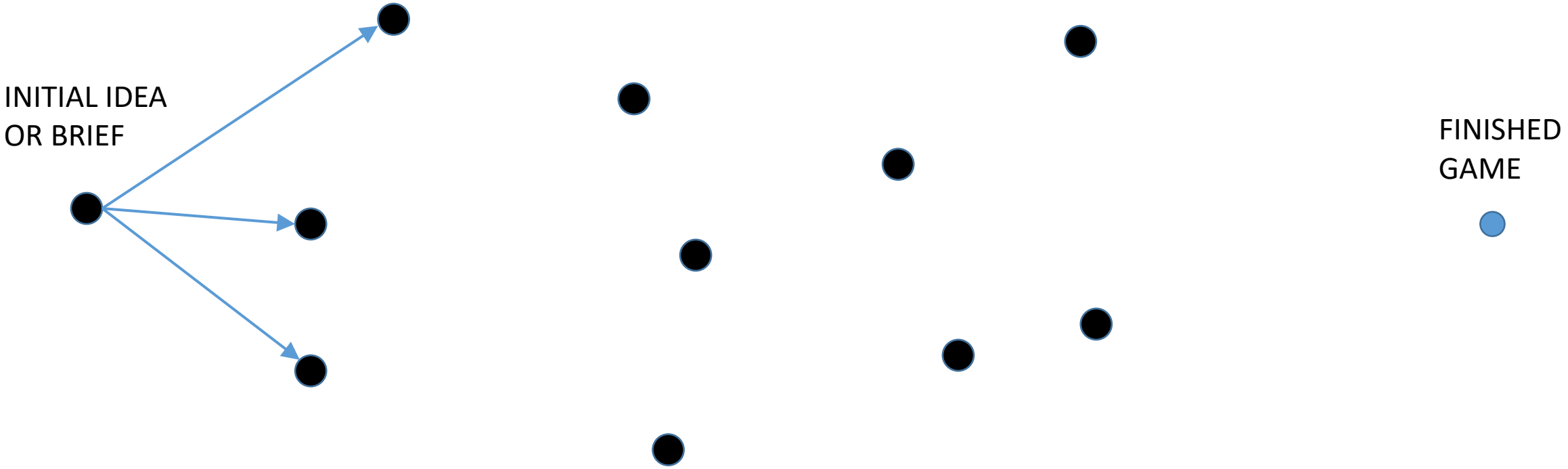


Bill Buxton 2007, Sketching User Experiences; Paul Laseau 1980, Graphic Thinking for Architects and Designers

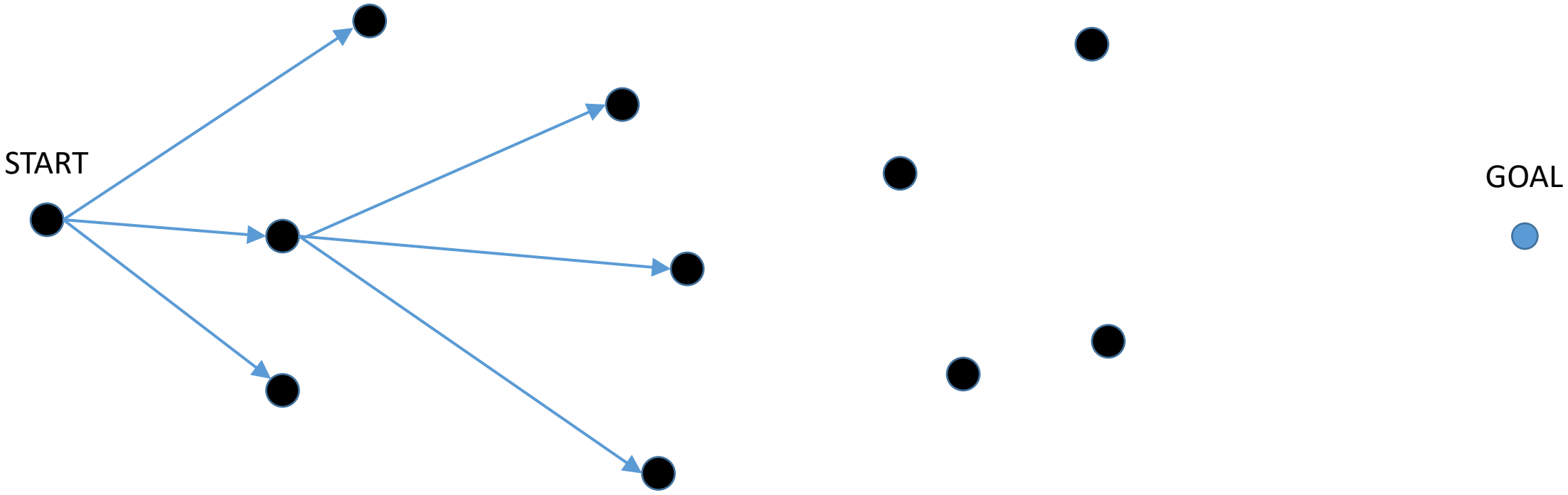
The Double Diamond Method



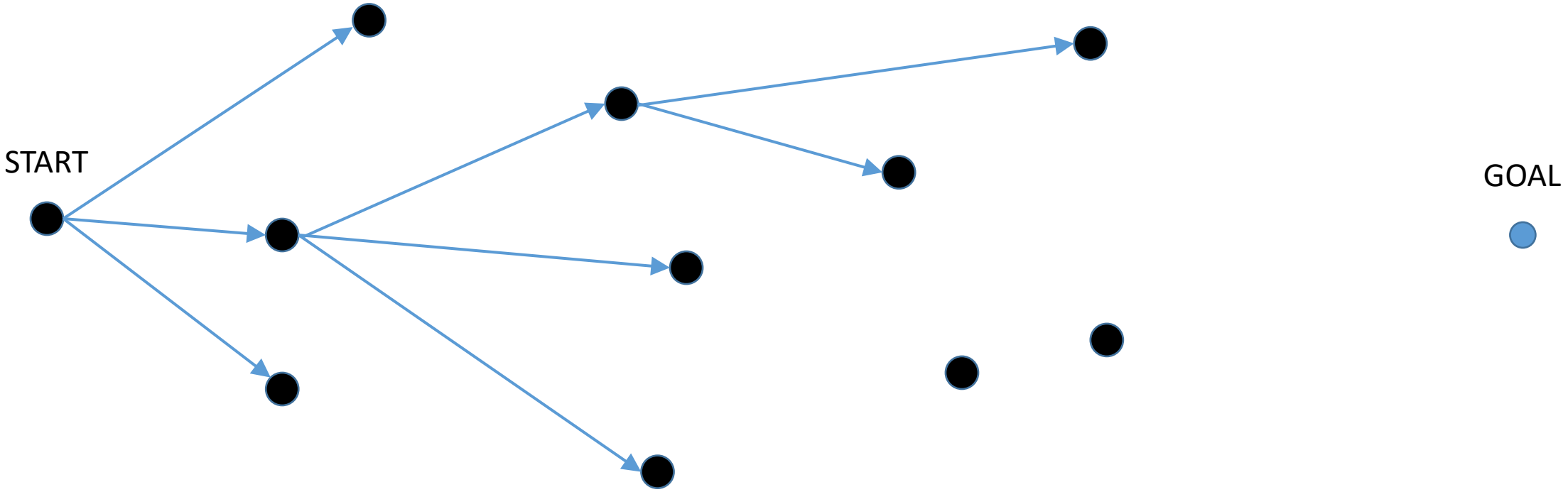
Game design as tree search



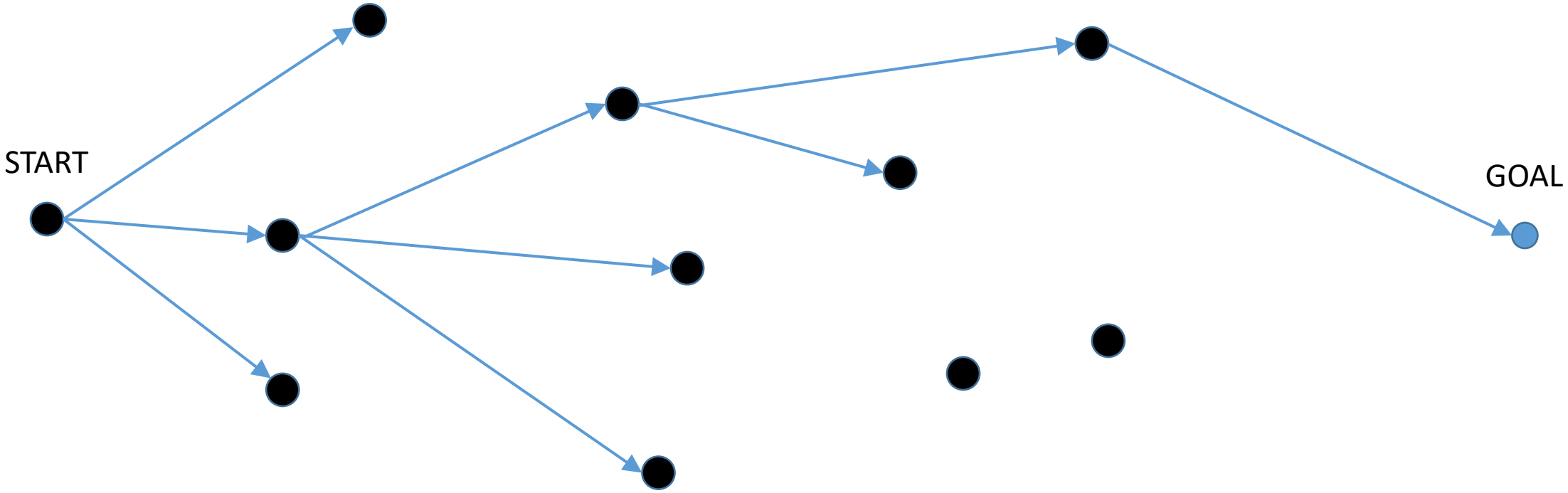
Game design as tree search



Game design as tree search



Game design as tree search



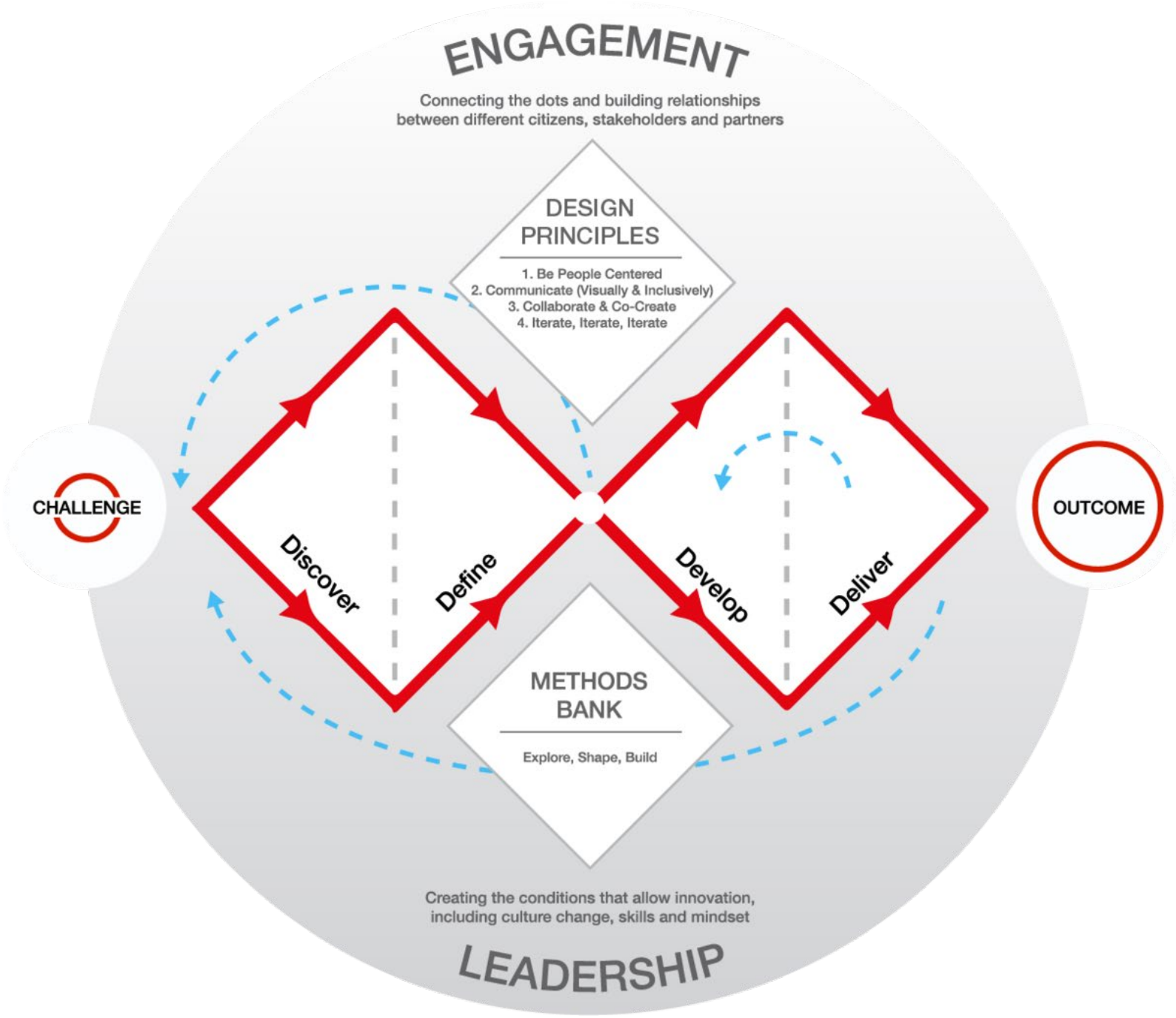
Why is design hard?

- Core problem: How can we elicit desired player behavior and experience?
- Example of what is desired: player stays motivated and completes the game, and has a strong emotional experience that they reflect and discuss with their friends.
- We can only indirectly affect the behavior and experience, through the game's design
- Behavior and experience are hard to predict

  ⇒Slow and iterative trial-and-error design process

  ⇒Both goals/problems and solutions may need to be reinvented during the process

Double diamond and iteration



https://www.designcouncil.org.uk/our-resources/framework-for-innovation/

Discuss: Based on these models, how can you minimize the amount of wasted effort?

https://presemo.aalto.fi/gameanalysis/

Tree search efficiency

- Time spent in implementing and evaluating a branch
  - Using agile tools and methods that speed up the feedback cycle.
  - Use player models to augment or replace slow and expensive playtesting
- Search depth
  - Scoping the game.
- Confidence in making decisions and selecting what alternatives to evaluate
  - Research-based best practices
  - Research-based predictions of the player experience and/or behavior resulting from a design decision or change
  - Research-based answers to questions that arise when discussing alternatives

Theory vs. practice

Figure 4: Seven timelines of Noita.

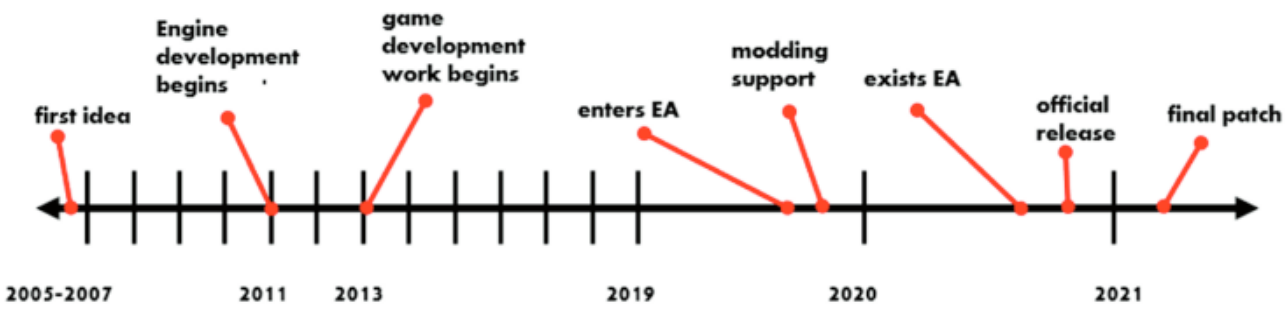


Figure 6: A rough timeline of Noita's *development.*

6. NOITA – A LONG JOURNEY OF A GAME IDEA

ANNAKAISA KULTIMA, RIINA OJANEN, AND NIKLAS NYLUND

https://todigra.org/index.php/todigra/article/view/2186/2183

ABSTRACT

In this article, we present a case study where we used timelines as a structuring method for understanding the creative process of game development spanning several years. In the case study, an indie game, *Noita*, with over ten years of development time, was analyzed through a multitude of sources such as devlogs, prototypes, builds, interviews and fan engagement. As a result, we came up with a timeline with over 150 entries in seven distinct phases to showcase the richness of the design journey, with multiple milestones and influences on the development process. In this article, we reflect on the research process and suggest the use of the timeline method as a part of the multidisciplinary toolset for studying game design.

KEYWORDS

timeline method, game design process, game development, game design praxiology, game production studies, game design, indie game development, Noita, Finnish games

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What is research?

- A process that produces **new knowledge**
- Different research approaches produce different types of knowledge
- Different research communities value different types of knowledge
- Value and validity of the **research contribution** is determined through **peer review**

Common contribution types and how to evaluate

- Empirical research
- Artifact (e.g., an experimental game)
- Methodological
- Theoretical
- Dataset
- Survey
- Opinion / essay

https://faculty.washington.edu/wobbrock/pubs/interactions-16.pdf

Jacob O. Wobbrock, University of Washington
Julie A. Kientz, University of Washington

Research Contributions in Human-Computer Interaction

Insights

- Knowledge generated by HCI research can be categorized into certain contribution types.
- Each contribution type has key characteristics that imply how it is judged.
- The contribution types used for submissions to the CHI conference have evolved over time to distill types of knowledge from other concerns.

IMAGE BY VARINTHRON MEKKAMON

All scholarly fields strive to contribute new knowledge. In the field of human-computer interaction (HCI), this new knowledge increasingly comes in rich forms like videos and demos, but the archival research paper remains the most widely used and accepted capture and delivery mechanism for research knowledge. The knowledge contribution made by a research paper—or more precisely, made by the work a research paper describes—is any research paper's central feature. For example, a theoretical physics paper may contribute a new mathematical model for the behavior of light near black holes. A civil engineering paper may contribute a new method for stress-testing bridges. A social anthropology paper may contribute an account of people's reactions to teen pregnancies in rural religious communities. Whatever the field of inquiry, whatever the phenomenon of interest, every research paper strives to make a research contribution by offering new knowledge. In an effort to distinguish this kind of knowledge from everyday know-how, some scholars even capitalize the term: Knowledge.

In the whole of human inquiry, there are, of course, countless specific research contributions to be made. But

Research as Problem-Solving

- Identifying, articulating, and solving problems
- Evaluation: Significance, Effectiveness, Efficiency, Transfer/generalizability, Confidence
- Problem domains in games: Technology, development methods & tools, player experience…
- Generally: empirical, conceptual, and constructive problems

HCI Research as Problem-Solving

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Aalto University, Finland

Kasper Hornbæk
University of Copenhagen, Denmark

ABSTRACT
This essay contributes a meta-scientific account of human–computer interaction (HCI) research as problem-solving. We build on the philosophy of Larry Laudan, who develops *problem* and *solution* as the foundational concepts of science. We argue that most HCI research is about three main types of problem: empirical, conceptual, and constructive. We elaborate upon Laudan's concept of *problem-solving capacity* as a universal criterion for determining the progress of solutions (outcomes): Instead of asking whether research is 'valid' or follows the 'right' approach, it urges us to ask how its solutions advance our capacity to solve important problems in human use of computers. This offers a rich, generative, and 'discipline-free' view of HCI and resolves some existing debates about what HCI is or should be. It may also help unify efforts across nominally disparate traditions in empirical research, theory, design, and engineering.

Author Keywords
Human–computer interaction; Problem-solving; Scientific progress; Research problem; Larry Laudan

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION
The spark for writing this essay comes from feelings of confusion, and even embarrassment, arising in describing our field to students and other researchers. What is human–computer interaction (HCI) as a field? As numerous ideas and disciplines contribute to HCI, its unique character is elusive. Although HCI is in intellectual debt to many other fields, few would agree that it reduces to them. It has its own subject of enquiry, which is *not* part of the natural or social sciences. It does not belong to engineering, computer science, or design either. So what is it?

The essay has a grand ambition: to develop a conceptually coherent account of the '95% of HCI research'. We know of no other paper offering an attempt to address the field as a whole. We are motivated first and foremost by the intellectual enigma pertaining to what HCI *is*: There is no accepted account that would tell how HCI's numerous approaches contribute to pursuit of shared objectives. In contrast, HCI has been criticised for lack of 'motor themes, mainstream topics, and schools of thought' [25] and for being fragmented 'across topics, theories, methods, and people' [38]. Consequently, some have called for 'a hard science' [36], others for 'strong concepts' [19] or an 'inter-discipline' [3]. These are serious concerns with serious implications for the field.

CHI'16, May 07-12, 2016, San Jose, CA, USA

DOI: http://dx.doi.org/10.1145/2858036.2858283

Why bother with a meta-scientific paper at a technical conference? Because the stakes are high. Philosophies of science are at worst an impotent topic worthy of hallway conversations. But if the critics are right, our field is seriously crippled, from the project level to the larger arenas of research *Realpolitik*. Lacking a coherent view of what HCI is, and what *good* research in HCI is, how can we communicate results to others, assess research, co-ordinate efforts, or compete? In addition, as we show, philosophical views offer thinking tools that can aid in generating ideas and generally enhance the quality of research.

The contribution here lies in describing HCI as *problem-solving*. An overview is given in Figure 1. The view originates from Larry Laudan's philosophy of science [28]. Laudan describes scientific progress in terms of two foundational concepts: *research problem* and *solution*. Laudan's 'problem' is not what we mean by the term in ordinary language. It is defined via inabilities and absences occurring in descriptions; knowledge; or, as often in HCI, constructive solutions. For example, a research problem may involve lack of understanding of how colour schemes on a web page affect the aesthetic experience of its use. More generally, Laudan's research problem subsumes what we traditionally understand in HCI as a 'design problem' but also problems to do with theory and empirical research.

Most of our argumentation builds on a concept put forth by Laudan that links problems with solutions: *problem-solving capacity*. For Laudan, a solution is something special, too. In the above-mentioned case of aesthetic perception of web pages, possible solutions range from descriptions of self-reports to models of aesthetic impressions. These solutions change the status of the inabilities and absences but in different ways. Laudan qualifies this in terms of *improvements to problem-solving capacity*. This is counter to some traditional notions of progress [28, p. 14]:

> In appraising the merits of theories, it is more important to ask whether they constitute adequate solutions to significant problems than it is to ask whether they are 'true',

Research Through Design (RtD)

- Earlier/alternative view of artifact and problem solving contributions such as experimental game prototypes
- *"Emphasizes practicing design and producing artifacts as a way of generating knowledge"* (https://dl.acm.org/doi/pdf/10.1145/3290607.3299011)
- Evaluation criteria (Zimmerman et al. 2007): Process, Invention, Relevance, Extensibility
- Gaver et al. 2012 argue against too restrictive evaluation criteria and embracing a diversity of RtD approaches and results https://dl.acm.org/doi/pdf/10.1145/2207676.2208538

Research Through Design as a Method for Interaction Design Research in HCI

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Carnegie Mellon University
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ABSTRACT
For years the HCI community has struggled to integrate design in research and practice. While design has gained a strong foothold in practice, it has had much less impact on the HCI research community. In this paper we propose a new model for interaction design research within HCI. Following a research through design approach, designers produce novel integrations of HCI research in an attempt to make the *right* thing: a product that transforms the world from its current state to a preferred state. This model allows interaction designers to make research contributions based on their strength in addressing under-constrained problems. To formalize this model, we provide a set of four lenses for evaluating the research contribution and a set of three examples to illustrate the benefits of this type of research.

Author Keywords
design, interaction design, interaction design research, HCI research, research through design, wicked problems, design theory, design method

ACM Classification Keywords
H5.2. User Interfaces: Theory and methods.

INTRODUCTION
In recent years we have both witnessed and participated in the struggle as several academic institutions have attempted to integrate design, with technology and behavioral science in support of HCI education and research. While there has been great excitement about the benefits integrating design can bring, we quickly realized that no agreed upon research model existed for interaction designers to make research contributions other than the development and evaluation of new design methods. Over the last two years we have undertaken a research project to (i) understand the nature of the relationship between interaction design and the HCI research community, and (ii) to discover and invent methods for interaction design researchers to more effectively participate in HCI research.

CHI 2007, April 28–May 3, 2007, San Jose, California, USA.

Through our inquiry we learned that many HCI researchers commonly view design as providing surface structure or decoration. In addition, we lack a unified vision of what design researchers can contribute to HCI research. This lack of a vision for interaction design research represents a lost opportunity for the HCI research community to benefit from the added perspective of design thinking in a collaborative research environment. The research community has much to gain from an added design perspective that takes a holistic approach to addressing under-constrained problems.

To address this situation, this paper makes two contributions: (i) a model of interaction design research designed to benefit the HCI research and practice communities, and (ii) a set of criteria for evaluating the quality of an interaction design research contribution. The model is based on Frayling's *research through design* [14], and it stresses how interaction designers can engage "wicked problems" [21]. What is unique to this approach to interaction design research is that it stresses design artifacts as outcomes that can transform the world from its current state to a preferred state. The artifacts produced in this type of research become design exemplars, providing an appropriate conduit for research findings to easily transfer to the HCI research and practice communities. While we in no way intend for this to be the only type of research contribution interaction designers can make, we view it as an important contribution in that it allows designers to employ their strongest skills in making a research contribution and in that it fits well within the current collaborative and interdisciplinary structure of HCI research.

Definitions
As we conducted this inquiry, we quickly realized that within both the HCI and design communities there is an inconsistent and confusing use of the following terms. Therefore, below we provide a set of definitions for these terms with respect to this paper.

Designer. Using such a generic term is a challenge at best. At CHI 2006's SIG: "The CHI Design Community", Bill Buxton sarcastically claimed that if everyone is a designer because they select their own clothes, then everyone is also a mathematician, because we all count our change. His comment captures what a loaded term "designer" is. Within

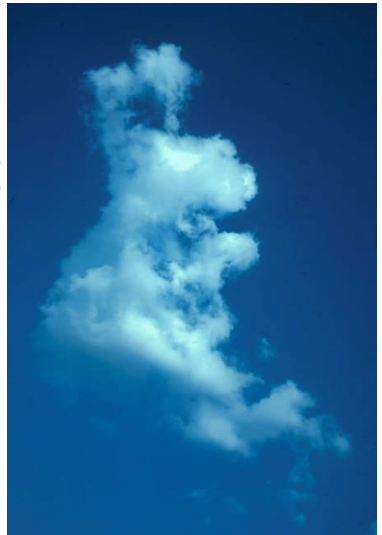
Science of game design?

- In game design and development, we constantly encounter questions and choices
  - Which design option is better for my target group?
  - How will players behave or feel if I implement this idea?
- Theories, models, and experimental research findings may help **answering questions** without costly prototyping and testing
- Research can also help us **ask the right questions**
- These can help in **generating, improving, and pruning ideas**, and **reduce the number of prototypes and iterations** needed to arrive at something that works

Asking the right questions to generate ideas

Two types of thinking

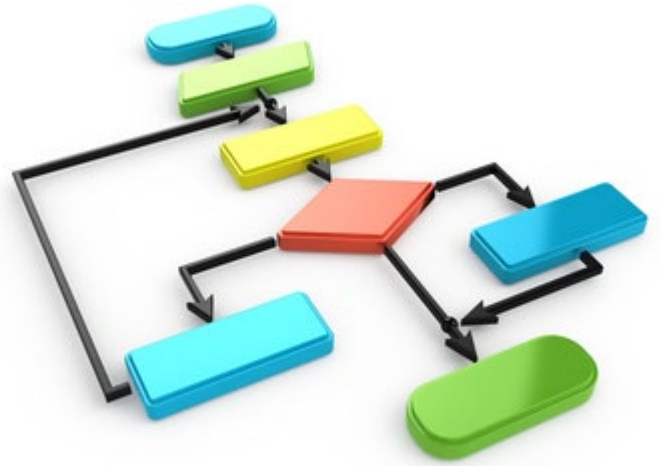
SYSTEM 1: IMPLICIT/UNCONSCIOUS: FAST, ASSOCIATIVE, EFFORTLESS, INTUITIVE



ASSOCIATION

Two types of thinking

SYSTEM 2: EXPLICIT/CONSCIOUS:
SLOW, ALGORITHMIC, EFFORTFUL



ATTENTION,
PRIMING,
INHIBITION

IDEAS,
ASSOCIATIONS,
IMPULSES
(AUTOMATION)

SYSTEM 1: IMPLICIT/UNCONSCIOUS:
FAST, ASSOCIATIVE, EFFORTLESS,
INTUITIVE

ASSOCIATION

Two types of thinking and AI

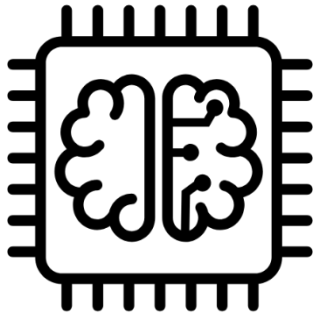
SYSTEM 2: EVALUATE, DISCRIMINATE, CURATE IDEAS

USER

PROMPT

RESPONSE

SYSTEM 1: GENERATE IDEAS

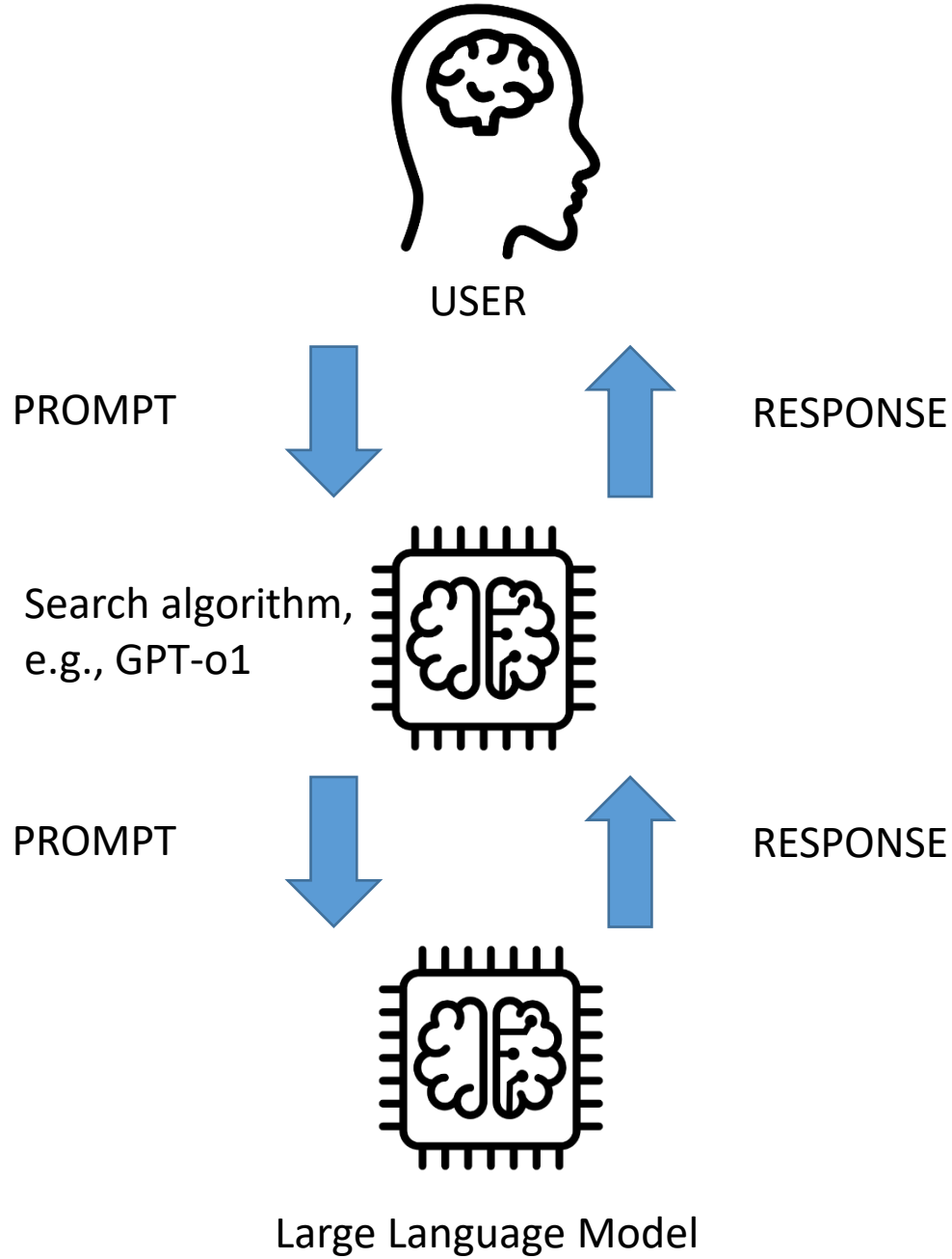


Large Language Model

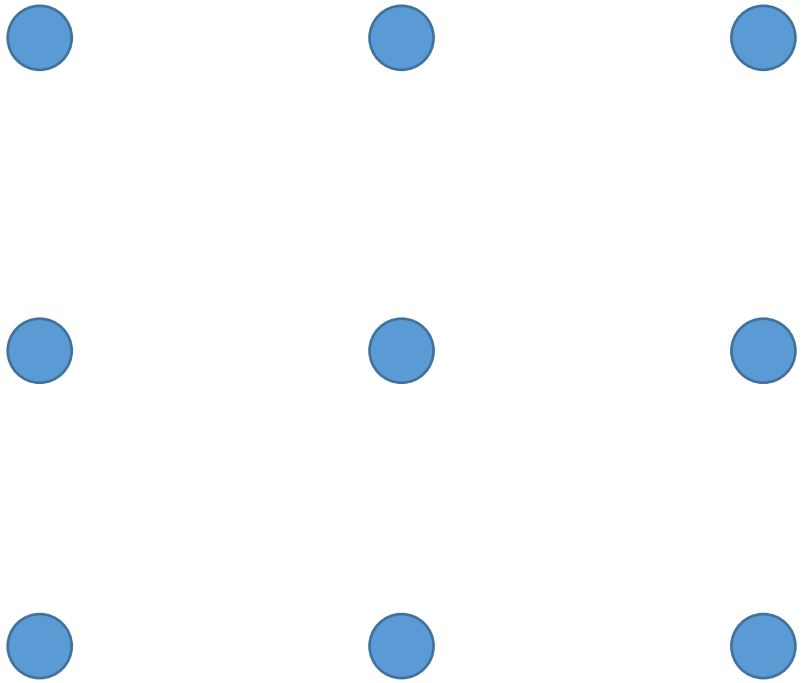
Two types of thinking and AI

SYSTEM 2: EVALUATE, DISCRIMINATE, CURATE IDEAS

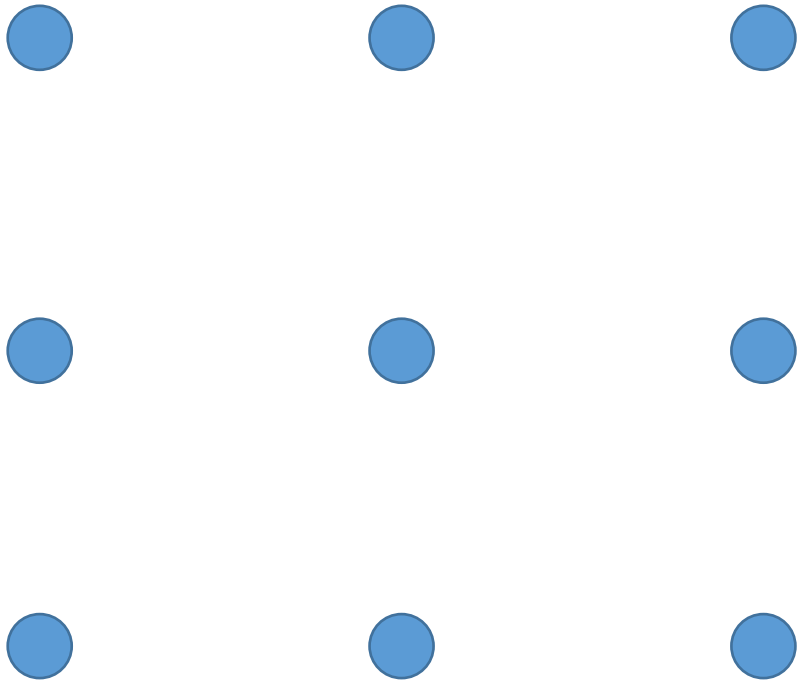
SYSTEM 1: GENERATE IDEAS



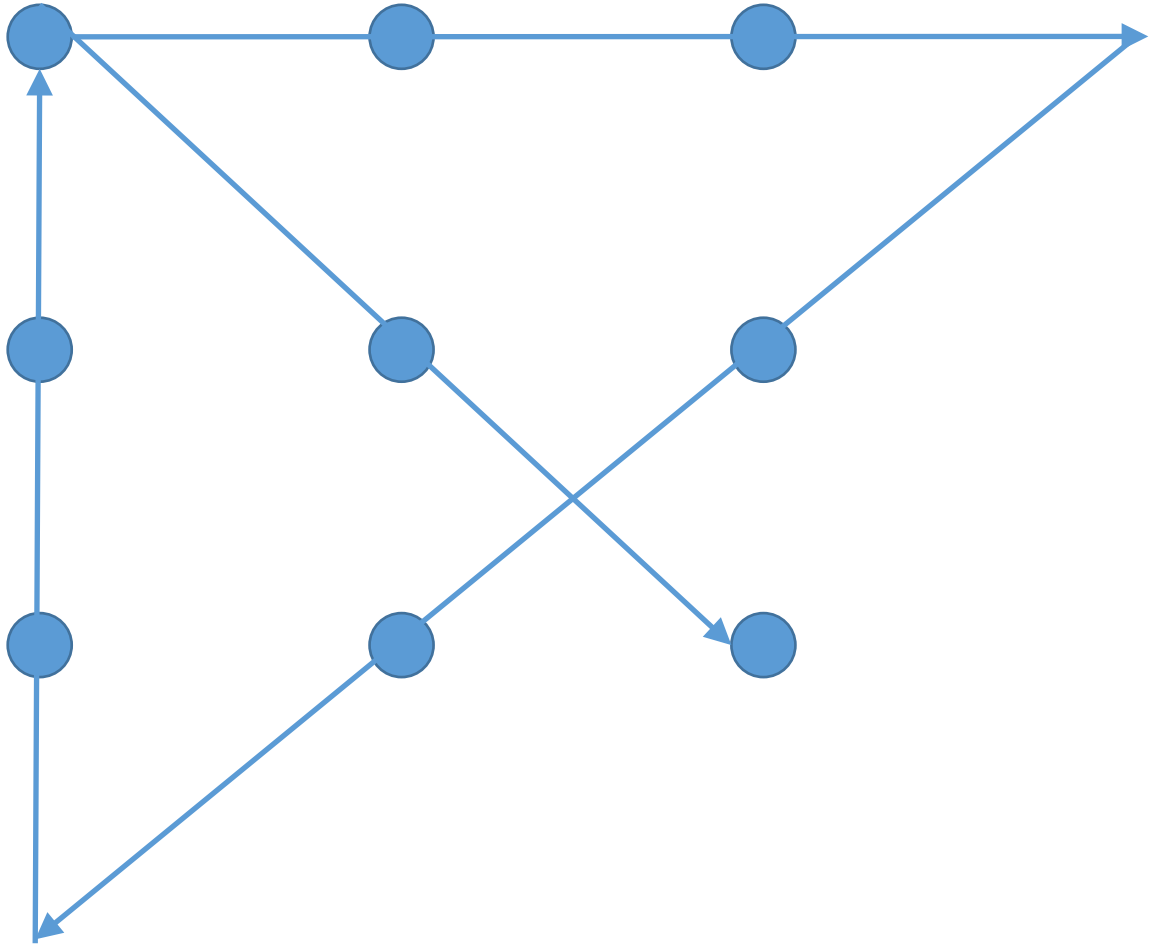
Asking the right questions: connect the dots with four connected straight lines



Can you think **outside the box**?



Can you think **outside the box**?



Human vs AI idea generation

- For humans, perhaps even more important than asking the right questions: Live, experience, be inspired by as many things as possible
  - New ideas are almost always recombinations of things you have seen, read, or experienced
  - The more material you have in your head, the easier it is to find useful recombinations
- AI creativity: Asking the right questions (providing the right prompt) really does matter
  - The largest AI models have already assimilated almost all human knowledge
  - The prompt defines which parts of that knowledge you'll be able to utilize
  - Good prompt includes 1) Precise instructions, 2) Concrete examples
  - https://platform.openai.com/docs/guides/gpt-best-practices

Let’s practice: Invent game poems with GPT-4

- Compare 3 different prompts in generating game poem ideas (see slide comments)
- https://platform.openai.com/playground (needs an OpenAI account)
- https://gpt.aalto.fi (needs an Aalto account and VPN)

Outside-the-box “What if?” questions in research papers

What if a game used an actual car?

Figure 1. Driver and player in GPA

Grand Push Auto: A Car Based Exertion Game

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CHI PLAY 2015, October 03-07, 2015, London, United Kingdom
ACM 978-1-4503-3466-2/15/10.
http://dx.doi.org/10.1145/2793107.2810314

Abstract
Grand Push Auto is an exertion game in which players aim to push a full sized car to ever increasing speeds. The re-appropriation of a car as essentially a large weight allows us to create a highly portable and distributable exertion game in which the main game element has a weight of over 1000 kilograms.

In this paper we discuss initial experiences with GPA, and present 3 questions for ongoing study which have been identified from our early testing:

How might we appropriate existing objects in exertion game design, and does appropriation change how we think about these objects in different contexts, for example environmental awareness?

How does this relate to more traditional sled based weight training?

How can we create exertion games that allow truly brutal levels of force?

Author Keywords
Car; game; exertion; exertion game;

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

What if amusement rides were breath-controlled?

Figure 2. Falling off the Broncomatic

Breath Control of Amusement Rides

Joe Marshall, Duncan Rowland[1], Stefan Rennick Egglestone, Steve Benford, Brendan Walker, Derek McAuley
Horizon Digital Economy Research & The Mixed Reality Laboratory
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ABSTRACT
Emerging robotic technologies are enabling the control of individual seats on rollercoasters and other thrill rides. We explore the potential of breathing as an effective and engaging way of driving this. Observations and interviews from trials of an enhanced bucking bronco ride show that breath-control is fun, challenging and intelligible, and reveal riders' tactics as they battled the machine. We conclude that breath control is feasible and appropriate for controlling rides, unpack its important characteristics, and consider how it might be built into future ride systems. We argue that the combination of voluntary and involuntary factors in breathing is especially appealing for controlling rides as it balances game-like elements of skill and learning against the thrill of surrendering control to the machine.

Author Keywords
Breathing, breath control, amusement ride, biosensing, affective computing, bucking bronco, thrill, themepark

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI)

General Terms
Design

INTRODUCTION
The earliest fairground rides were small-scale affairs in which human operators directly controlled speed and duration in response to riders' expressions of excitement and fear, especially screams [1]. Some even allowed fine-grained tuning such as when 'gaff lads' who collected money on 'waltzers' gave a carriage an extra spin. Driven by a desire for ever greater thrills, coupled to demands for increasing throughput, ride technology has since evolved into large-scale computer-controlled 'thrill rides' (rollercoasters and large 'spin rides') that provide riders with an identical experience. However, a new generation of ride technologies is emerging in which computer-controlled robotic systems steer individual carriages or seats. The Robocoaster G1, for example, consists of a pair of seats on the end of a large flexible robotic arm, while the G2 and G3 attach several arms to shuttles to create a rollercoaster in which small groups of seats can be moved around the track as the ride unfolds [22]. Looking forwards, future rides are likely to deliver thrilling but also highly personalized experiences. They might even learn about riders' reactions and adapt themselves on subsequent visits.

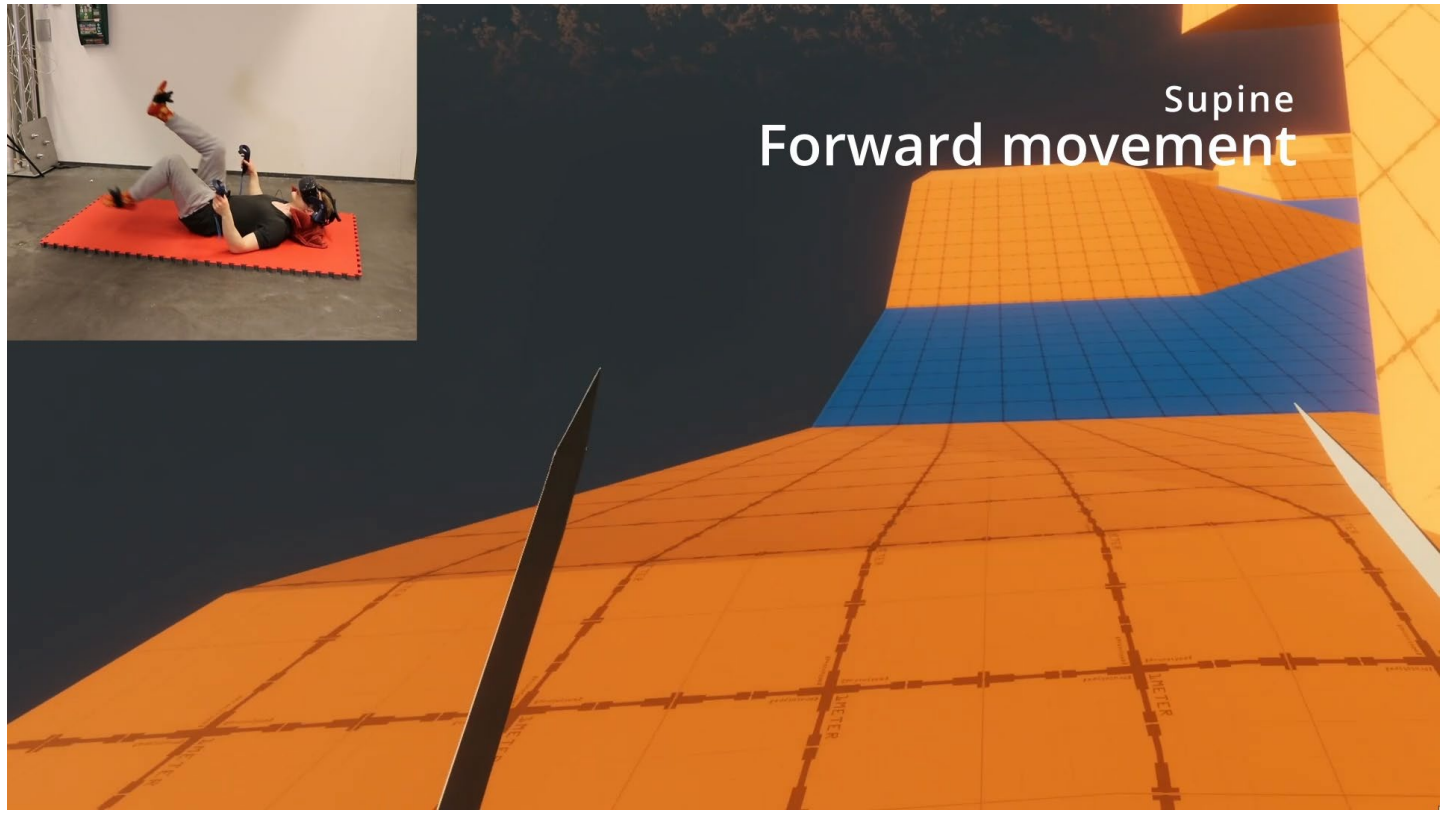
The key question now becomes: on what basis might such real-time control be achieved? How can a human interact with a robotic system that is pushing them around under high G-forces when they are also feeling excited or scared? What form of control might enhance the experience of a thrilling ride? One strategy is to give riders voluntary control over some aspects of their movement, allowing them to partially steer their own seats. An alternative is to use biosensing to measure the rider's involuntary responses and automatically adapt the ride accordingly, mirroring the role of the traditional human operator.

In this paper, we explore how both strategies can be combined through the use of breath control. We have four motivations for this: breath control offers an intriguing balance between voluntary and involuntary control; it responds to the ride pushing back at the rider, creating a direct physical feedback loop between human and machine; riders can be highly aware of their own breathing; and it may be feasible to measure it with sufficient reliability, even under the extreme conditions of an amusement ride. We have therefore developed a small-scale prototype ride and conducted public trials in order to explore the opportunities and challenges associated with breath-controlled rides. Our contributions are to demonstrate the feasibility of this approach; to explore what kinds of control are possible and how they feel; and then to consider how the approach might be deployed on future rides. More generally we seek to extend HCI's appreciation of the nuances of breath control as an interaction technique and to highlight the potentially productive tensions between voluntary and involuntary control of interactive systems.

RELATED WORK
Although amusement rides are a popular and commercially significant form of entertainment, they have received scant attention within HCI and related fields. Previous work has focused on designing virtual reality rides [19], technologies for controlling animatronics, lighting and sound on 'dark rides' [7], and revealing riders' physiological responses to spectators [24]. Our paper adopts a distinct focus on how

CHI 2011, May 7–12, 2011, Vancouver, BC, Canada.

What if one's legs were not needed for balancing in VR?



This was also Reetu Kontio's Master's thesis

https://www.youtube.com/watch?v=M5reE2oZuVw

"I Feel My Abs": Exploring Non-standing VR Locomotion

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Fig. 1. Two variants of our non-standing locomotion method: Chair (left) and Supine (middle). On the right, the in-game screenshot shows the user's 1st person view of the virtual environment in our user study, with a sword in the user's hand. Additionally, we explored Dip Rack and Rings variants (Figure 3) which were not pursued further after an initial evaluation.

Virtual Reality (VR) games and experiences predominantly have the users interact while standing or seated. However, this only represents a fraction of the full diversity of human movement. In this paper, we explore a novel non-standing approach to VR locomotion where the user performs locomotion movements in the air or only slightly touching the ground with their feet. For instance, the user may lie supine on the ground, reminiscent of the Bicycle Crunch, a core training movement common in Pilates and other forms of bodyweight exercise. Although this cannot generally replace traditional VR locomotion, it provides two benefits that we believe can be of use for specific application domains such as VR exergames: First, the user's lower body movement is not impeded by a small real-life space, allowing versatile navigation of large virtual worlds using walking, running, strafing, and jumping. Second, we allow new ways to activate parts of the body that remain passive in most existing VR interactions. We describe and discuss four different variants of the approach, and investigate two prototypes further in a qualitative user study, to better understand their strengths, weaknesses, and application potential.

CCS Concepts: • **Human-centered computing** → **Virtual reality**; **Interaction techniques**.

Additional Key Words and Phrases: virtual reality, VR, exergames, locomotion

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Honorable Mention

What if we could give players superpowers both in the real and virtual worlds?

Mixed reality empowerment for enhancing physical exercise

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Abstract
In this paper we explore the ways to motivate and enhance physical exercise by boosting users' abilities in both physical and in virtual worlds. Moreover, we discuss how skill exaggeration and ability boosting in an exergame could affect the players' and audience's perception of skill and fitness. Finally, we discuss research questions and hypotheses for studying these concepts.

Author Keywords
Exergames; exertion interfaces; augmented feedback; computer vision

ACM Classification Keywords
H.5.2. User Interfaces

Introduction
The last decade has brought about interesting developments in combining video games, sports, and exercise. So called motion games or exergames, also known as active video games (AVGs) have become mainstream thanks to technologies like Microsoft Kinect, PlayStation Move and Nintendo Wii. The games require the players to move their bodies instead of only fingers, thus providing a more physically active alternative to gaming. The Kinect depth camera and real-time computer vision

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http://mobilelifecentre.org/content/chi-workshop-hci-and-sports

Figure 1. The goal in the multiplayer Super Stomp game is to score the most points within a given time frame by jumping on top of the other player.

https://dl.acm.org/doi/pdf/10.1145/3311350.3347181

limit wins the game (see Figure 1). Super Stomp was developed using the Unity game engine [35, 38] through an iterative design process. It was the first multiplayer game developed for the ValoJump mixed-reality trampoline game platform, which consists of a display screen, a trampoline, a camera, proprietary motion tracking software, and a touchscreen display for administrative purposes (see Figure 2). A number of single-player games were developed for the ValoJump platform first, exploring the unique design space of trampoline interactions.

Figure 2. The ValoJump mixed-reality trampoline game platform consists of a display screen, a trampoline, a camera, proprietary motion tracking software, and a touchscreen display used for administrative purposes.

Placing the Screen
Trampoline game research [16, 17] has noted that watching a screen while jumping is feasible. However, different screen setups have not been compared in prior research. In early development, we tested various screen placements with the development team (5 testers). We tested different screen distances ranging from a screen attached to the trampoline to a screen placed 3 meters away and also compared different vertical locations.

In our experience, it is best not to attach the screen directly to the trampoline, though this is desirable due to smaller space requirements. Instead, the screen should be placed at least a few meters away from the trampoline so that players do not need to tilt their heads up and down while jumping. Increased distance also improves safety, preventing jumpers from accidentally hitting the screen. With regards to vertical placement, it is better to place the screen low because it lets jumpers keep the trampoline bed in their field of view while jumping. This aids spatial awareness and preparing for landing impacts.

Designing for Safe Trampoline Interactions
Trampolines suffer from the problem that basic jumping can quickly become boring, potentially making the user feel the need to perform tricks like somersaults in order to keep the activity fun. Performing tricks on trampolines is risky, especially when the user is inexperienced [4, 19]. ValoJump's games are controlled through basic jumping and side-to-side movement, reducing the need to perform tricks in order to enjoy trampolining. In this way, the game platform aids in providing a safe trampolining experience. In addition, most trampoline injuries are the result of multiple people jumping

Reducing choice: Asking the right questions to improve and criticize ideas

Playability heuristics

- Checklists for evaluating game design
- Represent general best practices
- E.g., “Is the game easy to learn,but harder to master?”

Game Usability Heuristics (PLAY) For Evaluating and Designing Better Games: The Next Iteration

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Abstract. Game developers have begun applying formal human-computer interaction (HCI) principles in design. Desurvire et al [2] adapted a set of Heuristics for productivity software to games. The resulting set, presented at CHI 2004, was *Heuristics to Evaluate Playability* (HEP). Generalization of these heuristics is required to make them applicable to a multiple of game genres and game deliveries. This follow-up study focused on the refined list, Heuristics of Playability (PLAY), that can be applied earlier in game development as well as aiding developers between formal usability/playability research during the development cycle. Heuristics were formed based on their efficacious scores on the popular game review website, metacritic.com. Fifty-four gamers rated High and Low ranked games on 116 potential heuristics. Implications for how these Heuristics will help developers improve game quality are discussed. PLAY has been found useful in design evaluation and elf-report survey format.

Keywords: Usability, Heuristics, playability, play testing, design guidelines, video games, computer games, games, evaluation, usability, user testing, HCI design principles.

ACM Classification Keywords: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems-*evaluation/methodology*

http://www.userbehavioristics.com/s/DesigningBetterGames-09HCI-Desurvire.pdf

Exercise: Can you think of a game that is successful but breaks these heuristics?

I. Category 1: Game Play
A. Heuristic: Enduring Play
A1. The players finds the game fun, with no repetitive or boring tasks A2. The players should not experience being penalized repetitively for the same failure. A3. The players should not lose any hard won possessions. A4. Gameplay is long and enduring and keeps the players' interest. A5. Any fatigue or boredom was minimized by varying activities and pacing during the game play.

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Movement-Based Game Guidelines

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ABSTRACT
Movement-based digital games are becoming increasingly popular, yet there is limited comprehensive guidance on how to design these games. We present a set of guidelines for movement-based game design that has emerged from our research-based game development practice. These guidelines have been examined and refined by 14 movement-based game design experts with experience in the academic, independent and commercial game development domains. We contextualize the guidelines using current findings about movement-based game and interaction design, taken from both published research papers and game design venues. Our primary contribution is a body of generative intermediate-level knowledge in the design research tradition that is readily accessible and actionable for the design of future movement-based games.

Author Keywords
Movement-based games; whole-body interaction; play; digital games; exertion

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: User Interfaces - Miscellaneous.

INTRODUCTION
There has been a recent increase in the number of movement-based games, i.e. digital games in which gross-motor bodily input influences the game's outcome [31]. This trend has been fueled by advances in sensor technology, incorporated in game console systems (e.g. Microsoft Kinect, Nintendo Wii and Sony Playstation Move), but also in mobile phones that can sense limb and body movement. Researching these games is important, as they can offer mental, social and physical health benefits [15, 17, 24] as well as entertainment opportunities [3], but also expand the design space for digital games [30, 31].

Movement-based games align with a larger trend in HCI around embodied interactions [10] that put the body in the center of the interactive experience. However, proponents of this trend have lamented that there is a limited understanding of how to design such experiences [1, 19, 31]. Researchers have pointed out that there has been progress on higher-level theory in the form of frameworks and abstract concepts [31]. However, what is still missing is intermediate-level knowledge in the design research tradition [13, 18, 47] that designers can use in their practice for creating these systems [19].

Such design knowledge could help game designers avoid previously identified pitfalls. It could also provide them with a structured approach to engage with movement-based game design, as well as opportunities to learn from other people's experiences. All this will result in higher quality games, advancing the field, and consequently supporting players in profiting from the benefits associated with playing movement-based games.

In this paper, we present intermediate-level knowledge in the form of practical guidelines for the design of movement-based games. These guidelines have emerged from our combined 20 years of research-based game design practice and engagement with the movement-based game field. The guidelines have been examined and refined by 14 movement-based academic, independent and commercial game design experts. The result is a readily accessible and actionable body of generative intermediate-level knowledge for the design of future movement-based games. We also present insights from our approach of generalizing practical guidance from design-research practice and surfacing associated tacit knowledge [35] from expert designers.

GUIDANCE FOR GAME DESIGNERS
Academic papers often aim to provide designers with abstract frameworks that can then be applicable to game design (for example see [3, 4]). Less theoretical guidance

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Facilitate social fun
Facilitate social fun by making movement a social experience.

Moving with others is fun. Movement is typically visible to others and easily becomes a performance, whether we intend it or not. Therefore, design for multi-player, including other players and an audience.

Figure 6: Yamove!

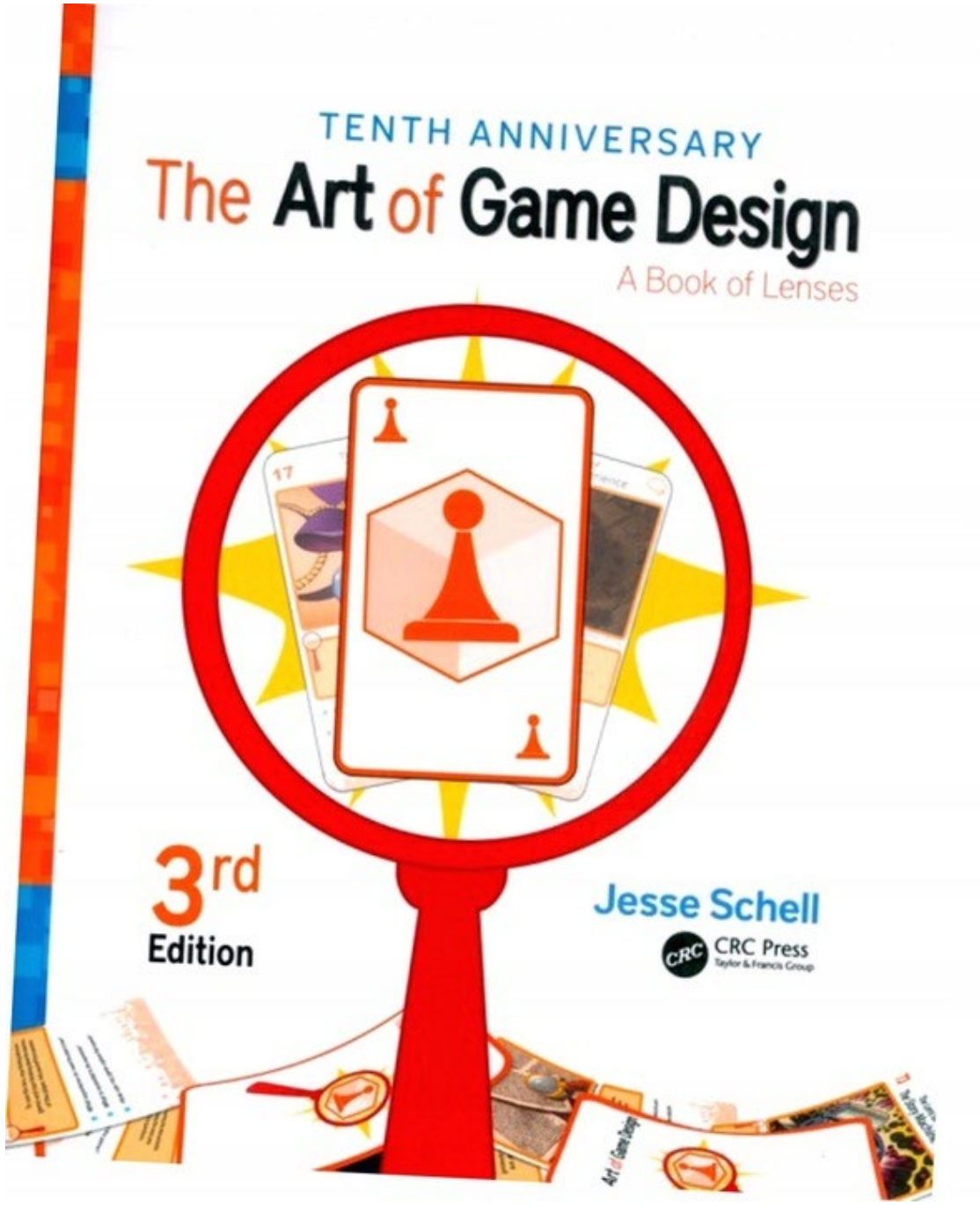
Yamove! (Fig. 6) is a b-boy style dance battle game. Players compete in pairs, aiming for high intensity, in-synch, diverse dance routines. Each player wears an iOS device strapped to the forearm. The game is hosted by an MC and scoring is based on accelerometer data from the devices. Yamove illustrates that a game can facilitate social fun for players, moderators, and spectators alike.

Strategies for Designers
- If you plan to design both multi-player and single-player modes for your game, consider starting with multi-player.
- Make the game a spectacle: encourage movements that are, by nature, a spectacle others enjoy watching.
- Turn bystanders into players: allow the audience to easily join the game.
- Make the game easy to learn by observing, so that spectators figure out what is going on quickly and want to try.

DOs and DON'Ts
DO engage other players and audiences by turning the movement into a performance.
DON'T forget that movement in spaces where others do not know that there is a game going on, such as public spaces, might create socially awkward situations.

Schell's lenses

100+ sets of questions for analyzing and informing game design from different points of view



Utilizing Gravity in Movement-Based Games and Play

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ABSTRACT

This paper seeks to expand the understanding of *gravity* as a powerful but underexplored design resource for movement-based games and play. We examine how gravity has been utilized and manipulated in digital, physical, and mixed reality games and sports, considering five central and gravity-related facets of user experience: realism, affect, challenge, movement diversity, and sociality. For each facet, we suggest new directions for expanding the field of movement-based games and play, for example through novel combinations of physical and digital elements.

Our primary contribution is a structured articulation of a novel point of view for designing games and interactions for the moving body. Additionally, we point out new research directions, and our conceptual framework can be used as a design tool. We demonstrate this in 1) creating and evaluating a novel gravity-based game mechanic, and 2) analyzing an existing movement-based game and suggesting future improvements.

Author Keywords

Gravity; movement-based games; exertion games; exergames; game design; bodily interaction.

ACM Classification Keywords

H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

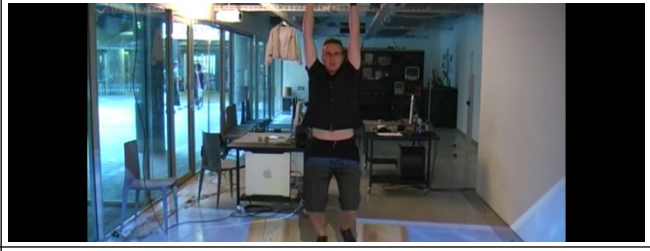
INTRODUCTION

Designing for the moving body is an increasingly active area of HCI research. Following the proliferation of low-cost sensors and increasing computing capability, early research into bodily games and HCI (e.g., [26]) has evolved into a diverse and vibrant field of research and practice. Yet, we are only beginning to understand the moving body

emotion [6], and the effect of virtual representations (avatars) on the user [47].

In this paper, we aim to promote the understanding of *gravity*, which both constrains human movement and creates meaningful complexity and challenge. Virtual gravity has been used in games and simulations at least since Spacewar, one of the earliest computer games developed in 1962 [1]. Spacewar demonstrated how simple simulations of Newtonian mechanics can lead to the emergence of interesting and complex gameplay. In bodily HCI and movement-based games[1], *real* gravity affects the user, the effects of which we believe are underexplored. We argue that the role of gravity is becoming more complex as gameplay evolves from seated to standing and ultimately all other modalities of balancing and moving, as illustrated in Figure 1. The snowboarding image was chosen to illustrate how 1) living-room movement-based games often pale in comparison to real-life sports, 2) defying gravity is often central to such vivid experiences, and 3) HCI in such experiences is still in its infancy (e.g., [32]).

Figure 1. Varying degrees of embodiment and movement in entertainment experiences, ranging from passive spectatorship to active bodily participation.

	Digital	Physical	Mixed reality
Realism			
Affect			
Challenge			
Movement diversity			
Sociality			

	Realism	Affect	Challenge	Diversity	Sociality
Realism	Could and should you manipulate gravity, e.g., using circus and sports equipment or exaggerated simulated physics? If gravity affects realism, e.g., through differences in the real and virtual environments, is the effect intended?	Can manipulating realism result in positive affect (empowerment, thrill)?	Can manipulating realism optimize challenge? What are the real and virtual challenges?	Does manipulating realism lead to increased or decreased diversity? E.g., does the experience empower the user to explore new movements?	Does the realism manipulation work for one or multiple players? How do other people perceive it, e.g., is the empowerment or thrill mediated?
Affect		Does gravity cause positive or negative emotions, e.g., fear, empowerment? Why?	Do the challenges promote positive affect as in, e.g., climbing, where thrill and sense of mastery grows as the climber gets higher?	Does the experience promote the joy of discovery of new movements?	Are people able to contribute to each other's affect and emotions? Climbers, for example, spot and cheer each other (while one climbs and others spectate), helping one to conquer fear and gravity.
Challenge			Does gravity present meaningful challenge? Can you create interesting puzzles using the body only as in climbing, or do you need manipulated real or virtual objects?	Are there challenges promoting movement diversity, e.g., a reward for coming up with a new climbing strategy?	Are gravity-related challenges individual (e.g., running) or social (e.g., building a human pyramid)? Could and should you include both components?
Diversity				Could and should you manipulate gravity-related movement constraints, e.g., using surfaces of different inclinations or using different body parts for balancing? If the user is e.g., lying on the floor, what display technology works best (e.g., a ceiling display or a HMD)?	Can people contribute to each other's movement exploration and discovery, e.g., by designing and sharing experiences for each other?
Sociality					What collaborative or competitive interactions does gravity enable or prevent?

Table 2. The framework facets and their combinations as lenses, i.e., sets of questions to inform design and research.

Exercise: Schell's lenses

- Pick a game you have made or are making. If you don't have one, pick an existing game that you know well.
- Scrutinize your game using some of the lenses. Here are some recommended ones:
  - #2 (Essential experience)
  - #12 (Resonance)
  - #13 (Infinite Inspiration)
  - #17 (Toy)
  - #100 (Love)
- **Log any thoughts, insights, or lessons learned in Presemo:** https://presemo.aalto.fi/gameanalysis/
- To access the lenses, **download the Art of Game Design: A Deck of Lenses free app.**

View/summarize presemo data

Further questions that research can answer

- Psychology & Cognitive science: How do people make decisions? What motivates us? What are emotions and how they affect behavior and experience?
- Sport & exercise psychology: What motivates people to move? What factors affect motor learning and performance?
- Technical game research: How to enable new types of experiences? How to implement X in the most efficient way possible?
- Human-Computer Interaction & games: Combines psychological and technical research, e.g., inventing new mechanics and technology to improve player performance or enable new experiences

Psychology of games

Negative Emotion, Positive Experience? Emotionally Moving Moments in Digital Games

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ABSTRACT
Emotions are key to the player experience (PX) and interest in the potential of games to provide unique emotional, sometimes uncomfortable experiences is growing. Yet there has been little empirical investigation of what game experiences players consider emotionally moving, their causes and effects, and whether players find these experiences rewarding at all. We analyzed 121 players' accounts of emotionally moving game experiences in terms of the feelings and thoughts they evoked, different PX constructs, as well as game-related and personal factors contributing to these. We found that most players enjoyed and appreciated experiencing negatively valenced emotions, such as sadness. Emotions were evoked by a variety of interactive and non-interactive game aspects, such as in-game loss, character attachment and (lack of) agency, but also personal memories, and were often accompanied by (self-)reflection. Our findings highlight the potential of games to provide emotionally rewarding and thought-provoking experiences, as well as outline opportunities for future research and design of such experiences. They also showcase that negative affect may contribute to enjoyment, thereby extending our notion of positive player experience.

Author Keywords
Emotion; Player Experience; Enjoyment; Appreciation.

ACM Classification Keywords
J.4 Social and Behavioral Sciences: Sociology, Psychology; K.8.0 Personal Computing: Games

Please note that this paper contains major spoilers for several games.

INTRODUCTION
People play games for the experience [20], and one of the aims of player experience (PX) research is to understand what constitutes and contributes to positive gaming experiences [23]. Emotions are commonly considered a key component of good PX [6, 20, 22, 30, 31]. Fun and enjoyment, in particular, are some of the most frequently explored constructs in player experience [6, 24]. Negative affective gaming experiences, however, are far less researched, because they are seemingly at odds with the focus on fun [20], positive affect and enjoyment [24]. Unfortunately, this may suggest that all negative affective experiences cannot by definition be considered positive, and implies that it is not worthwhile to design for such experiences [23], thereby restricting the spectrum of possible emotional experiences in games [6, 23]. Yet other forms of media such as literature or film are often acclaimed for their ability to convey a wide spectrum of emotional experiences [2, 3], and it has been argued that negative affect may also contribute to engaging player experiences [6, 10, 25]. Moreover, recent research on serious games suggests that emotionally challenging game experiences have the potential to stimulate reflection, thereby raising awareness of real world issues [16] and facilitating prosocial behavior [32].

While research on negative experiences and negatively valenced emotions in digital games is growing (e.g., [11, 15, 35]), the focus often lies on individual games or game aspects. Moreover, while several studies on serious games and uncomfortable experiences imply that players might value such experiences [9, 16, 32], it remains unclear how this relates to core PX concepts, such as enjoyment or need satisfaction.

The present paper reports on a study, in which 121 players reported an emotionally moving experience with a digital game. Employing both psychometric scales and open-ended questions, we explored what emotions were evoked, why players felt this way, what game components contributed to this, and whether players considered these experiences as rewarding. The contribution of this study is threefold: First, we provide evidence of the emotional and personal impact of games, highlighting the potential of emotional game experiences to stimulate (self-)reflection. Second, we identify a variety of interactive and non-interactive game aspects, but also personal factors as a possible source of emotions in games, which may provide a starting point for future research and design of emotional game experiences. Third, we contribute to a better understanding of the interplay between (negative) emotions and (positive) experiences in games, thereby broadening our notion of positive PX.

RELATED WORK
Emotions are oftentimes considered a core component of the media experience [2, 12, 33]. Consequently, a sizable amount of research has been conducted on the role of emotions for the entertainment experience, especially why many people seem to value media experiences evoking negatively valenced emotions, such as horror or drama movies. Oliver and Bartsch [26], for instance, introduced *appreciation* as a possible explanation for why people are drawn towards these genres. Ap-

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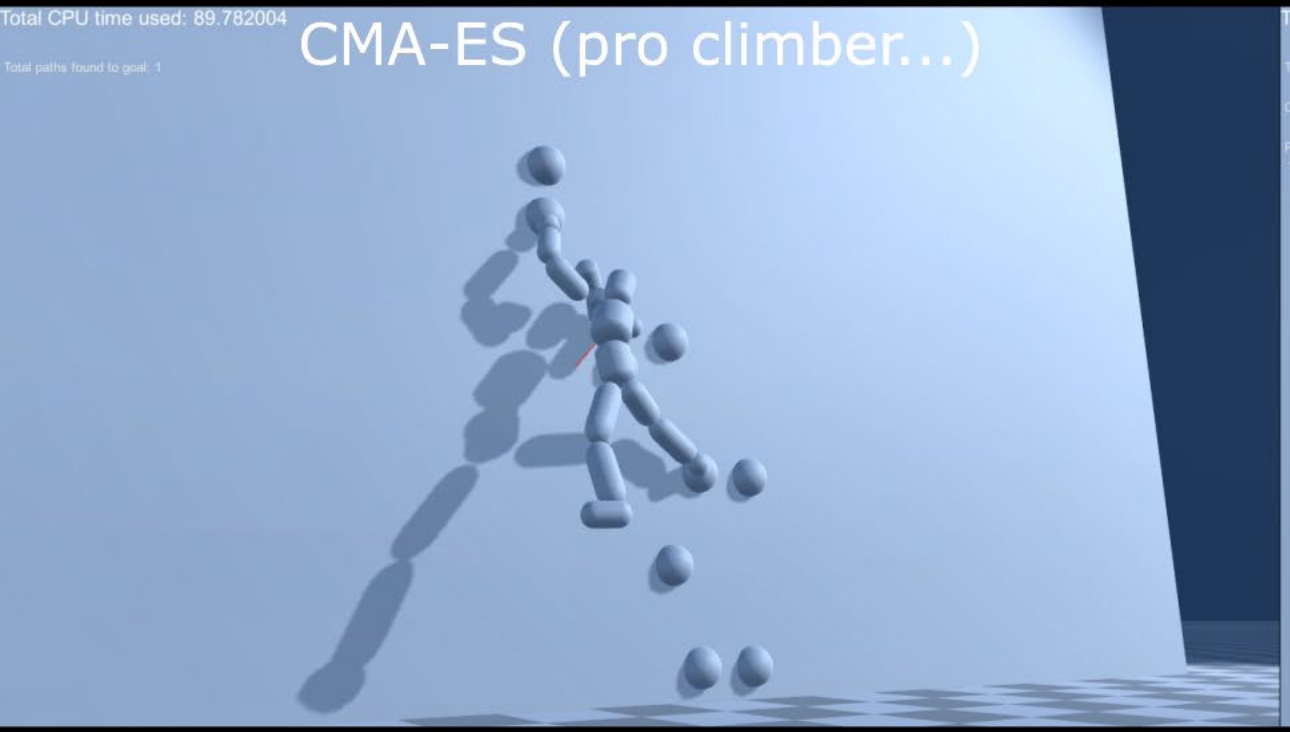
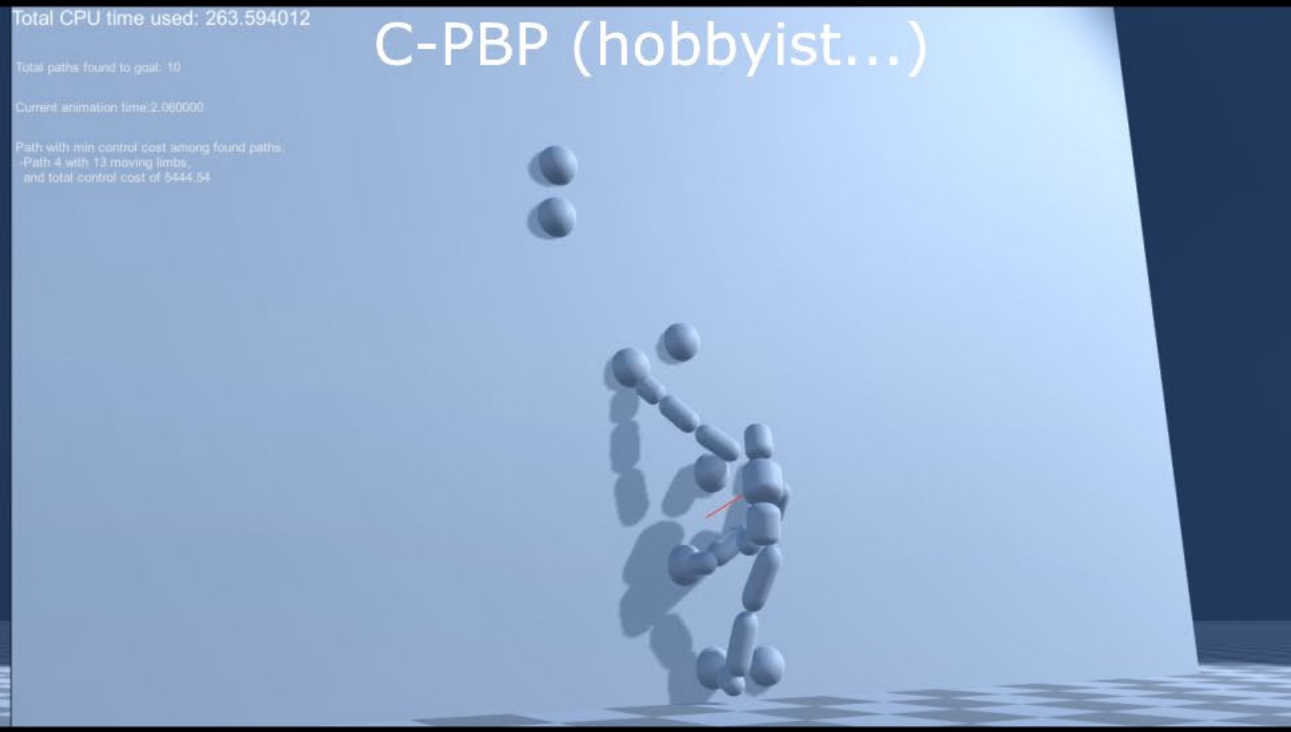
Technical game research





We present a combined path planning and movement optimization system for a physically based climber.

Human-Computer Interaction (HCI) and games

WAVE: Anticipatory Movement Visualization for VR Dancing

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Figure 1: Our proposed VR dance visualization technique. The user sees several model dancers with different time offsets, effectively becoming part of a crowd "making waves". The user can, therefore, mimic the moves of nearby dancers and anticipate upcoming movements. The image is a 3rd-person mixed-reality visualization with the user added inside the virtual world. See the supplementary video for a 1st-person view captured directly from a VR headset.

ABSTRACT

Dance games are one of the most popular game genres in Virtual Reality (VR), and active dance communities have emerged on social VR platforms such as VR Chat. However, effective instruction of dancing in VR or through other computerized means remains an unsolved human-computer interaction problem. Existing approaches either only instruct movements partially, abstracting away nuances, or require learning and memorizing symbolic notation. In contrast, we investigate how realistic, full-body movements designed by a professional choreographer can be instructed on the fly, without prior learning or memorization. Towards this end, we describe the design and evaluation of WAVE, a novel anticipatory movement visualization technique where the user joins a group of dancers performing the choreography with different time offsets, similar to spectators making waves in sports events. In our user study (N=36), the participants more accurately followed a choreography using WAVE, compared to following a single model dancer.

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https://doi.org/10.1145/3613904.3642145

CCS CONCEPTS

• **Computing methodologies** → **Virtual reality**; • **Human-centered computing** → **Interaction techniques**.

KEYWORDS

VR, dance instruction, dance game

ACM Reference Format:
Markus Laattala, Roosa Piitulainen, Nadia M. Ady, Monica Tamariz, and Perttu Hämäläinen. 2024. WAVE: Anticipatory Movement Visualization for VR Dancing. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24), May 11–16, 2024, Honolulu, HI, USA.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3613904.3642145

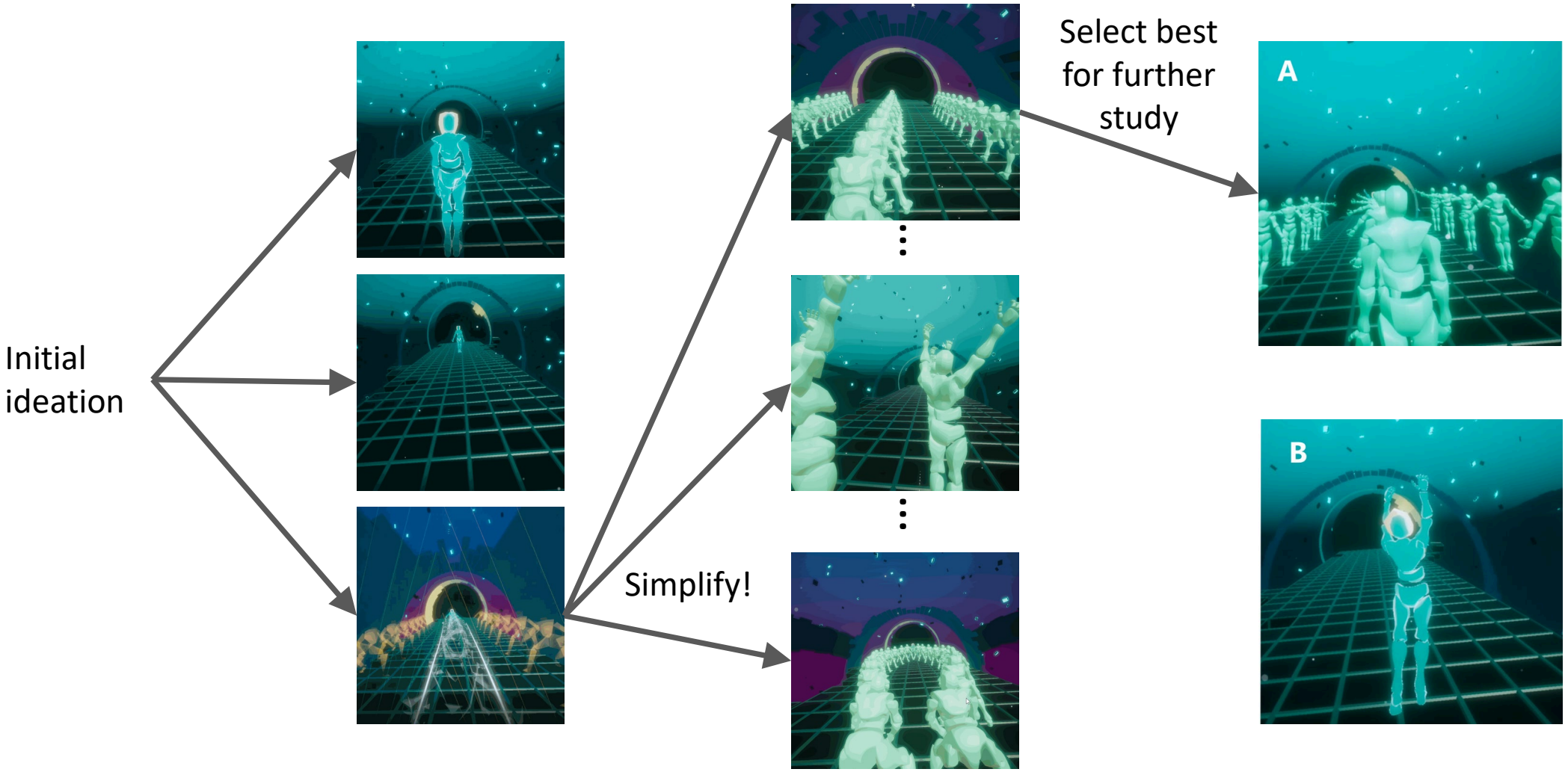
1 INTRODUCTION

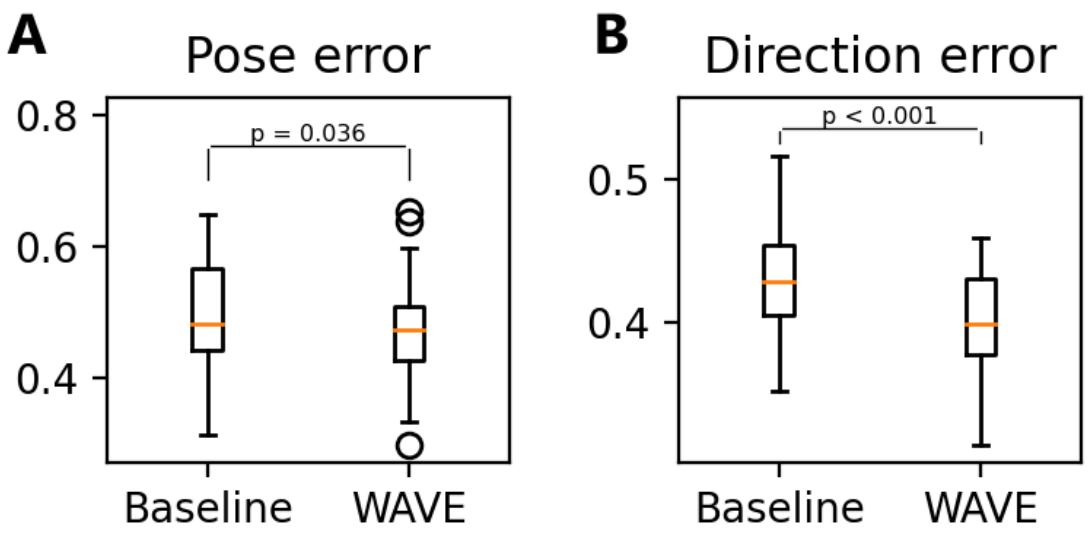
Dance and rhythm games have emerged as one of the most popular genres in consumer Virtual Reality (VR). A prime example is Beat Saber [14], the best-selling VR title of all time [5], in which the player wields dual lightsabers to slice targets in rhythm. Dance has

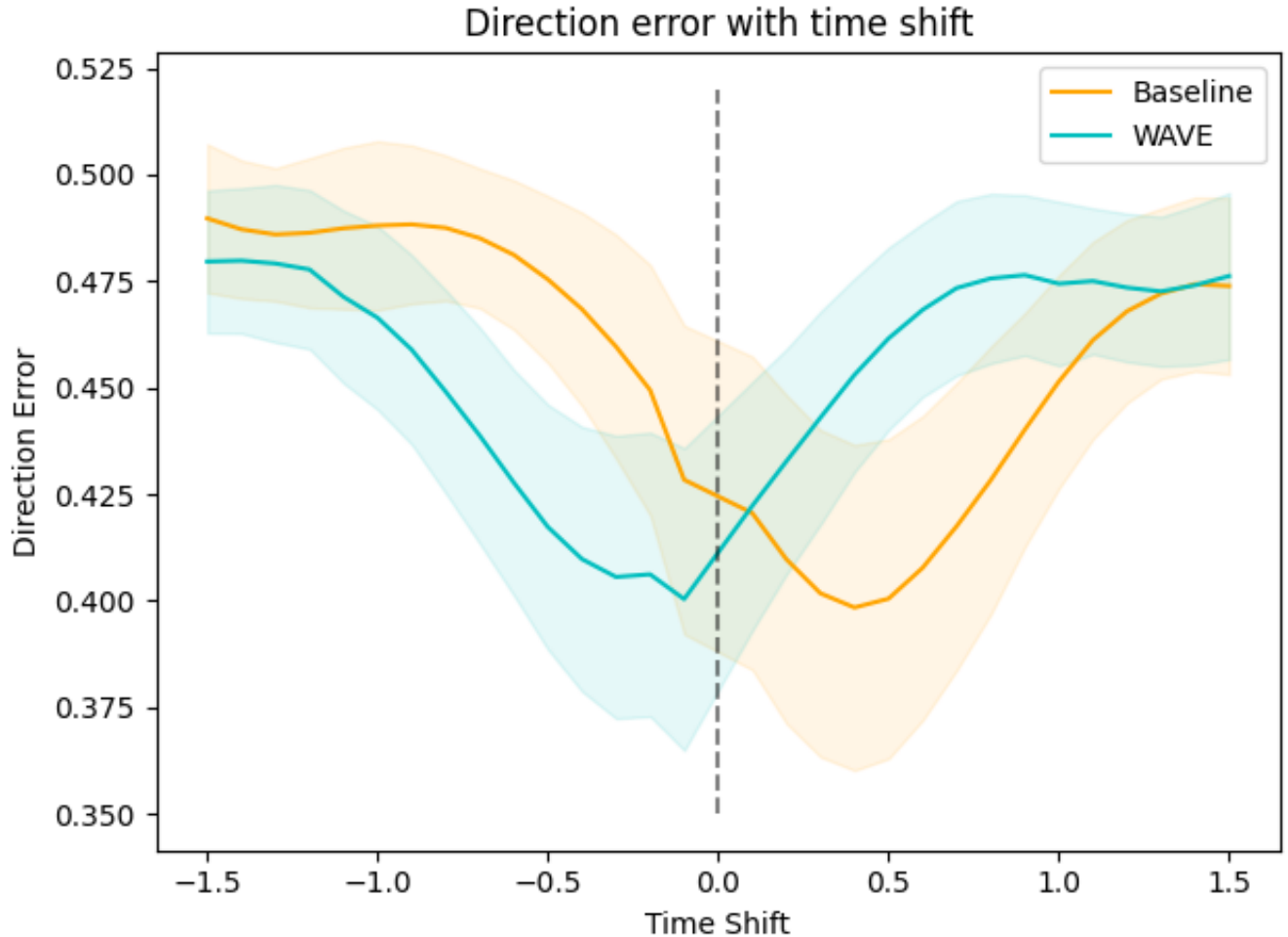
The virtual dancers do the same choreography,
but with different time offsets

https://www.youtube.com/watch?v=xC4vm1unpC0

Design & development process




A
Pose error
0.8
0.6
0.4
p = 0.036
Baseline
WAVE
B
Direction error
0.5
0.4
p < 0.001
Baseline
WAVE


Direction error with time shift
Direction Error
0.525
0.500
0.475
0.450
0.425
0.400
0.375
0.350
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
Time Shift
Baseline
WAVE

Non-standing VR movement

- Problems solved:
  - How to allow large-scale natural movement when the virtual space is larger than the real space?
  - How to make VR more accessible for people with different physical abilities?
- Our solution: The user can sit or lie down and “walk in the air”
- Qualitative user study (N=10) investigating potential benefits and drawbacks

https://www.youtube.com/watch?v=M5reE2oZuVw

“I Feel My Abs”: Exploring Non-standing VR Locomotion

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Fig. 1. Two variants of our non-standing locomotion method: Chair (left) and Supine (middle). On the right, the in-game screenshot shows the user’s 1st person view of the virtual environment in our user study, with a sword in the user’s hand. Additionally, we explored Dip Rack and Rings variants (Figure 3) which were not pursued further after an initial evaluation.

Virtual Reality (VR) games and experiences predominantly have the users interact while standing or seated. However, this only represents a fraction of the full diversity of human movement. In this paper, we explore a novel non-standing approach to VR locomotion where the user performs locomotion movements in the air or only slightly touching the ground with their feet. For instance, the user may lie supine on the ground, reminiscent of the Bicycle Crunch, a core training movement common in Pilates and other forms of bodyweight exercise. Although this cannot generally replace traditional VR locomotion, it provides two benefits that we believe can be of use for specific application domains such as VR exergames: First, the user’s lower body movement is not impeded by a small real-life space, allowing versatile navigation of large virtual worlds using walking, running, strafing, and jumping. Second, we allow new ways to activate parts of the body that remain passive in most existing VR interactions. We describe and discuss four different variants of the approach, and investigate two prototypes further in a qualitative user study, to better understand their strengths, weaknesses, and application potential.

CCS Concepts: • **Human-centered computing** → **Virtual reality**; **Interaction techniques**.

Additional Key Words and Phrases: virtual reality, VR, exergames, locomotion

ACM Reference Format:
Reetu Kontio, Markus Laattala, Robin Welsch, and Perttu Hämäläinen. 2023. “I Feel My Abs”: Exploring Non-standing VR Locomotion. *Proc. ACM Hum.-Comput. Interact.* 7, CHI PLAY, Article 423 (November 2023), 26 pages. https://doi.org/10.1145/3611069

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Honorable Mention

AI dance partner

Adas Slezas' Master's thesis, currently being reworked into a research paper: https://aaltodoc.aalto.fi/items/48eedb97-272b-4f4d-b942-567ddd60a79c

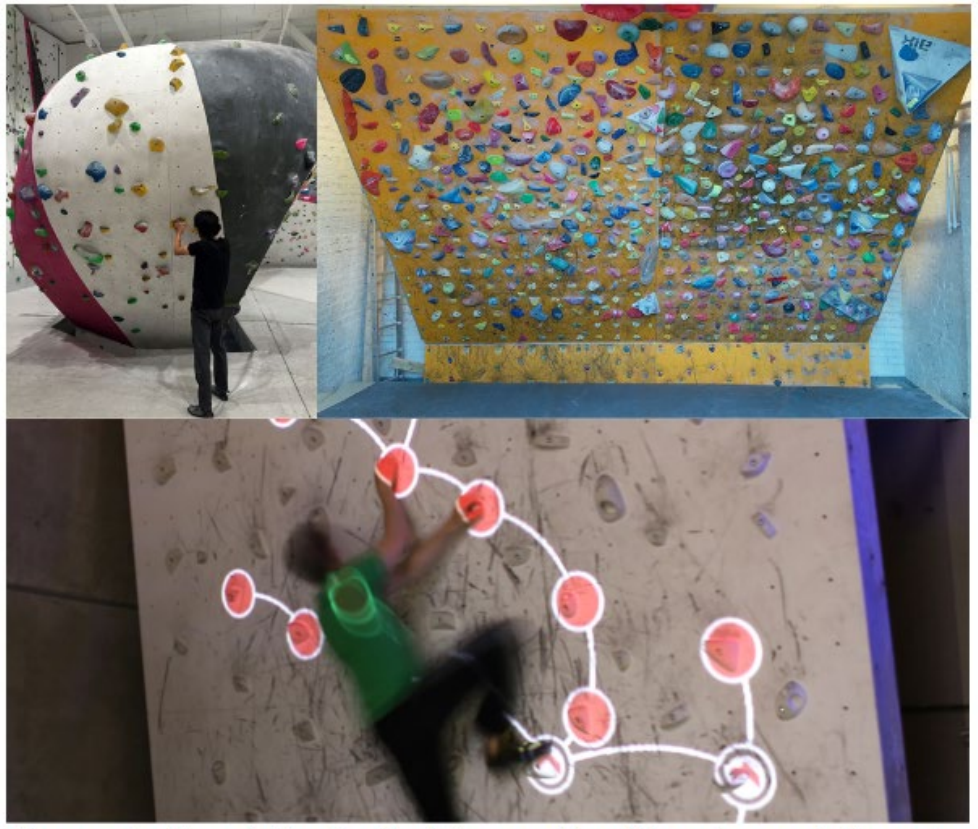

Figure 2. Top left: A climbing wall with color-coded routes. Top right: Adding several routes to a small wall may produce a visually cluttered result. Bottom: projected graphics highlight the holds, reducing clutter.

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The Augmented Climbing Wall: High-Exertion Proximity Interaction on a Wall-Sized Interactive Surface

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ABSTRACT
We present the design and evaluation of the Augmented Climbing Wall (ACW). The system combines computer vision and interactive projected graphics for motivating and instructing indoor wall climbing. We have installed the system in a commercial climbing center, where it has been successfully used by hundreds of climbers, including both children and adults. Our primary contribution is a novel movement-based game system that can inform the design of future games and augmented sports. We evaluate ACW based on three user studies (N=50, N=10, N=10) and further observations and interviews. We highlight three central themes of how digital augmentation can contribute to a sport: increasing diversity of movement and challenges, enabling user-created content in an otherwise risky environment, and enabling procedurally generated content. We further discuss how ACW represents an underexplored class of interactive systems, i.e., proximity interaction on wall-sized interactive surfaces, which presents novel human-computer interaction challenges.

Author Keywords
Human-computer interaction; sports; climbing; movement-based games; exertion interfaces; augmented reality

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Utilizing technology to increase excitement and motivation in physical exercise and sport has been increasingly researched in both HCI and sport science [2, 30, 32, 33, 43]. Computer-generated feedback has also been used to enhance movement skill acquisition [23, 26, 37]. However, almost all the studies have been conducted in laboratory setting or as one-off experiments where researchers actively participate in the experiment. Studies in the real world can reveal new aspects of interactive technologies, as participants use the technology on their own terms and without supervision [35].

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Figure 1. Our augmented climbing wall in a climbing gym. The climber is playing the Spark game, where the goal is climb from start to end (indicated by stop button) while avoiding the moving electricity lines. The bottom left corner shows the touchscreen used, e.g., to browse game levels. The touchscreen is attached to a cabinet hosting the computer and a Kinect V2 sensor. The projector is mounted on the ceiling.

This paper contributes to the limited knowledge of designing technology and movement-based games[1] outside the laboratory, in real-world sport environments. We have set out to study how climbers interact with technology in a climbing center. This is motivated by the relatively few previous studies on indoor climbing, despite it being a rapidly growing sport [7, 38] and being considered for inclusion in the Olympics [6]. We investigate the following questions that impact the design of interactive systems for sports:

- What are the opportunities and challenges of augmenting a sport with interactive technology?
- How does interactive technology change a sport? More specifically, in what ways can technology affect climbing or watching someone else climb?

Figure 1 shows our Augmented Climbing Wall system installed in a commercial climbing center. ACW combines projected graphics and depth camera body tracking to create interactive games and other training applications. ACW also includes a separate touch screen for more detailed and multiuser interaction, although we do also provide projected buttons on the wall for basic actions such as restarting a game level.

ACW is designed as a research instrument for probing the questions above, and also to solve the problem of providing several interesting climbing challenges and activities in a

[1] By movement-based games we denote games that require active full-body participation [32]

Understanding player experiences

Many of you have participated in this study

(the paper is the work-in progress version presented last week at CHI PLAY 2024)

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Understanding the Design of Emotionally Impactful Game Feel

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Figure 1: Examples of games where game feel design contributes to emotionally impactful gameplay. From left to right, *Celeste*[G3], *Arise: A Simple Story*[G10], *Ico*[G7] and *Journey*[G19].

Abstract

This paper seeks to understand the connections between two previously disjoint subfields of game research and design: 1) the study of emotionally impactful games and 2) the study of game feel. Regarding games and emotion, we now understand aspects such as how negative emotions are appreciated in games and can be a desirable quality for designers and players alike. We also understand aspects of game feel such as the importance of responsive player character control and juicy (i.e. exaggerated) feedback for player actions. However, the literature on game feel rarely links to emotion research and focuses on a narrow subset of emotions/feelings such as power and control. Research is lacking on how game feel design can impact a wider palette of emotions, including negative ones, and how this may require one to "break the rules" of good game feel design, e.g., making it purposefully hard to control the player character. In this work-in-progress paper, we begin a systematic mapping of such connections between game feel and emotion. We conduct a Constructivist Grounded Theory analysis on the game feel of 42 mechanics from a diverse selection of games such as Journey, Celeste, and Freedom Bridge. We identify two core concepts, Deviation and Motif, along with 8 design concepts, as central to crafting emotionally impactful game feel.

CCS Concepts

• **Applied computing** → **Computer games**; • **Human-centered computing** → **HCI theory, concepts and models**; • **Software and its engineering** → *Interactive games*.

Keywords

game design, game feel, juice, emotions, eudaimonia, video games, player experience

ACM Reference Format:
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https://doi.org/10.1145/3665463.3678781

1 Introduction

At their core, video games create and deliver experiences [30, 34] and game designers may focus on crafting different aspects of this experience. On the one hand, games like *Super Meat Boy* [G16] and *Celeste* [G3] focus on kinesthetic joy and mastery through carefully crafted movement, platforming mechanics and challenges. Steve Swink [33] popularized the term *Game Feel* to describe the experience of these moment-to-moment mechanics and virtual sensations [14, 26, 33]. The literature and discussions on game feel

Understanding player experiences

This paper is based on Nina Tepponen's final assignment for Game Analysis 2023

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Towards Understanding Waiting in Video Games

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Abstract

Waiting is an everyday activity that is often present in video games. Waiting situations in games can happen during, for instance, loading screens, turn-based action in multiplayer games, and cut-scenes. Different waiting situations can cause both positive emotions, such as anticipation, and negative emotions, such as frustration. Thus, understanding how waiting relates to players' emotions can be beneficial when designing player experiences. However, academic discussion on waiting in games is quite scattered, and there is no comprehensive overview available on the subject. In this work-in-progress paper, we contribute a literature review on the topic of waiting in video games. Based on the results, five categories of academic discussion are identified. These are (1) models of time in video games, (2) games with waiting as a core game mechanic, (3) mathematical analysis of game situations, (4) games as a research tool, and (5) other perspectives. We also identify many waiting situations that are not discussed in the existing literature; hence, we hope that our work stimulates and informs future work on this underexplored but important topic.

CCS Concepts

• **Applied computing** → **Computer games**; • **Human-centered computing** → *HCI theory, concepts and models.*

Keywords

Video games, Player experience, Waiting

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Nina Tepponen, Prabhav Bhatnagar, and Perttu Hämäläinen. 2024. Towards Understanding Waiting in Video Games. In *Companion Proceedings of the Annual Symposium on Computer-Human Interaction in Play (CHI PLAY Companion '24), October 14–17, 2024, Tampere, Finland*. ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3665463.3678791

1 Introduction

Waiting is a common, daily activity for most people. Whether it is waiting for the bus in the morning, waiting in line at the grocery store, or waiting for the coffee maker to finish brewing one's coffee, pauses in activity are present everywhere. Waiting situations can often create emotional responses in us, such as the frustration felt when the bus is not coming when it's supposed to, or the anticipation created by watching the coffee drip and knowing that soon it will be the time to drink it.

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In the domain of video games, much attention is paid to how a player feels in certain game situations. Various methods, such as pacing, difficulty, and inclusion of audio, visual, and narrative elements are used to nudge the player's emotions one way or another. It seems reasonable to assume that waiting could be used as one of such tools, as it has potential to create strong emotions in us.

Waiting, in the context of video games, could be described as a player experiencing a situation in which a certain amount of real time has to pass before they can continue to meaningfully interact with a game. While the concept of "meaningful interaction" is quite imprecise, this description highlights the subjectivity of how people experience waiting situations. As an example, watching a given cut-scene might be an interesting and valuable experience for one player, while another might consider it an annoyance they are required to sit through before they can proceed to the parts of the game that they find interesting.

Contribution. In this work-in-progress article, we contribute a literature review of how waiting has so far been discussed in the domain of game research. We additionally discuss some topics related to waiting that are not present in the current literature. To address this gap in follow-up work, we outline a plan for a questionnaire study. Our goal is to give new perspectives into how waiting can be utilized in video games, what types of waiting situations are common and most discussed in the domain of games, and what reactions and emotions these waiting situations can evoke in players. Furthermore, the literature review presents a categorized list of resources for further reading on the subject.

Research questions and scope. We articulate the research questions for our literature review as follows:

- RQ1: How much academic research has there been on the topic of waiting in video games? What are the main aspects and viewpoints of such discussion?
- RQ2: Have both positive and negative aspects of waiting in games been identified or discussed in literature?

As the goal of the literature review is to map out a rather wide area of discussion, the concept of waiting was not given a very strict definition when choosing which papers to include. Furthermore, the waiting situations that are considered relevant for this review can vary, as long as they involve the player having to wait for something to happen inside a video game. This includes both cases where the player waits with the game open and running, and cases where the player can close the game and perform other activities during the wait.

Although the goal of this work is to investigate waiting that happens inside video games, it's relevant to note that there have also been attempts to affect people's perception of wait times in other contexts by using games as a tool or a distraction. For instance,

AI-assisted player research

Augmenting slow and expensive playtesting and player research with AI

Here: Simulated playtesting using AI players, fitting a simple computational psychological model to data from real players

https://dl.acm.org/doi/pdf/10.1145/3410404.3414235

Predicting Game Difficulty and Churn Without Players

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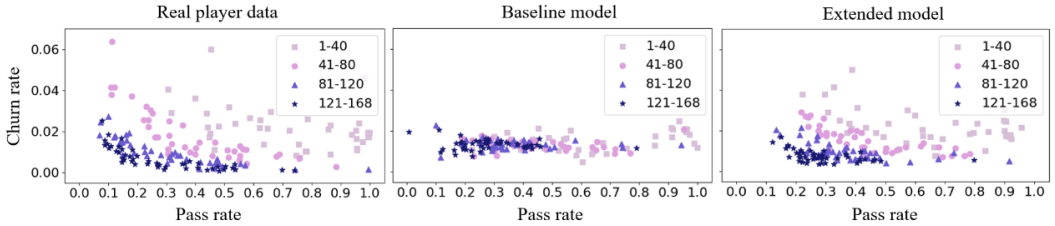

Figure 1: Scatter plots depicting the relation of pass rate (a measure of level difficulty) and churn rate over 168 game levels of Angry Birds Dream Blast, in both real player data and our simulations. Here, churn is defined as not playing for 7 days. The colors denote level numbers. The baseline simulation model predicts pass rate and churn directly from AI gameplay. Our proposed extended model augments this with a simulation of how the player population evolves over the levels.

ABSTRACT

We propose a novel simulation model that is able to predict the per-level churn and pass rates of Angry Birds Dream Blast, a popular mobile free-to-play game. Our primary contribution is to combine AI gameplay using Deep Reinforcement Learning (DRL) with a simulation of how the player population evolves over the levels. The AI players predict level difficulty, which is used to drive a player population model with simulated skill, persistence, and boredom. This allows us to model, e.g., how less persistent and skilled players are more sensitive to high difficulty, and how such players churn early, which makes the player population and the relation between difficulty and churn evolve level by level. Our work demonstrates that player behavior predictions produced by DRL gameplay can be significantly improved by even a very simple population-level simulation of individual player differences, without requiring costly retraining of agents or collecting new DRL gameplay data for each simulated player.

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CCS CONCEPTS

• **Human-centered computing** → **User models**; • **Computing methodologies** → *Modeling and simulation.*

KEYWORDS

Player Modeling; Game AI; Churn Prediction

ACM Reference Format:
Shaghayegh Roohi, Asko Relas, Jari Takatalo, Henri Heiskanen, and Perttu Hämäläinen. 2020. Predicting Game Difficulty and Churn Without Players. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '20), November 2–4, 2020, Virtual Event, Canada.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3410404.3414235

1 INTRODUCTION

One of the primary difficulties of game design and development is that player behavior is hard to predict. This leads to an iterative design process of prototyping and testing, which is slow and expensive. Ideally, research should produce models and tools that allow evaluating the effect of design decisions early on, before committing resources to real-life game testing. This is one of the foundational motivations of player and user modeling [29, 31, 49].

Better models and tools are in particular needed for predicting and optimizing business critical behavior such as churn, i.e., a player quitting the game and not coming back to it. Churn matters as many modern games accumulate their revenue gradually from in-game advertisements and purchases, instead of single up-front fee. To prevent churn, free-to-play game companies engage in extensive

SIM2VR: Towards Automated Biomechanical Testing in VR

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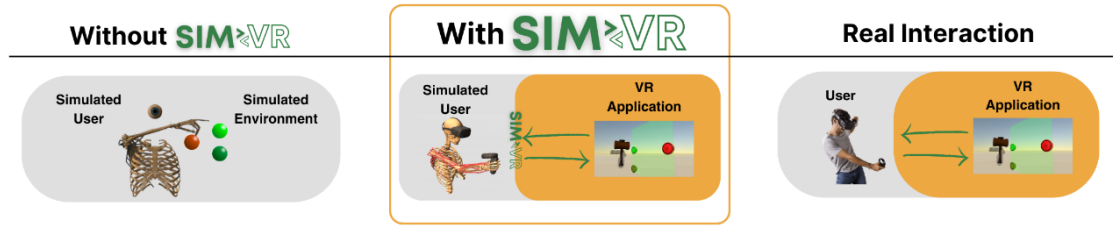

Figure 1: Simulating interactive user behaviour in VR typically requires re-implementing the game dynamics, logic and graphics of the VR application in another simulation engine, which is time-consuming, redundant and error-prone (left). SIM2VR (middle) enables VR designers, for the first time, to run state-of-the-art biomechanical user simulations directly in the same VR application real users are interacting with (right). By aligning simulated and real interaction with respect to VR input and output, as well as application dynamics, SIM2VR allows for more ecologically valid predictions of user performance, effort and strategies, supporting developers in the early stages of the design process.

ABSTRACT

Automated biomechanical testing has great potential for the development of VR applications, as initial insights into user behaviour can be gained *in silico* early in the design process. In particular, it allows prediction of user movements and ergonomic variables, such as fatigue, prior to conducting user studies. However, there is a fundamental disconnect between simulators hosting state-of-the-art biomechanical user models and simulators used to develop and run VR applications. Existing user simulators often struggle to capture the intricacies of real-world VR applications, reducing ecological validity of user predictions. In this paper, we introduce SIM2VR, a system that aligns user simulation with a given VR application by establishing a continuous closed loop between the two processes. This, for the first time, enables training simulated users directly in the same VR application that real users interact with. We demonstrate that SIM2VR can predict differences in user performance, ergonomics and strategies in a fast-paced, dynamic arcade game. In order to expand the scope of automated biomechanical testing beyond simple visuomotor tasks, advances in cognitive models and reward function design will be needed.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Systems and tools for interaction design**; **Virtual reality**; *User models.*

KEYWORDS

biomechanical simulation, interaction design, VR simulation alignment, automated testing, virtual reality, VR development, VR application, deep reinforcement learning

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*Both authors contributed equally to this research.

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https://dl.acm.org/doi/pdf/10.1145/3654777.3676452

Can one use LLMs to practice or simulate player interviews?

- Humans rate LLM-generated answers as more human-like than real human answers
- Human-likeness increases with LLM size
- The resulting data is less diverse than real data
- The diversity issue is pronounced with finetuned models such as ChatGPT, compared to “base models” such as GPT-3

https://dl.acm.org/doi/full/10.1145/3544548.3580688

Evaluating Large Language Models in Generating Synthetic HCI Research Data: a Case Study

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ABSTRACT

Collecting data is one of the bottlenecks of Human-Computer Interaction (HCI) research. Motivated by this, we explore the potential of large language models (LLMs) in generating synthetic user research data. We use OpenAI's GPT-3 model to generate open-ended questionnaire responses about experiencing video games as art, a topic not tractable with traditional computational user models. We test whether synthetic responses can be distinguished from real responses, analyze errors of synthetic data, and investigate content similarities between synthetic and real data. We conclude that GPT-3 can, in this context, yield believable accounts of HCI experiences. Given the low cost and high speed of LLM data generation, synthetic data should be useful in ideating and piloting new experiments, although any findings must obviously always be validated with real data. The results also raise concerns: if employed by malicious users of crowdsourcing services, LLMs may make crowdsourcing of self-report data fundamentally unreliable.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**.

KEYWORDS

User experience, User models, Language models, GPT-3

ACM Reference Format:
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1 INTRODUCTION

HCI Researcher: Dear AI, do you think you could role-play a user study participant for me?

AI: *Sure, I can try.*

Researcher: Let's imagine you're a scientist and the user study is about academic writing tools. What is your favorite writing tool and why?

AI: *My favorite writing tool would have to be Microsoft Word. I find it very user-friendly and versatile, and it has everything I need to get the job done.*

Researcher: Why do you prefer Word over LaTeX?

AI: *LaTeX is a great tool for typesetting, but I find it to be much more difficult to use than Word. With Word, I can easily format my document the way I want it to look, and I don't have to worry about code.*

The dialogue above was generated using OpenAI Playground[1], a tool that allows one to input a piece of text—*a prompt*—and ask the GPT-3 large language model (LLM) [10] to generate a plausible continuation. We wrote the boldface parts and let GPT-3 generate the italicized continuations. The result is characteristic of the phenomenon we investigate in this paper: Through learning to model and predict various kinds of human-produced texts ranging from technical documentation to online discussions and poetry, LLMs like GPT-3 give the appearance of "understanding" human experiences such as interactive product use. Of course, the internal operation of the models differs from the internal psychological and neurophysiological processes of humans—LLMs simply learn to predict the next symbol (or impute missing symbols) in a sequence. Nevertheless, on a purely behavioral level, the results can be very human-like.

Much of HCI research is conducted using verbal data such as interviews and questionnaires (e.g., [3, 61, 72]), but collecting such data can be slow and expensive. Therefore, the above suggests that *LLMs might be useful in generating synthetic/hypothetical data for HCI research*, a notion we explore empirically in this paper. LLMs are typically trained on enormous Internet datasets such as Common Crawl [67]), including an abundance of online discussions about interactive technology and products such as phones, computers, and games. Therefore, it seems plausible that LLMs could generate, e.g., realistic 1st-person accounts of technology use, and answer natural language questions about user experiences, motivations, and emotions. We emphasize that we do not claim that such synthetic LLM data could ever be a replacement for data from real human participants. We simply consider that synthetic based data might be useful in some contexts, for example, when piloting ideas or designing an interview paradigm.

In effect, we view LLMs as a new kind of search engine into the information, opinions, and experiences described in their Internet-scale training data. Unlike traditional search engines, LLMs can be queried in the form of a narrative such as a fictional interview. Furthermore, LLMs exhibit at least some generalization capability to new tasks and data (e.g., [45, 71, 81]). This presents an untapped opportunity for counterfactual *What if?* exploration, e.g., allowing

*Perttu Hämäläinen and Mikke Tavast contributed equally to this work.

CHI '23, April 23–28, 2023, Hamburg, Germany

ACM ISBN 978-1-4503-9421-5/23/04.
https://doi.org/10.1145/3544548.3580688

[1] https://beta.openai.com/playground

Master’s thesis?

- Many of the papers above are also Master’s theses by Aalto game students, or started as theses
- Don’t hesitate to contact me if interested in doing a thesis on topics such as VR/XR, understanding player experiences, or AI

Contents (today)

- What are games?
- What is game design?
- Why research & theory?
- **How to search and find research?**

Books

Books

Games & Animation

Making a successful video game is hard. Even games that are successful at launch may fail to engage and retain players in the long term due to issues with the user experience (UX). In a nutshell, game UX is about considering the gamer's brain: understanding human capabilities and limitations to anticipate how a game will be perceived, the emotions and motivation it will elicit, and how players will interact with it. This book is designed to help readers identify the ingredients for successful and engaging video games, empowering them to develop their own unique game recipe more efficiently.

Key Features:

- Provides a complete overview of how the brain works in a very accessible way.
- Provides a unique game UX framework, using numerous examples from released games.
- Covers design thinking, user research, analytics, and UX strategy.
- This book is a practical tool that any professional game developer or student can use right away and includes the most complete overview of UX in games existing today.

Author Bio:

Celia Hodent, Ph.D in psychology with over ten years of experience in the entertainment industry, is recognized as a leader in the application of user experience and psychology in video games, and in the development of UX strategy in game studios. Celia has worked at Ubisoft, LucasArts, and Epic Games on many projects across multiple platforms, including the *Tom Clancy's Rainbow Six* franchise, *Star Wars: 1313*, *Paragon*, *Fortnite*, and *Spyjinx*

Reviews:

"The beauty of this book is that it is two things at the same time:

1. *An amazingly complete introduction to psychology, using examples from video games to make the concepts clear and memorable.*
2. *An amazingly complete introduction to video game design, using psychology to help design more compelling games*

So whether you are a game designer, a player, or someone wishing to understand psychology, this is the book for you."

—**Don Norman**, Director, the Design Lab at the University of California, San Diego
author of *The Design of Everyday Things*

"By blending up-to-date brain science with game-relevant UX design principles, this book doesn't just give great tips about how to make better games, it gives designers the mental tools to get better at thinking about games. Read this, and suddenly you'll know what you're talking about."

—**Jesse Schell**, Game Designer, author of *A Theory of Fun for Game Design*

"This book is an invaluable asset for game developers, whether you work in game design, user experience, or programming. With a lucid overview of the current best knowledge from cognitive psychology, Hodent provides guidelines and approaches to improve the game experience for players that are based on actual science."

—**Raph Koster**, author of *A Theory of Fun for Game Design*

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ISBN-13: 978-1-4987-7550-2
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HODENT THE GAMER'S BRAIN CRC Press

The Gamer's Brain

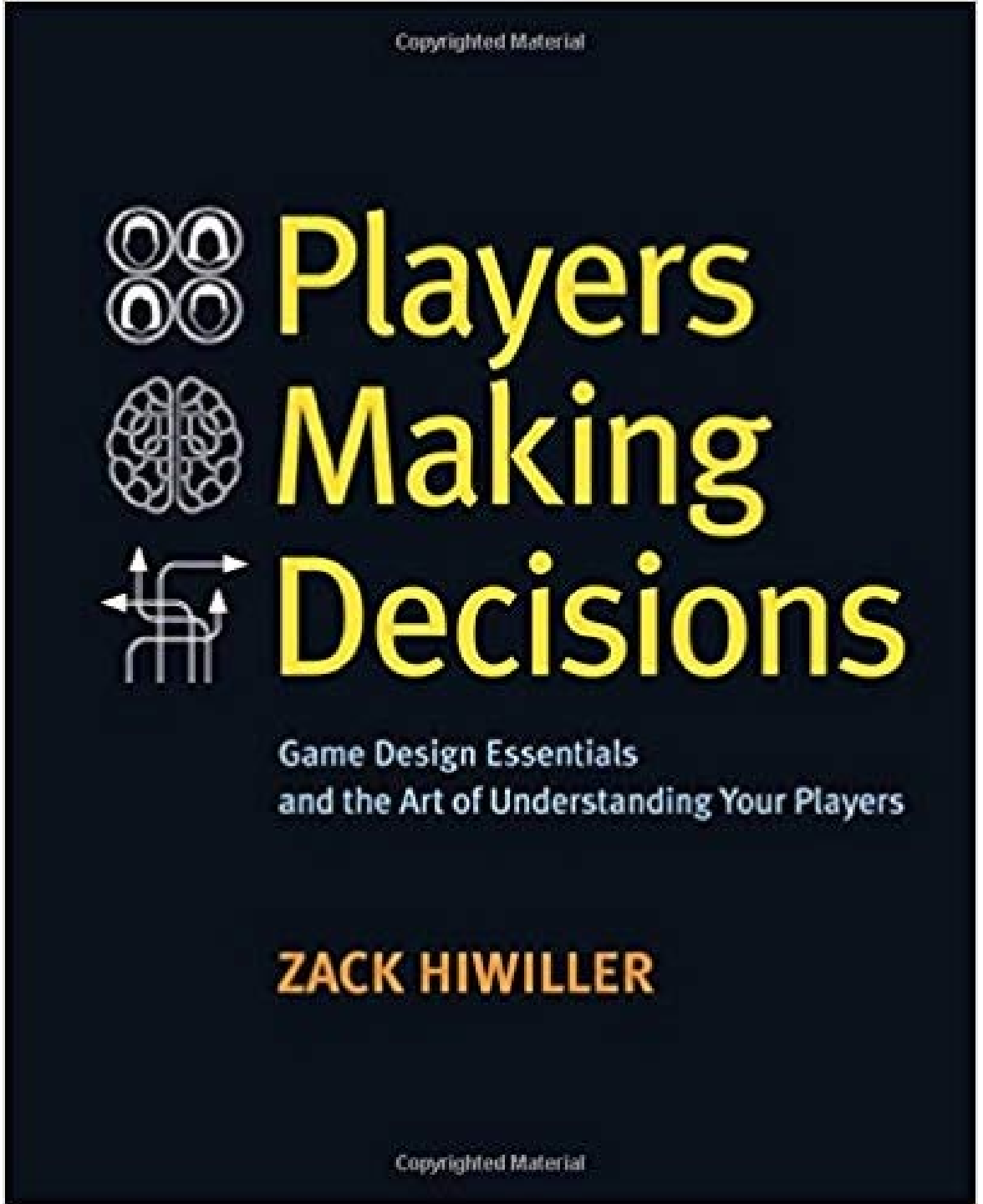
How Neuroscience and UX Can Impact Video Game Design

Celia Hodent

Foreword by **Brenda Romero**

CRC Press
Taylor & Francis Group

Books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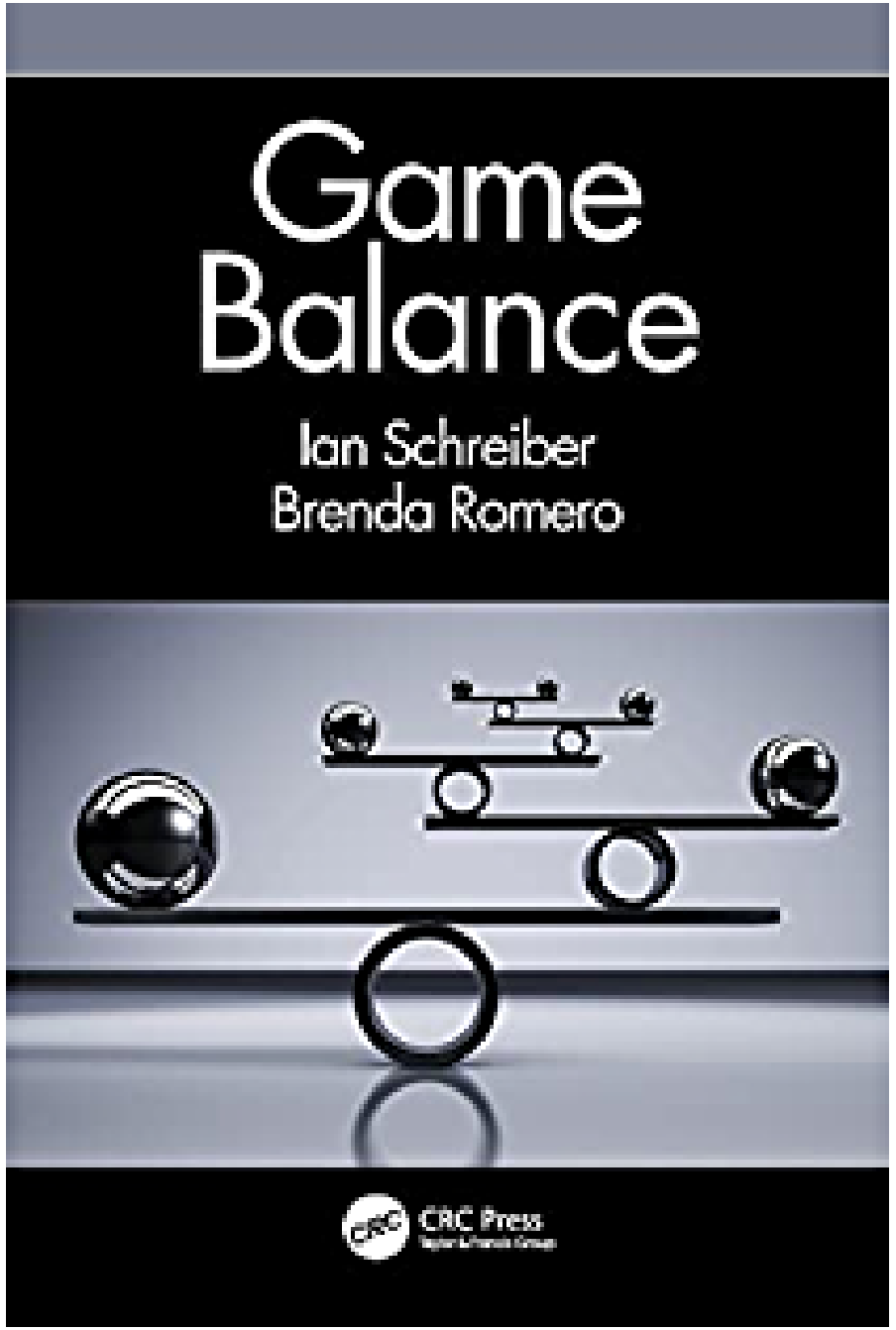
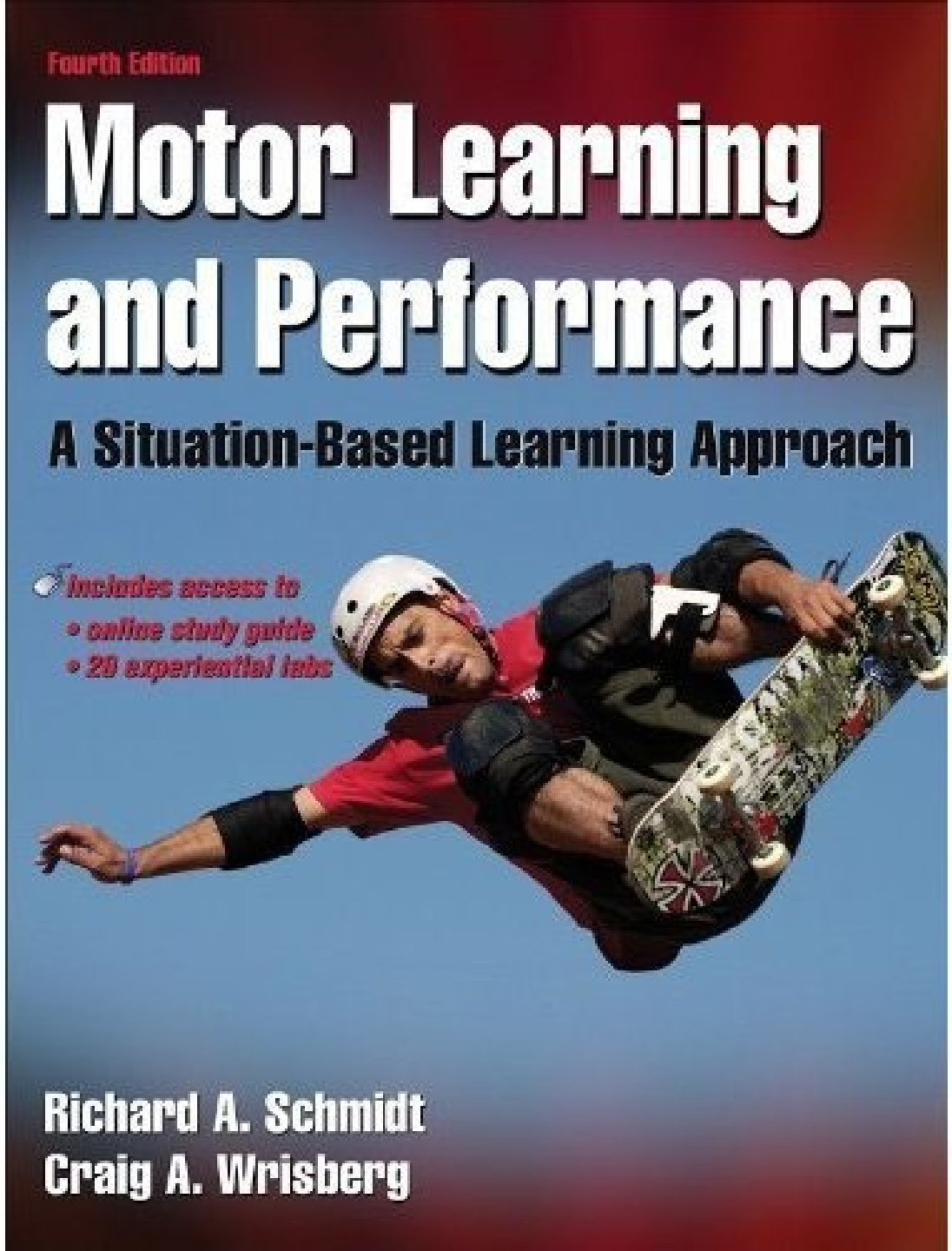


Books


Fourth Edition
Motor Learning and Performance
A Situation-Based Learning Approach
Includes access to
• online study guide
• 20 experiential labs
Richard A. Schmidt
Craig A. Wrisberg

Research papers and talks

- High-quality conferences and journals: CHI PLAY, CHI, UIST, SIGGRAPH, Proceedings of the ACM on HCI, ACM Transactions on Graphics
- Also good: Designing Interactive Systems (DIS), Foundations of Digital Games (FDG), Digra
- GDC talks can be good, but they are not peer-reviewed before presenting, and the quality and reliability of what is said varies a lot
- https://arxiv.org/: Used a lot in technical areas, but might not yet be peer-reviewed and trustworthy
- https://osf.io/preprints/psyarxiv/: Like arxiv but for psychology

How to find? (Demo)

The best research search engine: https://scholar.google.com/

Demo: search citing articles

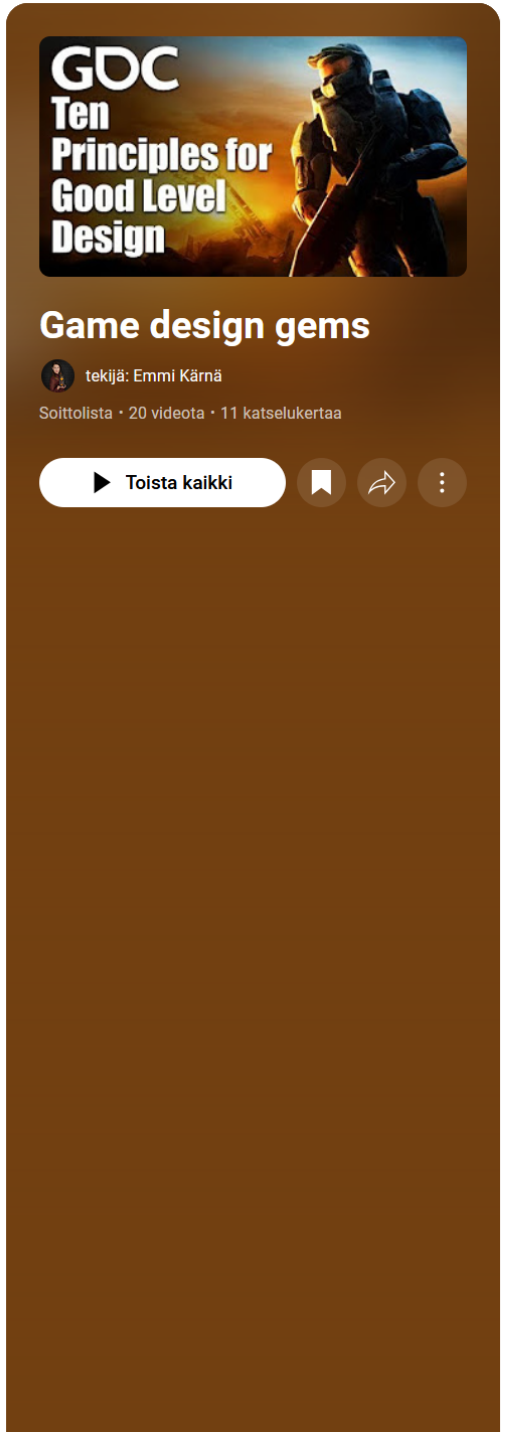
ACM SIGCHI conferences (CHI, CHI PLAY, UIST). 2020 onwards, this includes talk videos: https://programs.sigchi.org/

Demo: filter by awards

GDC YouTube channel: https://www.youtube.com/@Gdconf

Best playlists?

Emmi Kärnä is an Aalto games graduate



1 Ten Principles for Good Level Design
GDC 2025 • 484 t. katselukertaa • 6 vuotta sitten

2 Maximizing Artistic Critique: Improving Communication for Everyone Involved in Critical Feedback
GDC 2025 • 17 t. katselukertaa • 6 vuotta sitten

3 Ready Player Me x Unity Live Capture / Face Capture App
Sarge • 30 t. katselukertaa • 2 vuotta sitten

4 Storytelling with Verbs: Integrating Gameplay and Narrative
GDC 2025 • 24 t. katselukertaa • 4 vuotta sitten

5 Will Wright's Dynamics for Designers
GDC 2025 • 20 t. katselukertaa • 7 vuotta sitten

6 Meaningful Choice in Game Level Design
GDC 2025 • 84 t. katselukertaa • 8 vuotta sitten

7 Twine 2 Chapbook Story Format Basics
noirnerd • 2,3 t. katselukertaa • 3 vuotta sitten

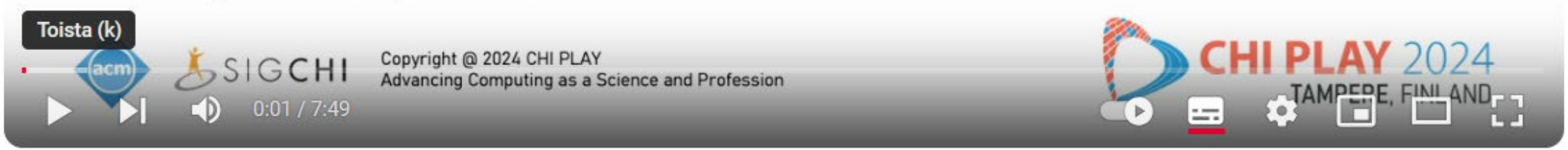
8 Sparking Curiosity-Driven Exploration Through Narrative in 'Outer Wilds'
GDC 2025 • 29 t. katselukertaa • 2 vuotta sitten

Examples of research presentations

Aiming, Pointing, Steering: A Core Task Analysis Framework for Gameplay

Bastian Ilsø Hougaard[1], Hendrik Knoche[1]

[1] Aalborg University, Denmark



Aiming, Pointing, Steering: A Core Task Analysis Framework for Gameplay

https://www.youtube.com/watch?v=JUE-LWBCAH8

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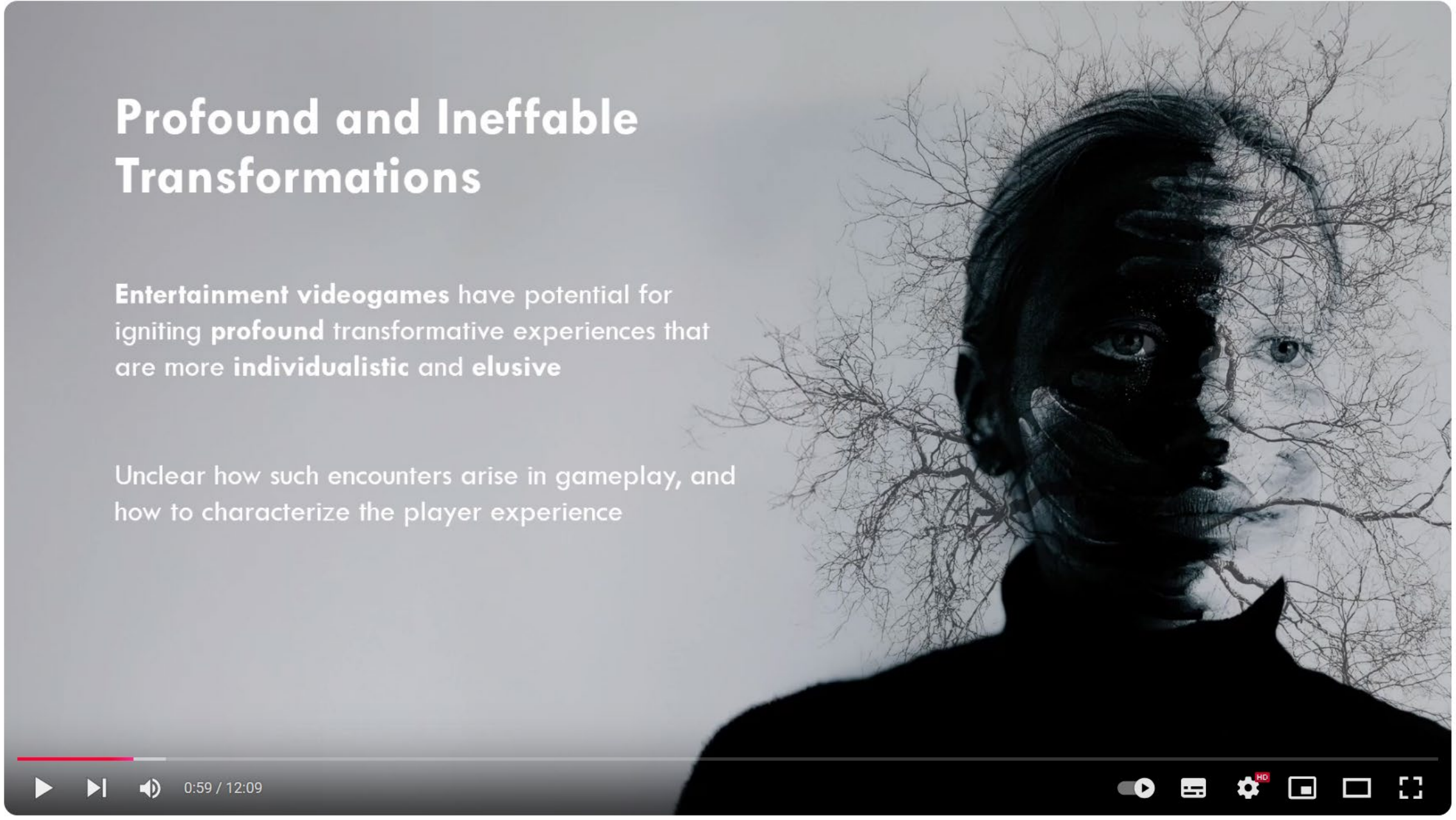
2 | Jaa | Klippi | Tallenna | ...



From Disorientation to Harmony: Autoethnographic Insights into Transformative Videogame Experiences

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https://www.youtube.com/watch?v=ezPDlA-5_w4
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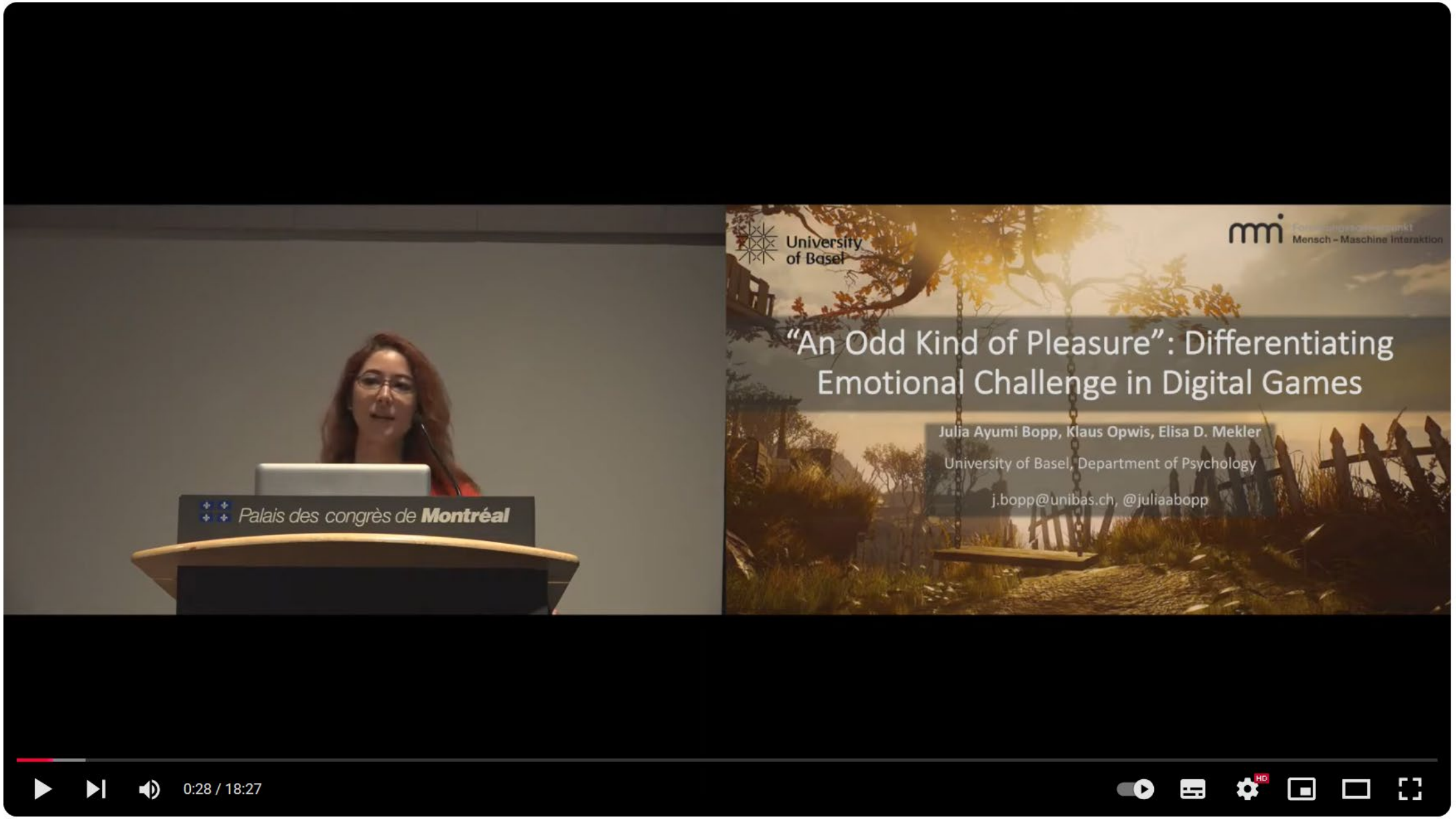

"An Odd Kind of Pleasure": Differentiating Emotional Challenge in Digital Games

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https://www.youtube.com/watch?v=mj27koxzpdI
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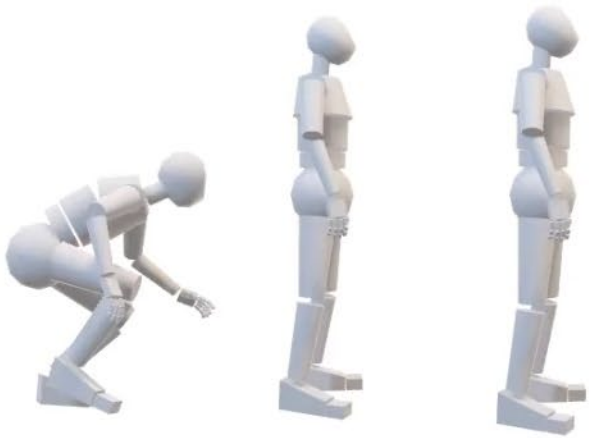
Motivation & Related Work

CHI PLAY 2020

How to combine the following in VR?

1. Body Movement Interactions ⊕
2. Navigating Large Spaces ⊕
3. Minimum Cybersickness



1:03 / 5:56

3PP-R: Enabling Natural Movement in 3rd Person Virtual Reality, CHI PLAY 2020

Inan Evin
88 tilaajaa
Tilaa
https://www.youtube.com/watch?v=qpYDgfD6vdM
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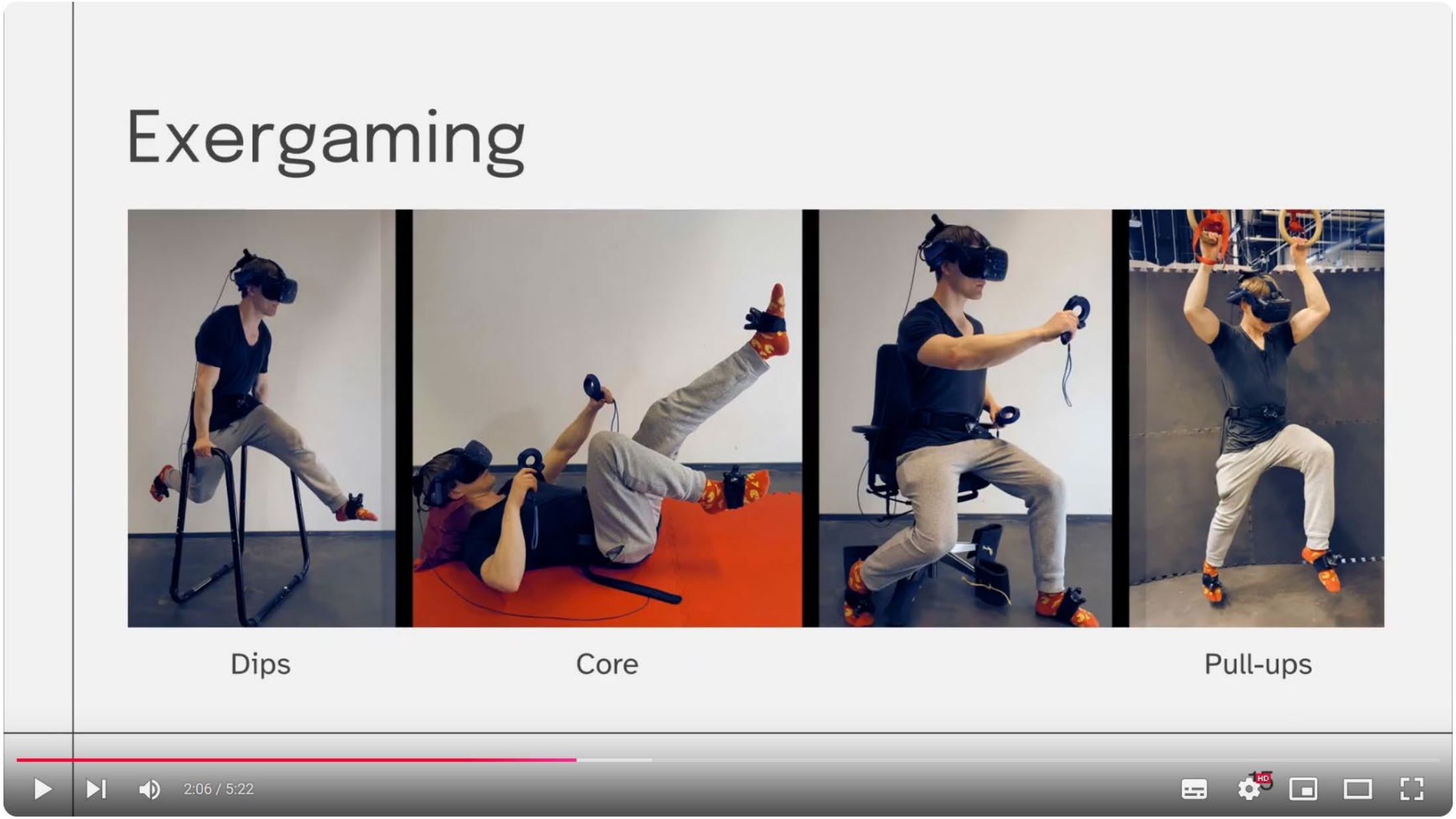

“I Feel My Abs”: Exploring Non-standing VR Locomotion

Piilotettu

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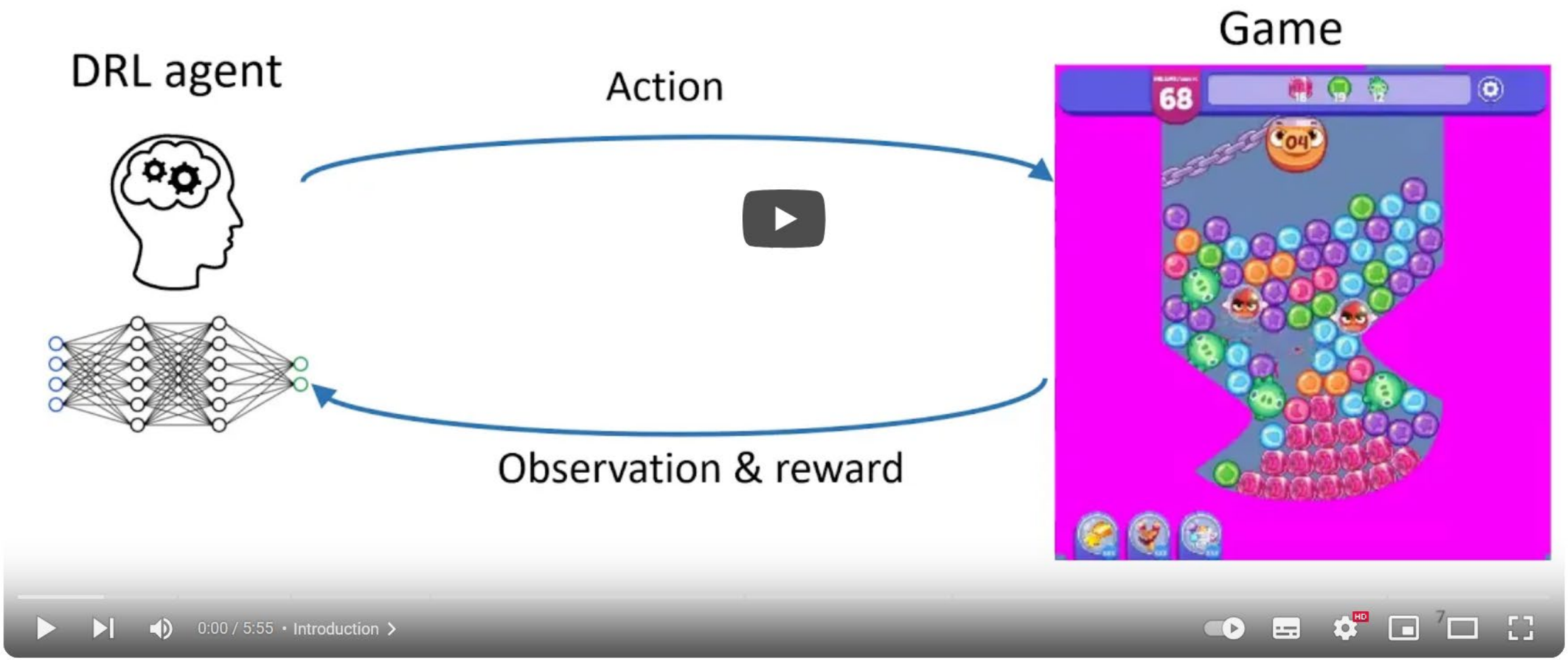
https://youtu.be/NdltiKhsnMg?si=wUmVtwxRU3p_OQN2

2 Jaa Klippi Tallenna ⋯

Game-playing AI



Predicting Game Difficulty and Churn Without Players

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https://www.youtube.com/watch?v=DahxCgxNJ7s
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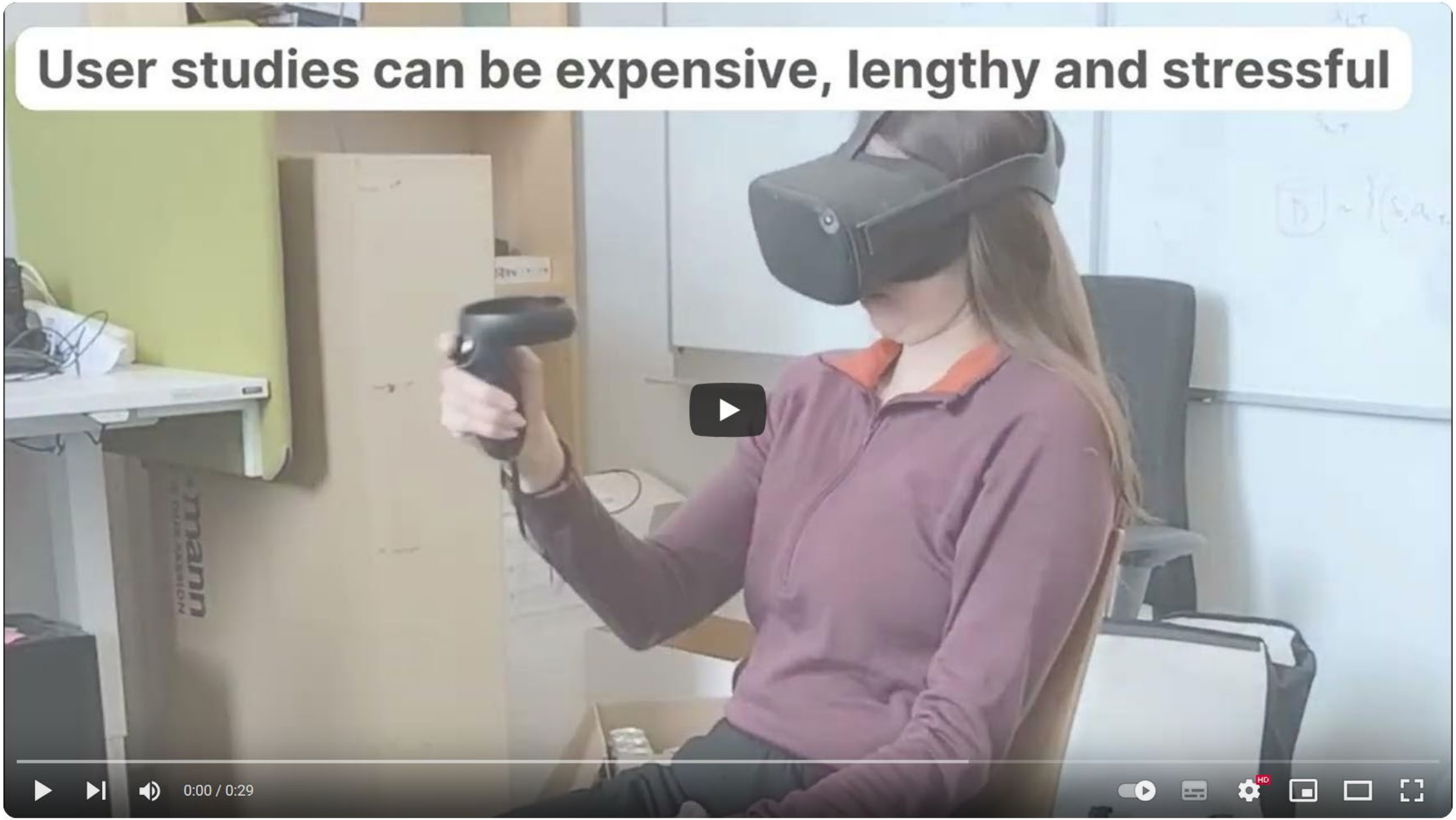

SIM2VR: Towards Automated Biomechanical Testing in VR

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Tilaa

https://www.youtube.com/watch?v=AdfWf8FOsAI

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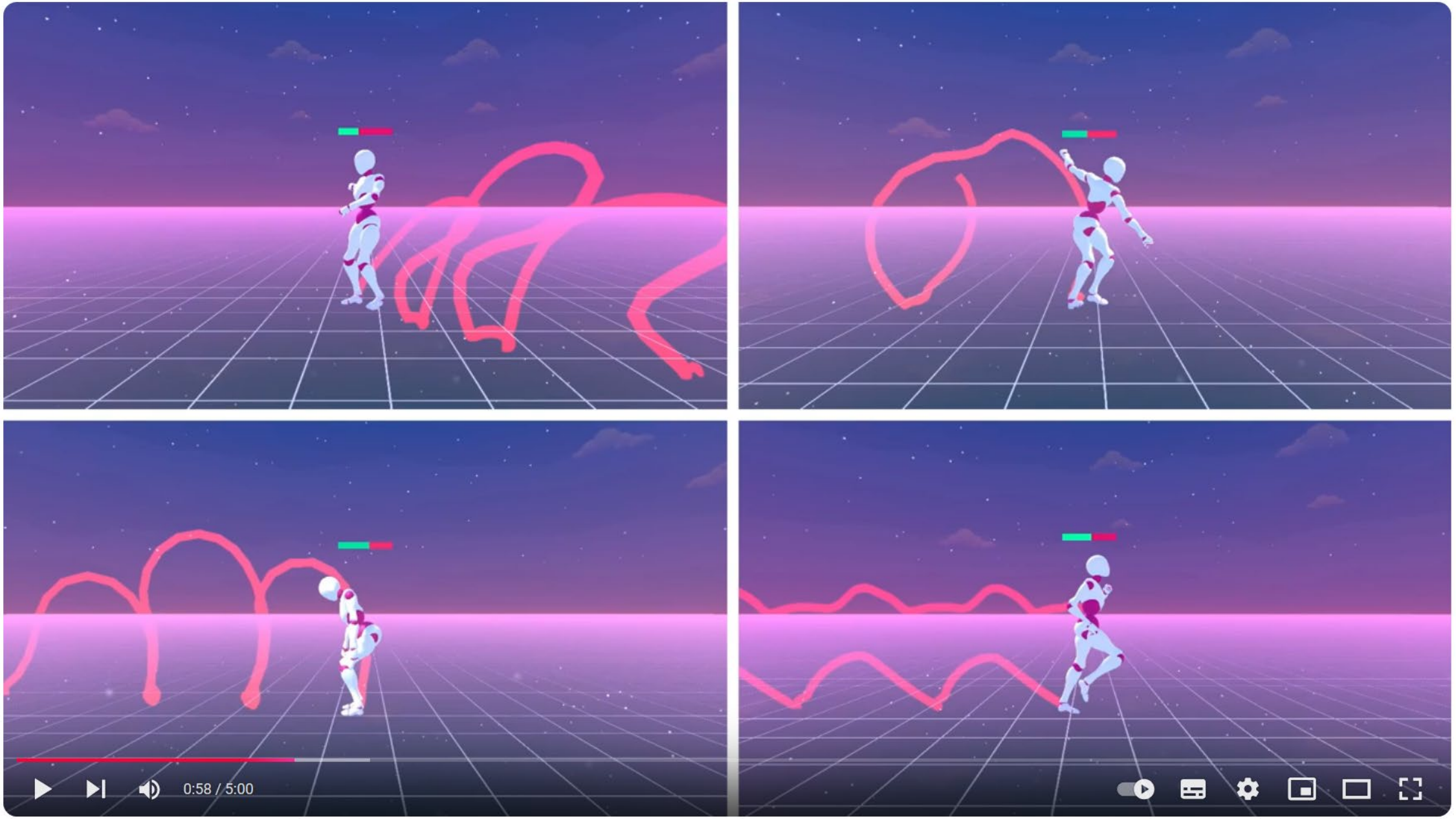

[SIGGRAPH Asia 2023] Discovering Fatigued Movements for Virtual Character Animation

Noshaba
7 tilaajaa
Tilaa
https://www.youtube.com/watch?v=FVOWVz0k1dI
10
Jaa
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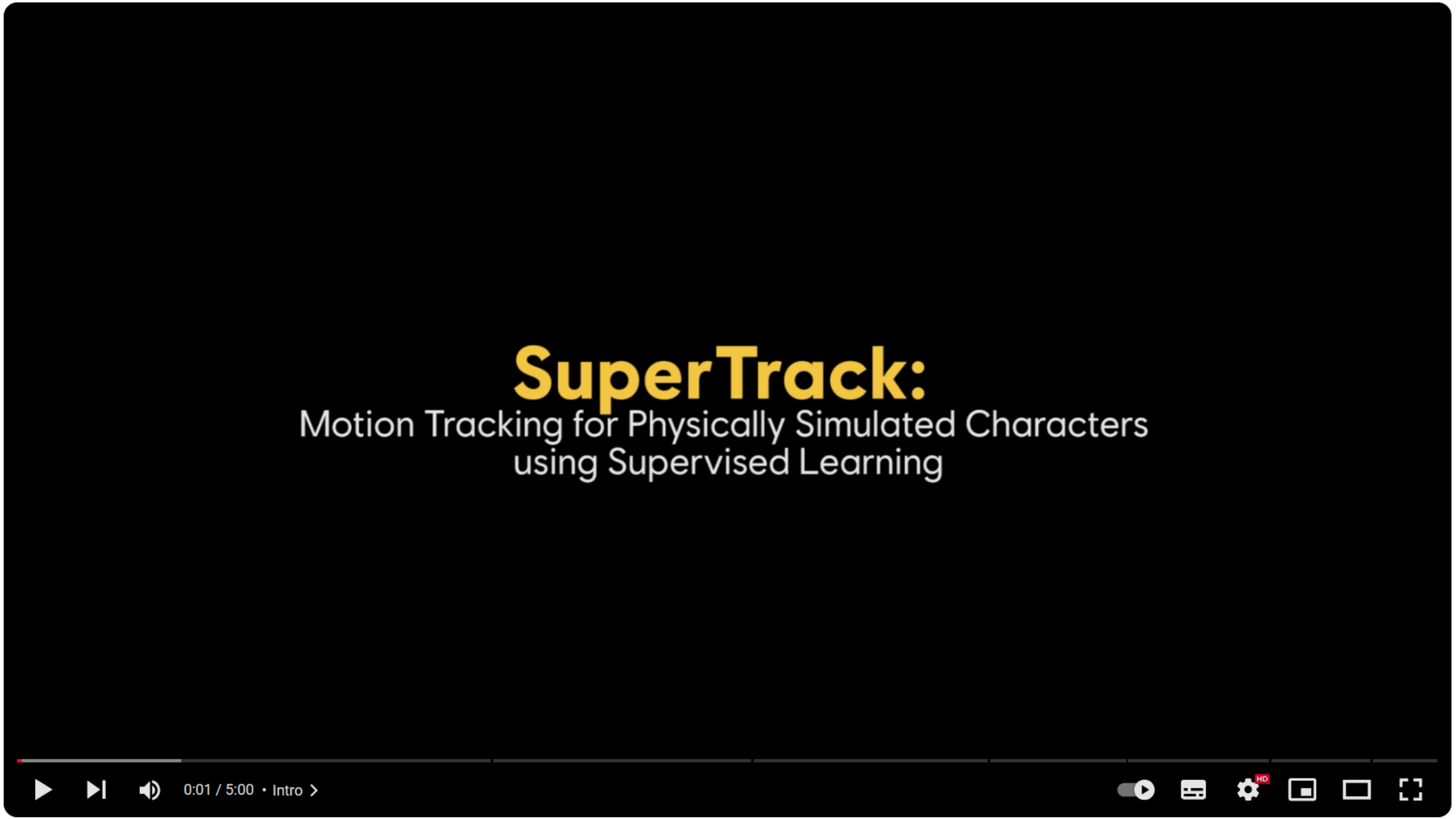
Tallenna

SIGGRAPH 2020 | Learned Motion Matching

Ubisoft La Forge
3,46 t. tilaajaa
Tilaa

https://www.youtube.com/watch?v=16CHDQK4W5k

2,9 t. Jaa Klippi Tallenna



SuperTrack: Motion Tracking for Physically Simulated Characters using Supervised Learning

Ubisoft La Forge
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https://www.youtube.com/watch?v=8sMjfGkQ4bw

224 Jaa Klippi Tallenna ⋯

[SIGGRAPH Asia 2019] DReCon: Data-Driven Responsive Control of Physics-Based Characters

Ubisoft La Forge
3,46 t. tilaajaa
Tilaa

https://www.youtube.com/watch?v=tsdzwmEGl2o

407 Jaa Klippi Tallenna ⋯

Contents (today)

- What are games?
  Many definitions, and many of the most interesting works stretch or defy the definitions
- What is game design?
  Iterative process comprising cycles of divergent and convergent thinking. Key to avoiding wasted effort: scope down, fail fast, prototype and iterate smartly – don't prototype the wrong things or with the wrong tools (storyboards, mock-up screenshots etc. can be tested faster than full interactive prototypes)
- Why research & theory?
  Helps in both answering questions and asking the right questions. Minimizing the amount of prototypes and iterations needed.
- How to search and find research?
  Google Scholar, https://programs.sigchi.org (filter by awards), GDC youtube channel. High-quality publication venues: CHI, CHI PLAY, SIGGRAPH, FDG