Background and Related Work

Driving simulators is combination of software and hardware to simulate the process of driving. Driving simulators exist for different types of vehicles e.g. cars, motorcycles, trains, trucks and plains. They reduce the cost and allow simulating dangerous and complex scenarios. Training in advanced simulators has been found to have a similar training effectiveness than using the real system \ref{Uhr}. The increasingly complexity of driving systems made simulators popular for a wide range of applications. Driving simulations are used in teaching, entertainment, product engineering, product improvements and research. Important applications are\ref{CSDrivingsumulator2017}:

* Driver training: Simulators are used in driving schools to teach basic driving and driving safety concepts \ref{Vlakveld}. In racing, simulators give drivers extra miles behind the wheel and engineers extra time to find the best car setups \ref{Gitlin2018}.
* Research: Scientific research simulators are used in studies to test the effects of impairment on driver performance. Researchers can experience how it feels to drive under influence of alcohol or drugs \ref{Furniere}.
* Eco drive simulations: Eco-driving simulation systems are used to train efficient driving to reduce green-house gases \ref{Gardelis}. Direct feedback while driving is a powerful approach to change driving behaviour.
* Risk management: Simulators are used in crisis management exercise in police, ambulance and firefighter training \ref{CSDrivingsumulator2017}. Training in a simulator helps to practice driving in traffic and the recognition of hazards. Special scenarios offer excellent opportunities to train rare unexpected real world situations.
* Entertainment: Realistic race simulations are a popular video game genre. Fans enjoy racing, realism and the diversity of cars and tracks \ref{ESA}.
* Car development: Driving simulators are used in the development process of a vehicle. Engineers can model vehicle dynamics, ride comfort, design and simulate smart assistance systems \ref{Cruden}.

We focus our research in the area of human factors to monitor driver behaviour and performance. In this project, we developed a model for driver education and entertainment with a focus on improving and measuring performance. Our main objectives are:

* Entertainment: Create enjoyment for the players by providing balanced competition.
* Education: Improving driving skill using direct feedback.
* Performance: Measuring and improving performance and motivation.

We want to find an individualized competitive learning approach for racing simulations with limited computational resources. This chapter will give an overview of different aspects of race simulations, ranging from conventional racing simulations over game based design principles to player psychology. The chapter addresses the challenges of developing a racing simulation with an emphasis on the main objectives: Entertainment, Education and Performance. The first section is dedicated to existing racing games and driving simulators and their development over the past decade. The following sections will focus on introducing basic game design principles, concepts to generate entertainment for the players and the building blocks of a challenging environment.

<https://www.cruden.com/automotive-driving-simulators/> Cruden

Development of an Eco-Driving Simulation Training System with Natural and Haptic Interaction in Virtual Reality Environments - Gardelis

<http://www.flanderstoday.eu/innovation/simulator-shows-risk-driving-under-influence> - Furniere

This isn’t a game: We try out a professional driver-in-the-loop simulator – Gitlin2018

<https://cs-driving-simulator.com/2017/05/05/driving-simulator-applications/> - CSDrivingsumulator2017 / Carnetsoft2019

The use of simulators in basic driver training - Vlakveld

<https://en.wikipedia.org/wiki/Video_game_genre>

<https://de.wikipedia.org/wiki/Fahrsimulator>

<https://en.wikipedia.org/wiki/Driving_simulator>

They are also used for research purposes in the area of human factors and medical research, to monitor driver behavior, performance, and attention and in the car industry to design and evaluate new vehicles or new advanced driver assistance systems.

TRANSFER OF TRAINING IN AN ADVANCED DRIVING SIMULATOR: COMPARISON BETWEEN REAL WORLD ENVIRONMENT AND SIMULATION IN A MANOEUVRING DRIVING TASK - Uhr

Learning how to drive a race car is a both challenging and time-consuming task. In traditional race games you often times have the option of competing against yourself in a time trial mode. Many motorsport categories use a similar format to determine the starting order. Formula 1 allows multiple attempts to set the fastest time and win pole position (F1Rules). The most popular race simulations are Project Cars 2 and Gran Turismo Sport. In their time trial modus, you have the option to race against a “transparent” recording of a previous run. This allows analysing and improving driving without checking section times and lap times.

The time trial mode is very educational, but this is often times perceived as boring (Budday2012). Especially designed coaching models, which use collaborative and competitive learning, can offer a rich and challenging environment (Silvia). However, appropriate approaches also have drawbacks, such as increased processing resources and dealing with different skilled players. We want to find an individualized competitive learning approach for race simulations with limited computational resources. The following sections will focus on introducing basic game design principles and player preferences in race games. The next section addresses the challenges of developing a game with emphasis on generating entertainment for the players and discusses the building blocks of a challenging environment.

<https://www.formula1.com/en/championship/inside-f1/rules-regs/Practice_qualifying_and_race_start_procedure.html> - F1Rules

Fun and Games and Boredom - Buday2012

A Study and a Proposal of a Collaborative and Competitive Learning Methodology –Silva

# Race Games and Simulators

Humans where always fascinated by speed and competition (Sheen2014). One form of competition which combines both aspects is racing. Race competition has come a long way from the first nomadic horse races around 4500 B.C. in Asia to the international, technology driven motorsport events today (Crego2003). Since the beginnings of video games in the 1970s, race games have been a popular game type (Arcademachines). There are various forms of motor racing e.g. stock car, road racing, touring car racing and drag racing. Each genre is unique and needs a different driver skill set (Hassan2014). The same can be said about race games. All racing games are designed to be fun, but challenge the players in different ways. Table shows how race games can be categorised in terms of realism (arcardesimulator). In this section I want to introduce each category, give examples, and examine the main differences.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Arcade Racing | Simcade Racing | Simulators |
| Focus | Fun | Fun / Realism | Realism |
| Engine | Simple Physics | Realistic Physics | Realistic Physics |
| Learning Curve | Flat | Moderate | Steep |
| Audience | Casual Gamers | Race Game Enthusiast | Professional Race Drivers |

## Arcade Racing

The arcade genre originates from coin-operated entertainment machines in the 1940s (Arcademachines). Shortly after the first video arcade games appeared Atari innovated the race game format with “Space Race” in 1973 (Wolf2008). The arcade game genre does not refer to the games that originated as arcarde machines, but to fast pace action games with very simple gameplay similar to coin-operated arcade games (Mobygenres). In arcade race games, it is all about fun by just accelerating and steering. (Towell) defines the main properties of arcade racers:

**Limited time:** The race is against the clock as well as other cars

**Larger-than-life graphics:** Excessive, unrealistic scenes stimulating the imagination.

**Incredible track design:** Race tracks are not based on real locations.

**Crashes:** Massive crashes, car damage and destruction.

**High score:** Lap time score is supplemented with bonus scores for drafting, jumping and causes crashes.

## Simcade racing

(arcardesimulator) defines simcade race games: “Simcade racing games try to hit the sweet spot between fun and realism, between the easy to play arcade games, and the highly technical simulators.” These games are designed for the masses. The games feature a high degree of realism, with tire management, weight distribution and suspension models, but still endorse gameplay features at the cost of realism (arcardesimulator). The founder of Gran Turismo (GT), Kazunori Yamauchi explains his philosophy behind Gran Turismo Sports: "Current car models are pretty close to the optimum level of modelling you could want in a game. I don't think any higher precision is necessary anymore we are almost there. However, the hardest part isn't creating realistic cars and handling - the GT team has 20 years' experience in that. Today's biggest challenge is about creating an entertaining broadcast” (Sodah).

## Simulators

The game needs to have a high level of realism to be considered a simulator (Mobygenres). They are tools for real racing drivers to learn the tracks and the cars for real life racing (arcardesimulator). For an average person it’s extremely hard to control the car and drive a clean lap. Hirscher showed that driving simulators are an excellent tool to learn driving. Hyper-real racing simulations are indistinguishable from behind the wheel, technologies such as three-dimensional laser-scanning, dynamic track conditions and weather effects create an astonishing racing experience (iRacing.com). The car models are very realistic, typically laser-scanned. To generate realistic driving dynamics they work with manufactures, race car constructors or even disassemble vehicles on their own (iRacing.com).

Professional simulators are built around motion systems with force feedback systems. These systems manipulate the way we perceive our body and our surroundings (simcraftmotion). The three main classes in human physiology to generate immersion in simulations are:

* Proprioceptors: Proprioception is the sensation of body position and movement (Tuthill). It is often referred to as ‘sixth sense’. The brain generates a feeling where you are in space as external forces act on your body. The simulator can generate a feeling of movement by moving the platform when accelerating, breaking or turning.
* Vestibular System: The Vestibular System is the balancing system of the body (Jones2009). To stimulate a sense of motion the simulator has to move through all three planes in space e.g. longitudinal, lateral and vertical.
* Visual Inputs: The visual input is the most basic way to generate immersion. It’s important to synchronise all sources of information in motion simulation to avoid motion sickness (simcraftmotion).

This section discussed different race game genres and their attributes. Each genre is unique and enables different playstyles. All racing games are designed to be fun but challenge the players in different ways. Table \ref{tab:rel:racegamecategories} shows how racing games can be categorised in terms of realism \citep{Grolleman2016}. Arcade racing focuses only on fun and has no implication for driver education. Simcade racing provides all mechanism to create an environment for driver education, but is mainly used for entertainment. Players have to be incentivised to turn of assisting systems to achieve an educational effect. Simulators have the highest grade of realism. They can be used as substitution for real world driving and have numerous applications. In the next section, we focus on racing simulators and how they are used for Education.

## Application Scenarios

Table \ref{} shows a comparison of professional simulator. We identified three common applications for simulators: racing simulation, driver training and virtual testing. Racing simulators prepare drivers and engineers in a realistic environment. Engineers optimized and tested car setup while drivers increase speed and consistency. The focus is on realistic race cars and optimization. These systems provide the highest immersion for drivers by stimulate motions on a high level. Simulators for driver training simulate a variety of driving situations for research institutions, driving schools and government institutions. The goal is to prepare for real dangerous driving scenarios. The focus is on a natural training environment by matching the décor of the target vehicle. Virtual testing is used by manufactures to save money by testing early. The simulators implement large worlds and realistic vehicle dynamics to test ADAS systems and autonomous driving.

|  |  |  |
| --- | --- | --- |
| Simulator | Application | Method |
| SimCraft | Racing simulation | Physics |
| Cruden | Driver training, autonomous driving, vehicle dynamics | Hexapod |
| CXC | Racing simulation | Seat Mover |
| VRX | Racing simulation | D-BOX |
| Adiona Safety | In-vehicle driver training: police, driving schools, government agencies | Drive Square Simulation System |
| AVL RACING Driving Simulator | Racing simulation | AVL Vehicle Simulation Model |
| rFpro | ADAS, autonomous driving, vehicle dynamic | rFpro workstation |

Anatomical and Physiological Considerations in Vestibular Dysfunction and Compensation - Jones

<https://www.cell.com/current-biology/fulltext/S0960-9822(18)30097-6?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0960982218300976%3Fshowall%3Dtrue> - Tuthill

<https://www.simcraft.com/human-physiology-of-motion/> - simcraftmotion

<https://www.iracing.com/track-technology/> - iRacing.com

https://www.thesun.co.uk/tech/gaming/7795374/how-sonys-gran-turismo-is-fuelling-a-new-age-of-racing-drivers/ - Jonny Sodah

<https://www.gamesradar.com/where-have-all-arcade-racers-gone/> - Towell

<https://www.mobygames.com/glossary/genres> - Mobygenres

<http://www.pinrepair.com/arcade/> - Arcademachines

<https://virtualracingschool.com/academy/iracing-career-guide/before-you-get-started/arcade-vs-simcade-vs-simulators/> arcardesimulator

Sports and Games of the 18th and 19th Centuries - Crego2003

Car Racing – Sheen2014

The Video Game Explosion: A History from PONG to Playstation and Beyond - Wolf2008

The History of Motor Sport: A Case Study Analysis - Hassan2014

Transfer of Skills Learned on a Driving Simulator to On-Road Driving Behavior - Hirscher

# Game Design

\epigraph{Gamers are everywhere coming in all ages and genders, and developers have grown up, too.}{Warren Spector}

Video games are everywhere. (theesa) reports that in 2018 about 60 percent of Americans play video games dailyThe same report states that the U.S. game industry made \$43.4 billion in revenue, matching the U.S. film industry for the first time. Creating an enjoyable and profitable video game is a challenging task. Making a video game requires a multitude of skills. Video game development teams include software developers, artists, musicians, writers and many others(Liming). Video game developers have to adopt a set of good practises to create the best experiences for the players, handle complex development tasks and achieve profitability. Many of the software practices come from traditional software engineering. Researchers have developed additional guidelines to deal with the complex game development specific requirements(Aleema).

The game development process always starts with an idea. The ideas can origin from a single person or a whole team(Dörner). Common idea generation methods are: brainstorming and idea sketchbooks. The central vision of the game should never be lost. Rogers emphasized in this context: “Gamers can feel when developers are passionate about their games. They can smell it like a dog smells fear. Don't be afraid to hold onto your unique vision: just be aware that it may not turn out exactly how you envisioned.”



Figure 1: Game development process(Dörner)

The preparation phase focuses on planning the project, having a clear concept, set up the team and financing. The result is a design document with all design decisions and organisational conditions. Every subsequent step extends the design document. The implementation phases consist of iterative implementation and testing cycles. The focus is on agile software development to deal with the cross-functional teams and rapidly respond to bugs. As illustrated in figure, the testing process is an iterative process itself between testers and developers. Testers report bugs back to the developers, who fix them and release a new build, which the testers check again and so on (chopra).



Figure 2: Iterative testing process

The last phase of the development process contains the market access and the maintenance process begins(Moore). Game developers can use downloadable patches to make balance adjustments and fix bugs.

AudienceNet/New Paradigm Strategy Group

http://www.theesa.com/article/essential-facts-computer-video-game-industry-2018/

Work for Play: Careers in Video Game Development - Liming and Vilorio 2011

Game Development Software Engineering Process Life Cycle: A Systematic Review – Aleema

Level Up!: The Guide to Great Video Game Design – Scott

Serious Games - Dörner, R., Göbel, S., Effelsberg

Software Testing - RAJIV CHOPRA

Game Development Essentials: Game Industry Career Guide - Michael E. Moore

# Game Design Principles

A core task in game design is creating a positive player experience. Making a game is a very complex process. Only a few games are excellent and profitable(Bethke). The developers have to model extensive functionality, while maintaining usability and optimizing player experience. Game genres provide very different experiences, but there are some common fundamental design features. Looking at different game design principles can inspire and help to identify problems. \textcite{Despain2012} collected 100 widespread principles of game design. The principles can be classified in four universal categories:

* Game Innovation: Idea creation, Brainstorming, Analyse existing games
* Game Creation: Software design, Artistic guidelines
* Game Balancing: Level design, Skill levels, Assistances
* Troubleshooting: Bug fixing, Find vulnerabilities

Out of the large number of principles we want to find the key principles, which can take a game from good to great. In table we compare independent articles which rank game design principles and assign the principles to the universal categories. We classify most mentioned principles as central and universal applicable. The most mentioned innovation principle is to understand the domain. This includes everything from documentation to gameplay and balancing. It can also help to investigate similar games and analyse what works for them.

The most mentioned creational principle is rewarding the player. Reward systems are important player motivators. \textcite{Kloster2004} found that people like learning but lean towards laziness. Balanced rewards incentivise players to keep playing. Another vital principle is to build around core game mechanics. Game mechanics create gameplay and are the key to a great game(Adams). Core mechanics are the most influential aspects of a game; they influence almost all moving objects (e.g. strength of gravity in a platform game). Table shows core game metrics and non-core metrics for different game genres. For race simulations the focus is on realistic and detailed physics.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Physics | Economy | Progression | Tactical Manoeuvring | Social Interaction |
| Action | **Detailed physics for movement, shooting etc.** | Power ups, Health… | Storyline |  |  |
| Strategy | Physics for movement and fighting | **Unit building, resource harvesting** | Scenarios / New challenges | **Positioning of units** | Competition between players |
| Role Playing | Physics for movement and fighting | **Character Equipment** | **Storyline** | Party tactics | Play-acting |
| Sports | **Detailed simulation** | Team Management | Seasons, Tournaments | Team tactics |  |
| Vehicle Simulation | **Detailed simulation** | Vehicle upgrades | Races, Seasons, Tournaments |  |  |
| Management Simulation |  | **Management of resources** | Scenarios / New challenges | Management of resources | Coordinated actions, Competition |
| Adventure |  | Managing a player’s inventory | **Storyline** |  |  |
| Puzzle | **Physics to create challenges** |  | Short levels with increasing difficulty |  |  |
| Social Games |  | **Resource harvesting** | Quests, Challenges |  | **Resource exchange, Cooperation, Competition** |

Adams: Core Game Mechanics and Game Genres

The central game balance principle is “Teach Without Teaching”. Even in complex games, the users should be able to learn the game as they play it. Learning curves come in different shapes but must match the skills of the target audience in order to avoid frustration\citep{Nacke2011}.

A central factor for basically all software applications which is not mentioned in table is the ease of use[User-centered design in games]. This includes controls and interface for video games. Challenge is a critical factor to the enjoyment of a game. It must be adapted to every individual player for the best results.

An important troubleshooting metric is pacing. It is the rate in which players go through new challenges. Play test can show if there is a problem with pacing\textcite{Despain2012}. Designers at Microsoft have their own version of "Powers of Ten" (Charles and Ray’s documentary, Powers of Ten—one of most famous short films ever made). The game must keep the user’s attention at 10 seconds, 10 minutes, 10 hours and 100 hours. It is important to give players a great experience at these critical junctions. The first hour is of special importance []. It is the entry point into the main experience of the game and vital time in the learning process. [] found that momentary enjoyment is less valuable than intriguing and engagement.

Part of the project is to create an interactive 3D racing game. The game is rendered in the browser. Different browsers demand different standards. In order to have a stress-free transition between different platforms, we focused on a simple, plain design and the most trivial functions. This also helps to enhance the performance. In order to make the entry point to the game as smooth and easy as possible we employed the conventional control system and traditional graphical visualization known from other racing games. The tutorial level is utilised the basic controls but also estimate the initial skill level. The difficulty is adjusted automatically when progressing across the laps. This allows for a flexible learning process, adjusted on the individual skill of the player.

Towards a Framework of Player Experience Research

User-centered design in games.

Eames, Charles and Ray Eames, directors. Powers of Ten. Powers of Ten, IBM, 1977, [www.youtube.com/watch?v=0fKBhvDjuy0](http://www.youtube.com/watch?v=0fKBhvDjuy0).

A survey method for assessing perceptions of a game: The consumer playtest in game design

The First Hour Experience: How the Initial Play can Engage (or Lose) New Players

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Universal Principles | The 3 Primary Principles of Game Design | Three Principles Every Video Game Designer Should Follow | Seven Design Game  Principles | 3 Indispensable Game Design Principles |
| Game Innovation | Understanding the Domain |  | Think up first |  |
| Game Creation | Reward The Player | More Rewards than Punishments, More Power-Ups than Obstacles | Balancing rewards | Give Players a Feeling of Accomplishment |
|  | Build Around a Core Game Mechanic | Start With A Core Mechanic And Build From It | Clear Objectives, Limitations and Success Criteria’s | Introduce New Elements in Isolation |
| Game Balancing | Easy To Learn But Fun To Master | Easy to Learn, Hard to Master |  | Teach Without Teaching |
| Troubleshooting |  |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Universal Principles | gamedesigning.org | nyfa.edu | thedesigngym.com | binpress.com |
| Game Innovation | Understanding the Domain |  | Think up first |  |
| Game Creation | Reward The Player | More Rewards than Punishments | Balancing rewards | Give Players a Feeling of Accomplishment |
|  | Build Around a Core Game Mechanic | Start With A Core Mechanic And Build From It | Clear Objectives, Limitations and Success Criteria’s | Introduce New Elements in Isolation |
| Game Balancing | Easy To Learn But Fun To Master | Easy to Learn, Hard to Master |  | Teach Without Teaching |

<https://www.binpress.com/game-design-principles/> - 3 Indispensable Game Design Principles

<https://www.thedesigngym.com/seven-principles-of-game-design-and-five-innovation-games-that-work/> - SEVEN DESIGN GAME PRINCIPLES

https://www.gamedesigning.org/learn/game-design-principles/ - The 3 Primary Principles of Game Design

https://www.nyfa.edu/student-resources/three-principles-every-game-designer-should-follow/ - Three Principles Every Video Game Designer Should Follow

A Theory of Fun for Game Design – Kloster2004

Game Mechanics: Advanced Game Design - Ernest Adams, Joris Dormans

Game Development and Production - Erik Bethke

# Enjoyment in Games

Understanding human nature and understanding emotions has been a central research topic for a long time(George2003). Plato examined how emotion influences human decision making: “Human behaviour flows from three main sources: desire, emotion, and knowledge”. Studying emotions in games is a popular research topic. Most of the research concentrates on the negative effects of gaming(Granic2014). \textcite{Brunborg2014} showed that video game addiction is associated with depression, decreased academic achievement, and with conduct problems. Game developers are looking at the psychological side of enjoyment and happiness, to extract features that generate entertainment for the player. Granic2014 discusses a multitude of benefits in different areas. Figure illustrates the different areas.

Action games provide mostly cognitive benefits. (Green) showed that gaming enhances learning and attentional control. The spatial skills learned in games are also useful in science, technology, engineering, and mathematics (utal). Bavelier used brain imaging to compare attentional network recruitment and distractor processing. They found that gamers have developed more efficient resource management and the ability to filter out irrelevant information more effectively. One of the biggest cognitive benefits is the enhancement of creativity. Independent of the video game type, gender or race ethnicity, gaming facilitates creative thinking(Jackson).

Gaming has become a social experience. Over 97% of teens ages 12-17 play video games and only a quarter plays alone(Lenhart). Farmville one of the most popular social games on facebook had 40 million active users every month in 2012(FarmvilleUser). Social gaming opens a new dimension for the developers, like the addition of special events features. In 2019 over 10.7 million people attended the virtual concert of the US-DJ Marshmellow in Fortnite. Ferguson found that playing action games is associated with small increased civic engagement in the real world. In particular the ability to organize groups and lead likeminded people in social causes. Games with civic learning opportunities (e.g. helping others) raise the interest in politics and charities(Lenhart).

People use diverse forms of media like video games to escape from routines or for emotional release (Ruggiero). Enjoyment goes beyond the feeling of pleasure. It is characterised by achieving something unexpected and special. In games we want to create enjoyment, the deep involvement that removes the frustrations of everyday life and make hours pass like minutes. Several studies have shown that playing video games generate positive feelings (Ryan, Russoniello). \textcite{Csikszentmihalyi1991} defines the major building blocks for enjoyment. Some important components are:

\begin{itemize}

\item Clear goals

\item Reasonable chance of completion

\item Immediate feedback

\item Control over the actions

\end{itemize}

Granic2014 describes the motivational power of game designers: “Game designers are wizards of engagement. They have mastered the art of pulling people of all ages into virtual environments, having them work toward meaningful goals, persevere in the face of multiple failures, and celebrate the rare moments of triumph after successfully completing challenging tasks.” \textcite{Csikszentmihalyi1991} describes the most important features of motivating activities. The feeling of pleasure is essentially a feeling of contentment when a personal or social expectation has been met. Sweester found that in order to get the optimal conditions for motivation you have to balance the level of challenge.

Russoniello

Cognitive Benefits of Gaming

* Navigating three-dimensional space efficiently
* Enhanced creativity

Motivational Benefits of Gaming

* Triumph after successfully completing challenging tasks
* Healthy motivational

Emotional Benefits of Gaming

* Generate positive feelings
* Generate fun

Social Benefits of Gaming

* Average gamer is not a socially isolated
* Over 42 percent play with friends (theesa.com)

\textcite{Malone1980} analysed the theoretical principles of challenging environment. For an environment to be challenging it needs uncertain goal attainment. There are at least four ways to create uncertain goals in video games: variable difficulty level, multiple level goals, hidden information and randomness. \textcite{Yannakakis2005} follows the principles to make predator/prey games more interesting. The criteria for the best predator/prey opponents are:

\begin{itemize}

\item Balanced (neither too hard nor too easy)

\item Diverse behaviour (strategy is not predictable)

\item Aggressive behaviour (rather than static)

\end{itemize}

In race simulations the environment is mostly set. Nowadays, race tracks are laser scanned to create venues from around the world. The scanning technology records every pothole and comes extremely close to reality. It has become common practice to collaborate with car manufactures to translate car designs and driving characteristics into the game. When all put together including weather, day-and-night transitions and natural vegetation game developer are able create “living” tracks. The environment already reflects very well the authenticity and beauty of motorsport, but to further improve the enjoyment we can refine the gameplay. We followed the recommendation from Csikszentmihalyi to emphasis on clear objectives, rapid feedback on sector times and having a well-adjusted chance of winning a race.

The Psychology of Emotion and Politics – Brader2003

The Benefits of Playing Video Games - Granic2014

Is video gaming, or video game addiction, associated with depression, academic achievement, heavy episodic drinking, or conduct problems? - Brunborg2014

Learning attentional control and action video games – Green

The Malleability of Spatial Skills: A Meta-Analysis of Training Studies – Uttal

Uses and Gratifications Theoryin the 21st Century - Thomas E. Ruggiero

EEG HRV and Psychological Correlates while Playing – Russoniello

The Motivational Pull of Video Games: A Self-Determination Theory Approach – Ryan

GameFlow: A Model for Evaluating Player Enjoyment in Games - Sweester

Teens Video Games and Civics - Amanda Lenhart

<https://www.polygon.com/2013/1/4/3837236/farmville-2-infographic-40-million-monthly-active-users> - FarmvilleUser

<https://www.theverge.com/2019/2/21/18234980/fortnite-marshmello-concert-viewer-numbers> - Marshmellow

Call of (civic) duty: Action games and civic behavior in a large sample of youth - Christopher J. Ferguson

Neural bases of selective attention in action video game players. - D.Bavelier

Information technology use and creativity: Findings from the Children and Technology Project - Jackson

# Player Preferences

In today’s competitive market, developing new products that satisfy consumers’ needs and preferences is a very important issue (Dagher). Research in marketing on product positioning and product design suggests that a firm should optimize its goals with respect to product attributes and then translate these attributes into marketing (Kaul). Player preferences in video games are most commonly expressed in terms of genre (Klevjer). Theesa conducted customer survey, the bestselling genres in 2017 were action/shooter, followed by role playing/adventure, sport and driving/racing.

To provide the best player experience within a genre, it’s important to understand the preferences of the players. To reach a brought audience it`s beneficial to allow a vast number of different playstyles. One of the best practical implementations of this principle is the action role-playing game “Deus Ex”\footcite{DeusEx2000}. It offered unprecedented freedom of action at that time and was an important milestone for video games. Other games like the “The Elder Scrolls”\footcite{ElderScrolls2016} series persuade the players with big open worlds and stimulate the creativity with diversified narratives. \textcite{Drachen2009} found the game mechanics and the main character already defines the audience and expected behaviours. To understand the player base in “Forca Motorsports 5”, \textcite{Zimmermann2015} analysed log data to create engagement profiles. This method visualises the player behaviour on a high abstraction level. It also is used to analyse the effectiveness of reward systems.

The next step is to translate the user needs to the game. Researches in Human-Computer Interaction (HCI) have created guidelines to develop applications for specific user groups. In the book “The Inmates are Running the Asylum”, \textcite{Cooper1999} introduces the Goal-Directed Design (GDD). In GDD developers define personas based on the target group. The personas have to be defined very specific and detailed. The whole development process is based around these fictional users. This strategy is incredible powerful. The alternative is Task-Centred System Design (TCSD). In TCSD the developers think of tasks which are presented and tested with real users\citep{Rieman1993}. Both methodologies present efficient strategies to ensure user requirements are fulfilled. Table shows the advantages of each approach.

Table 1: Task-Centred System Design (Greenberg) vs Goal-Directed Design (Dubberly)

|  |  |  |
| --- | --- | --- |
| Requirements | Task-Centred System Design | Goal-Directed Design |
| Systems | Only for non-critical systems | Complex systems |
| Budget | Cost effective | Needs big budget |
| Method | Simple | Complex |
| Result | Vague | Precise |

Study of the correlations between user preferences and design factors application to car front-end design – Dagher

Research for product positioning and design decisions: An integrative review – Kaul

The Structure of Videogame Preference – Klevjer

Working Through Task-Centered System Design – Greenberg

Alan Cooper and the Goal Directed Design Process - Hugh Dubberly

# Skill level progression and level generation

Most skill level estimation research focuses on traditional sports. To measure sport skills (e.g. soccer skill) a sequence of test like dashes, jumps and endurance shuttle runs are performed (Malina). There are applications where the style of movement is important. A method for complex movements uses a combination of computer vision and machine learning (Ilg). Computer vision allows the detection of trajectories. Utilizing machine learning on these trajectories generates models for sequences of movements with different styles. This method can be used in sport for example to analyse complex karate movements or in medical gait analysis to quantify the movement disorders.

Characteristics of youth soccer players aged 13–15 years classified by skill level – Malina

Estimation of Skill Levels in Sports based on Hierarchical Spatio-Temporal Correspondences – Ilg

# Psychological modelling

Asendorpf defined personality psychology as “Personality psychology attempts to describe, predict and explain those recurrent behaviours that set an individual apart from some or all other agemates”. The stable tendencies that characterise the personality of an individual are called personality traits (Funder). On psycholical basis we can define our self as a network of memories in our brains (Fuster). (Ledoux) emphasises that memory, experience and our gene history contributes to who we are. Genes and experience can be seen as different ways of doing the same thing. Understanding core personality traits is critical to understand mental disorders and making effective diagnostic and treatment decisions (Whittle).

In this chapter I provide an overview of personality, with a particular focus on the relations between personality and driving.

First, I discuss personality theory and measurements of personality.

Secondly, I expand this analysis from personality traits to interindividual differences in one trait in one situation.

Thirdly, I further expand this perspective to inter-individual differences in one trait across multiple situations, including the important case where the situation is defined by another person.

Fourthly, I deal with the tricky question of how one should define a situation in personality research. Finally, I conclude with a discussion of possible mechanisms that relate traits to situations.

Cambridge Handbook Personality Psychology

Network memory - Fuster

Personality: Traits and situations. – Asendorpf

Global Traits: A Neo-Allportian Approach to Personality - David C. Funder

The self: Clues from the brain - Joseph Ledoux

The neurobiological basis of temperament: Towards a better understanding of psychopathology - Whittle

# Personality theory

Video games are more widespread than ever. The classic gaming demographic group playing console or computer still exists but smartphones drive the growth (isfe). Popular games go from casual games like Candy Crush to graphically stunning and immersive action games like Anthem. Not everyone likes playing video games equally and different people like different genres of games. Research has shown that this relates to one exemplification of an individual: personality (Nagle). The concept of personality in general aims to explain human behaviour (Ferro2018). Researchers found relationships between game genre and personalities (Chory, Johnson). Tekofsky found also a significant correlation between personality and playstyle. There is also a link between personality and emotions. Fang showed that that choosing the correct video game for a player personality has a significant and positive effect on enjoyment. It can also lead to better performances (Bauer).

Nagle suggest that games should be individualized for a player based on their personality, to make games more enjoyable and incentivise players to play for a longer time. Video game publisher always look to for new ways to sell games. Individualised games could open games for broader audiences. There have been attempts to individualize the game experience. Only few were successful. Lankveld attempted to individualize a top-down role-playing using personal questions, but the test group was only small. Silent Hill: Shattered Memories is the only successful commercial video game we found using psychological profiling. Every action changes you personality score and influences the storyline. The exact mechanism has not been made public. The game had great reviews and the innovative personality profiling system played a big part in its success. Mark Simmons, the director of Silent Hill: Shattered Memories mentioned in this context: “Certainly a lot of anecdotal evidence from the forums is that families are playing this game together, they're seeing what personality the game is giving each person and how the game's changing differently for each of the family that's played it” (Neon Kelly). Game individualisation has a lot of potential for game designers with small resources, especially in domains like casual games and serious games. However it requires more research into what makes games enjoyable (Nagle).

**Towards a system of customized video game mechanics based on player personality: Relating the Big Five personality traits with difficulty adaptation in a first-person shooter game – Nagle**

<https://www.isfe.eu/about-isfe/news/new-faces-gaming> - The New Faces of Gaming -NTERACTIVE SOFTWARE FEDERATION OF EUROPE – isfe

Personality Assessment Through Gaming Behavior – Tekofsky

Is basic personality related to violent and non-violent video game play and preferences? – Chory

Personality, motivation and video games –Johnson

Personality and enjoyment of computer game play – Fang

Using Adaptive Difficulty to Optimize Videogame-Based Training Performance: The Moderating Role of Personality – Bauer

**Games as personality profiling tools – Lankveld**

An analysis of players’ personality type and preferences for game elements and mechanics - Ferro2018

<https://www.videogamer.com/previews/20100122092821-silent-hill-shattered-memories-interview> - Neon Kelly

<https://www.ign.com/articles/2009/12/05/silent-hill-shattered-memories-review?page=3> – IGNSillentHill

# Sensation Seeking and Gaming

Research into online gaming has steadily increased over the last decade. Especially the negative impact of online games has received a lot of attention \citep{Wan2006}. A overuse of computer and internet can lead to addiction with consequences such as consequences such as failing school, family, and relationship problems \citep{Ng2005}. \textcite{Mehroof2010} showed a relationship between Sensation Seeking and gaming addiction. Aggressive gameplay is particularly dangerous for players with the sensation seeking trait. It is very pleasing for those players and can lead to excessive play \citep{Mehroof2010}. Joireman2002 showed that gaming can serve as an exciting opportunity for experiencing relatively novel experiences and demonstrating dominance. This correlates with the sensation seeking personality trait. There research also indicated that winning close games is correlated with high sensation seeking scores. This is consistent with Mazur, which found a high testosterone level when winning.

TESTOSTERONE AND DOMINANCE IN MEN - Mazur, Booth, & Dabbs

Sensation seeking and involvement in chess - Joireman2002

Online Gaming Addiction: The Role of Sensation Seeking, Self-Control, Neuroticism, Aggression, State Anxiety, and Trait Anxiety (Mehroof2010)

Psychological motives and online games addiction: a test of flow theory and humanistic needs theory for Taiwanese adolescents. (Wan2006)

Addiction to the Internet and Online Gaming (NG2005)

# Learning

The key to successful learning is motivation. Prensky2003 emphasised in this context: “A motivated learner can’t be stopped”. Unfortunately, more often than not the content that needs to be learned is not motivating. This causes teachers and trainers to struggle. For today’s generation of digital natives traditional teaching techniques are no longer suitable. Computers, Smartphones and the Internet are an integral part of their life. Prensky2001 proposes that the brains of digital natives are physically different: “It is now clear that as a result of this ubiquitous environment and the sheer volume of their interaction with it, today’s students think and process information fundamentally differently from their predecessors.” Educational games integrate learning in games to increase motivation and make learning an enjoyable experience.

The better a player performs, the more one enjoys the game. A special motivation is social collaboration or competition. Social motives operate within a context where there is interdependence between own and other's outcomes and strategies (McClintock). People can be distinguished with regard to their social value orientation e.g. preference about how to allocate resources (Vorderer). The next section examines how video game developers use competitive and cooperative environments to increase the enjoyment felt by computer game players.

Social Motivation--A Set of Propositions - McClintock

Explaining the enjoyment of playing video games The role of competition - Vorderer

Digital Game-Based Learning – Prensky2003

Digital Natives, Digital Immigrants – Prenskey2001

# Cooperative Motivation

It’s well known that groups of people can solve problems and make decisions that none of their members could do alone (Fraidin, Laughlin). Group work can also improve the motivation and performance of individual members (Hertel, Tindale). Working in groups requires coordination. The task of coordination can decrease productivity. Lampridis found that the loss depends on the characteristics of the group members and the size of the group. A mixed-sex group introduces more motivation than same-sex groups or individuals (Kerr). There are multiple studies which reported group motivation gains:

1. Co-workers cover up for poor performances of individuals in important tasks (Karau).
2. Performing in front of an audience can facilitate the performance (Zajonc1965).
3. Setting difficult goals makes groups work harder than individuals (Matsui1987).
4. People performing physical persistence task perform better when working together (Hertel).

For most tasks, group work does not increase the performance (Hertel). Another down sides of cooperation is that it can restrict creativity (Diehl).

The three major problems in groups with low productivity are:

1. Production blocking: Individuals inhibit others ideas (Diehl1991)
2. Evaluation apprehension: Fear of negative evaluations prevents more original ideas (Collaros1996)
3. Free riding: Lesser effectiveness and identifiability of individual contributions decreases the performance of some individuals (Frey)

Self-interest and collective action: The economics and psychology of public goods - Frey

Effect of perceived expertness upon creativity of members of brainstorming groups - Collaros1996

Productivity Loss in Idea-Generating Groups: Tracking Down the Blocking Effect - Diehl1991

Motivation Gains in Performance Groups: Paradigmatic and Theoretical Developments on the Köhler Effect - Hertel

Effects of Goals and Feedback on Performance in Groups - Matsui1987

Group sex composition and member task motivation - Kerr

Social Faciliation - Zajonc1965

Social Loafing and Social Compensation: The Effects of Expectations of Co-Worker Performance - Karau

Group performance and group productivity the case of process loss - Lampridis

When is one head better than two - Fraidin

Demonstrability and social combination processes on mathematical intellective tasks – Laughlin

Assembly Bonus Effect or Typical Group Performance?: A Comment on Michaelsen, Watson, and Black (1989) – Tindale

Productivity Loss In Brainstorming Groups Toward the Solution of a Riddle - Diehl

**Cooperative Motivation in Video Games**

In terms of motivation, playing video games together beats playing alone. Inkpen found that children playing together in a cooperative setting were more successful. In addition, the level of motivation to continue playing was higher. The desire to continue working well with the other people is one of the reasons cooperative games are successful (Ewoldsen). Even in the era before online gaming, people would meet with their friends, or visit LAN-Events to play face to face. Janz analysed that people at LAN-Events are motivated by social contact. Today, there are a lot of cooperation based games very successful. The most popular cooperation based games on the gaming platform steam (Steamcoop) are:

* Portal 2 - Puzzle
* Terraria - Sandbox
* Factorio – Base Building
* Left 4 Dead 2 - Zomies
* The Binding of Isaac: Rebirth – RPG

Commercial cooperative are limited on specific genres. Most games in that list are building or survival games. They have only trivial story. These games generate engagement and challenge using a balance between construction, survival and cooperation. Researchers have noticed a highly motivating effect of cooperation in educational games and exergames. Jong analysed a cooperative online learning game for students. They found an amplified desire to win the game, which motivates students to learn from online course materials before they play. Cooperative exergames produced higher intrinsic motivation and related to higher energy expenditure (Staiano). Cooperative play is a promising method for engaging overweight youth and improving teaching.

<https://steam250.com/tag/co-op> - Steamcoop

Gaming at a LAN event the social context of playing video games - Janz

Effect of Playing Violent Video Games Cooperatively or Competitively on Subsequent Cooperative Behavior – Ewoldsen

Playing Together Beats Playing Apart, Especially for Girls – Inkpen

Motivating Effects of Cooperative Exergame Play for Overweight and Obese Adolescents – Staiano

Using Game-Based Cooperative Learning to Improve Learning Motivation: A Study of Online Game Use in an Operating Systems Course - Jong

# Competitive Motivation

A widespread social phenomenon is a rivalry. It is closely connected to the competition. A rivalry is a broader culture pattern going beyond our hunting instinct, aggression and the need to excel in sports \citep{Sipes1973}. In traditional sports, excellence is the quality of being outstanding in relation to others. Many people believe that doing well means doing better than other people \citep{Stanne1999}. It’s the essence, which drives elite persons in sport, science and economy. Proponents argue that competition brings out the best in a person. According to one of the all-time greatest coaches Vince Lombardi, “Winning is not everything, but wanting to win is”. The downside is that people with no chance of winning can experience a lack of motivation. A rivalry is the combination of a relationship and history between competitors. \textcite{Kilduff2014} showed that rivalry motivates and boosts the performance independent of the stakes. He also defined three important factors which can cause rivalry. First, similar competitors increase social comparison. People are naturally driven towards self-evaluation and the comparison with other persons \citep{Festinger1954}. Second, the level of competitiveness can increase when facing the same opponent multiple times. Finally, evenly matched games, when narrowly decided, result in greater emotional responses. \textcite{Kilduff2014} evaluated that rivalry can improve motivation and performance. The results indicate that the odds of victory are more important than previous results. In some situations, motivation can transform into a desire to win. In this state, the person maximizes relative pay-outs at all costs. \textcite{Bazerman1992} evaluated that people display more apprehension for personal profit than overall profit. The desire to win has a high impact on the decision-making process. It diminishes concerns and increases the aggregation with the focus on beating the opponent \citep{Malhotra2010}. The desire to win is a powerful motivation boost. The effect is hard to measure. Good indicators are the presence of rivalry and time pressure. Both are presents in real-life racing competitions and racing games. The next section discusses the effects of competition in video games.

**Competitive Motivation in Video Games**

Interacting with other players can make the game more exciting. Researchers have mixed opinions if competition also increases motivation. \textcite{Kohn1986} makes a case that competition almost never increases performance. In contrast \textcite{Chang2003}, argues that a competitive environment not only motivates winners and losers but also that players prefer playing against competitive opponents. There is also danger in having competitors. Competition can cause a lack of confidence, interest and efficiency when not handled correctly. Pedro \textcite{MunozMerino2014} found that the negative effects can be mitigated when the challenge is modified for the individual person. The study indicated a strong motivation effect when players with equal skill level are matched. The woman had a slightly worse perception of their own motivation than men. Similar effects are shown in competitive learning systems \citep{Regueras2009}. A study of \textcite{Ravaja2006} found that the nature of the opponent also influences emotional responses and the perception of the challenge. The presence of a stranger increases attention. Additionally, playing against a friend results in higher arousal. The positive impact of playing with other people in video games can be measured with Electromyography (EMG). \citetext{Ravaja2004} found that playing against a friend increased positive and decreased negative emotional responses.

# Measuring Motivation

overlaps between cognition, motivation, and emotion make it difficult to separate and distinguish their respective territories.

<http://acs.ist.psu.edu/misc/dirk-files/Papers/Cognition&Emotion/Cognition%20and%20motivation%20in%20emotion..htm>

# Ranking System

A ranking is a relationship between a set of items. Tucker describes a ranking mathematically as: “A ranking is simply an arrangement, or permutation, of the n candidates.” Mathematics and statistics offer different strategies for assigning rankings. For example it is not always possible to assign each candidate a unique rank, then two or more candidates should have the same rank. Cichosz lists the most common ranking strategies:

Competition ranking: Instances with equal attribute values receive the same rank and then a gap is left to adjust for the number if those instances e.g. (1 2 2 4)

Dense ranking: Instances with equal attribute values receive the same rank and then no gap is left e.g. (1 2 2 3)

Ordinal ranking: Instances with equal attribute values receive different consecutive ranks in an arbitrary order e.g. (1 2 3 4)

Fractional ranking: Instances with equal attribute values receive the same rank, equal to the mean of ranks they would receive under ordinal ranking e.g. (1 2.5 2.5 4)

When humans are asked to express preferences among a set of options, they prefer to report a partial order—where comparisons are made between certain pairs of options but not between others (Keller). They are known as partially ordered sets.

This section focuses on rating systems in sport. Section introduces sport rating systems in general. Section focuses on the ELO system, original used in chess.

# \subsubsection{Rating Systems}

Rating systems are vital in different application domains. The most common application is to calculate the competitive strength of sport teams. Skill ratings in competitive sports serve three main functions (Hebrich):

* They allow players to be matched with other players of similar skill leading to interesting, balanced matches.
* The ratings can be made available to the players and to the interested public and thus stimulate interest and competition.
* Ratings can be used as criteria of qualification for tournaments.

Until several years ago, the rankings were decided purely based on collective opinion of experts (Boginski). Nowadays, computer-based ranking systems utilizing various mathematical techniques and remove possible biased opinions of expert. Colley introduced a matrix based to rank colleague football teams. Colley identified: “The scheme adjusts effectively for strength of schedule, in a way that is free of bias toward conference, tradition, or region.” The provided ratings can also be used to make power rankings and predict the outcome of future matches. \textcite{Timmaraju2013} used pseudo-likelihood statistics to predict the outcome of English Premier League matches. They took the number of goals for each team in a match to train a machine learning algorithm. The model predicted the matches with up to 66\% accuracy. It outperformed experts and the betting market. TrueSkill is a skill-based ranking system patented by Microsoft(Hebrich). It is used for matchmaking on Xbox Live. The next section introduces the ELO system a similar but license free system.

TrueSkillTM: A Bayesian Skill Rating System - Hebrich

Data Mining Algorithms: Explained Using R – Cichosz

Applied Combinatorics – Keller

Applied Combinatorics - Alan Tucker

Mathematics and Sports – Sadovskiĭ

Matrix-based Methods for College Football Rankings – Boginski

Colley’s Bias Free College Football Ranking Method - Colley

# Measuring Driving Performance

Driving performance measurements are used for a wide range of applications, including driver drowsiness and/or drug influence detection, driver training, road infrastructure evaluation and the assessment of effects of in-vehicle systems(metrics). The driving task can be described on different levels of abstraction. (Michon) proposed a widely adopted scheme where the driving task is divided in three levels of skills and control:

* Strategic level: Defines the general planning stage of a trip.
* Tactical level: Execution of driving manoeuvres e.g. lane changes
* Operational level: Vehicle control in every moment.

This chapter reviews metrics that quantify performance on the tactical and operation levels.

In section a range of metrics are presented related to driving performance. Driving performance deals with the driver’s ability to control the car.

Section introduces spatiotemporal pattern recognition to analyse movement patterns and create driving models. Spatiotemporal pattern recognition can be used to identify risky driving behaviours.

A CRITICAL VIEW OF DRIVER BEHAVIOR MODELS: WHAT DO WE KNOW, WHAT SHOULD WE DO? - Michon

# Driving Performance Assessment Metrics

This section of driving performance metrics is structured based on the concrete physical and behavioural quantities that are measured (metrics): The metrics are grouped into the three main categories:

• Longitudinal control metrics

o Speed

o Vehicle following

• Lateral control metrics

o Steering wheel movement

o Lane keeping

• Event detection metrics

**Speed metrics**

There is strong evidence that speed is a major factor affecting road accident frequency and severity (Hirst). A large number of speed metrics could be computed. The most commonly used in automotive engineering are (metrics):

* **Mean speed:** The average of the longitudinal speed relative to the road surface.
* **Standard deviation/variance of speed**
* **Maximum speed:** The single maximum speed value.

**Vehicle following metrics**

Drivers tend to drive faster or slower than the surrounding traffic depending on their driving style (Saad). Vehicle following entails the interaction of nearby vehicles in the same lane (Bevrani). Distance based metrics are based on the car in front. The distance headway is defined as the average distance to the lead vehicle e.g. from bumper to bumper (metrics). Common distance based metrics are(metrics):

* ***Mean distance headway****:* The average distance headway.
* ***Standard deviation of distance headway***
* ***Minimum distance headway****:* The minimum value of the distance headway signal. ´

Time headway is defined as the distance to the lead vehicle divided by the travel speed of the own vehicle(metrics). Common time based metrics are(metrics):

* **Mean time headway**
* **Standard deviation of time headway**
* **Minimum time headway**

**Steering wheel metrics**

Steering wheel metrics are very common in driver performance assessment. It is used to observed changes in the steering wheel activity relate. A low activity can indicate that the driver performs a secondary task (visual or cognitive) or the driving demand is low (e.g. straight and wide road, low traffic) (McDonald). The most common metrics are(metrics):

* **Standard deviation/variance of steering wheel angle**
* **Steering wheel reversal rate:** Number of times that the steering wheel is reversed by a magnitude larger than a specific angle, or gap.
* **Steering wheel action rate:** Number of steering wheel movements per second faster than a threshold velocity.

**Lane keeping metrics**

Lane keeping metrics are almost always included in In-Vehicle-Information-Systems evaluation studies, especially when the lane position standard deviation/variance and the proportion of the lane exist (metrics). Many studies showed a correlation between lane keeping and visual tasks and e.g. tasks on a navigation system or a cell phone. (Farber) demonstrated a strong relationship between visual tasks and lane keeping performance. (Östlund) observed that lane keeping tended to be a sensitive measure for the visual tasks especially for elderly drivers. Similar to (Vehicle following metrics) there are distance-based and time-based metrics. The most common distance-based lane keeping metrics are (metrics):

* **Mean lane position:** The mean lane position is defined as the mean distance between a reference point on the vehicle and an arbitrary position in the lane.
* **Standard deviation/variance of lane position**
* **Lane exceedences:** The most common measure is LANEX. Defined as the proportion of a time any part of the vehicle is outside the lane boundary.

To time-based metrics are based on the time-to-line-crossing concept, representing the time necessary for the vehicle to reach either edge of the driving lane (Godthelp). Based on the time-to-line-crossing computation, different statistic metrics can be computed (Godthelp):

• Median TLC

• 15% level TLC: 15% of the time-to-line-crossing values are below this value

**Event detection metrics**

Event detection is strongly related to crash probability, and thus one of the performance metric classes with the strongest safety relevance (metrics). It can be measured to stimuli that relevant to the primary task. Typical driving-related detection tasks are the detection of braking lead vehicles or suddenly appearing pedestrians(metrics). Event detection can be used to evaluate cognitive tasks. (Alm) found that a mobile telephone task has a negative effect upon the drivers' choice reaction time, and that the effect is more pronounced for the elderly drivers. (McKnight) observed increased nonresponses by about one-third under all of the telephone distractions for drivers over age 50. The main event detection metrics are(metrics):

* **Response time:** The metric is defined as the time from presentation of a specified stimulus (with specified start time) to the time that the driver responds correctly, either verbally or with appropriate hand or foot motion.
* **Response distance:** The distance of the driver from the stimulus when the driver responds correctly, either verbally or with appropriate hand or foot motion.
* **Errors of omission:** The number of times that the driver fails to respond to a specified stimulus presentation.
* **Errors of commission:** The number of times that the driver responds incorrectly to a specified stimulus presentation.

The effect of cellular phone use upon driver attention - McKnight

The effects of a mobile telephone task on driver behaviour in a car following situation. - Alm

The Development of a Time-related Measure to Describe Driving Strategy - Godthelp

Surrogate Measures of Visual Demand while Driving - Farber

Human Machine Interface And the Safety of Traffic in Europe - Östlund

<http://www.aide-eu.org/pdf/sp2_deliv_new/aide_d2_2_1.pdf> metrics

Driver Behaviour and Training, Band 3 – Dorn

Are speed enforcement cameras more effective than other speed management measures - Hirst

Car Following Model Improvement for Traffic Safety Metrics Reproduction - Bevrani

Behavioural adaptations to new driver support systems Some critical issues – Saad

Review of relationships between steering wheel reversal rate and driving task demand. - McDonald,

# Racing Algorithms

In computer science, an algorithm is a set of instructions designed to perform a specific task (techterms). It’s important to design efficient algorithms to perform the task fast and needing only minimal resources (techterms). As \textcite{Aho1974} emphasizes: "The designer should continue to examine a problem from a number of viewpoints until he is convinced that he has the most suitable algorithm for his needs." In this work we explored algorithms related to driving and gaming:

Section focuses on race game algorithms which solve two related problems:

* How to model intelligent agents (e.g. virtual opponent) in games to increase player enjoyment?
* How to dynamically adjust the difficulty of the game to increase player enjoyment?

Section explores algorithms to estimate the skill level of a player. This algorithms allow players to be matched with other players of similar skill leading to interesting, balanced matches \citep{Herbrich2006}.

Section introduces advanced analytics for games and driving. This includes methods for data transformation and analysis to uncover trends and patterns within their data.

<https://techterms.com/definition/algorithm> techterms

# Summary

Learning racing is a challenging task. Racing simulations offer a safe environment to learn racing principles. Simulators for driver training can simulate a variety of driving situations. Traditional racing games and racing simulations focus on either enjoyment or education. Drivers and gamers could benefit from a combined approach. Researchers found that motivation and engagement benefit the learning outcome. In particular, learning models based on competition can be applied to racing games.

To maximize Enjoyment and Motivation games have to be balanced. Rating systems estimate the skill of the players. The correct estimation of the race driver skill level allows matching the racer with the optimal opponent. To make a race “fair”, each player should have a winning chance of around 50\%. The Elo rating system can be adopted for racing games. The best match is constructed the Elo ratings of the participating players are very close. The optimal match has players with identical Elo score, but this situation is extremely hard to achieve. Having fair matches is a huge priority to ensure the race is competitive, but there are other factors to consider. Long loading times are frustrating. The algorithm has to be fast. A further restriction is that skill is normal distributed on the player base. This can make it difficult to find equal skilled opponents for very low or very high rated players.

Game design principles help to create a positive player experience, find vulnerabilities and optimize runtime performance. Task-Centred System Design revolves around tasks which are presented and tested with real users (Lewis &Rieman, 1993). It offers an effective strategy to ensure player satisfaction.

To validate our method we have to measure Enjoyment, Motivation and Performance. The Geneva Emotion Wheel is a tool to evaluate emotions qualities and the intensity of the feeling. The most impactful variables are challenge and certainty in both positive and negative experiences. When designing a game we have to control the challenge and the certainty of the situation to control the emotion of the player. An effective technique to evaluate driver performance is the analysis of driving metrics. Important metrics are: speed, vehicle following, steering wheel movement and lane keeping. Driving pattern analysis helps to identify risky driving behaviours. In the next chapter, TEAL’s requirements are identified to design and adapt the corresponding concepts in a virtual 3D racing environment.

since a designer can never completely predict user behaviour. HEP appears to be very useful for creating highly usable and playable game design, particularly in the preliminary design phase prior

<http://210.240.189.214/gamedesign/resources/02_class/02_class2/00_game_paper/BIT094101/BIT094101_Late%20breaking%20result%20papers_Using%20heuristics%20to%20evaluate%20the%20playability%20of%20games_%E4%BE%AF%E6%84%B7%E5%9D%87.pdf>

%We adopted the Elo rating system for racing games. The correct estimation of the race driver skill level allows matching the racer with the optimal opponent. To make a race “fair”, each player should have a winning chance of around 50\%. The best match is constructed the Elo ratings of the participating players are very close. The optimal match has players with identical Elo score, but this situation is extremely hard to achieve. Having fair matches is a huge priority to ensure the race is competitive, but there are plenty of other factors we have to consider. Long loading times are frustrating. This means the algorithm has to be fast. Sometimes, players just have bad games! The rating system should take this into account and prioritise losing streaks rather than punishing single mistakes. A further restriction is that skill is normal distributed on the player base. This can make it difficult to find equal skilled opponents for very low or very high rated players. The matchmaking algorithm is a vital part of racing games because part of what makes racing so competitive is getting to face similarly-skilled opponents.

# Result

Because of the large variations commonly present in human behaviour and the large number of factors influencing this behaviour (personality, intelligence and learned associations) psychologists consider the following correlations to be indicative for effect sizes in a relationship between personality and the participants' game behaviour (Cohen, 1988, 1992).

r = :10 (1% of variance explained)  
r = :30 (9% of variance explained)  
r = :50 (25% of variance explained)

Games as personality profiling tools – Lankveld

# Useful

Video games as a tool to train visual skills

Does driving experience in video games count? Hazard anticipation and visual exploration of male gamers as function of driving experience