# Unleashing Brain Powers

## A Study on Development of BCI-Enhanced Computer Games

LYU1006 Fall Semester Presentation (2010-2011)


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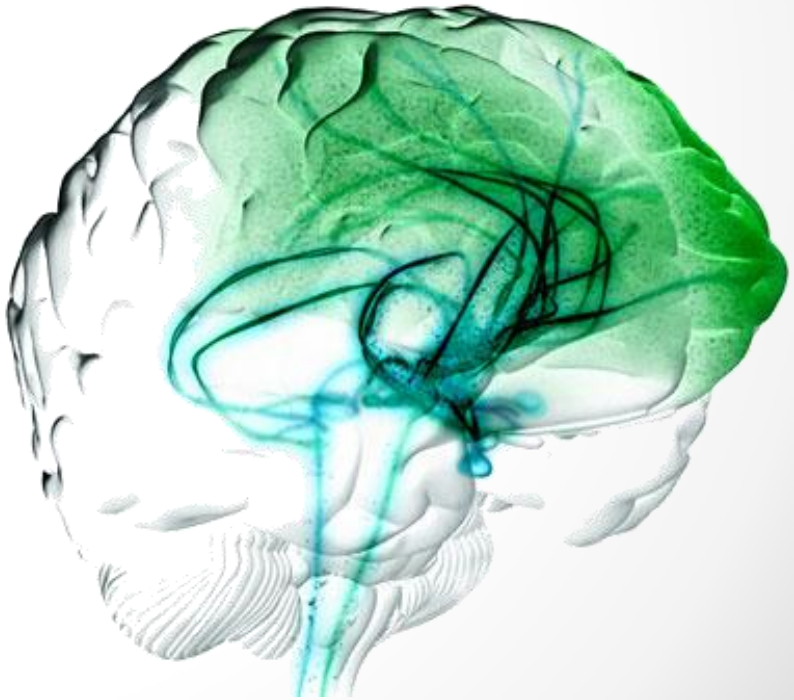


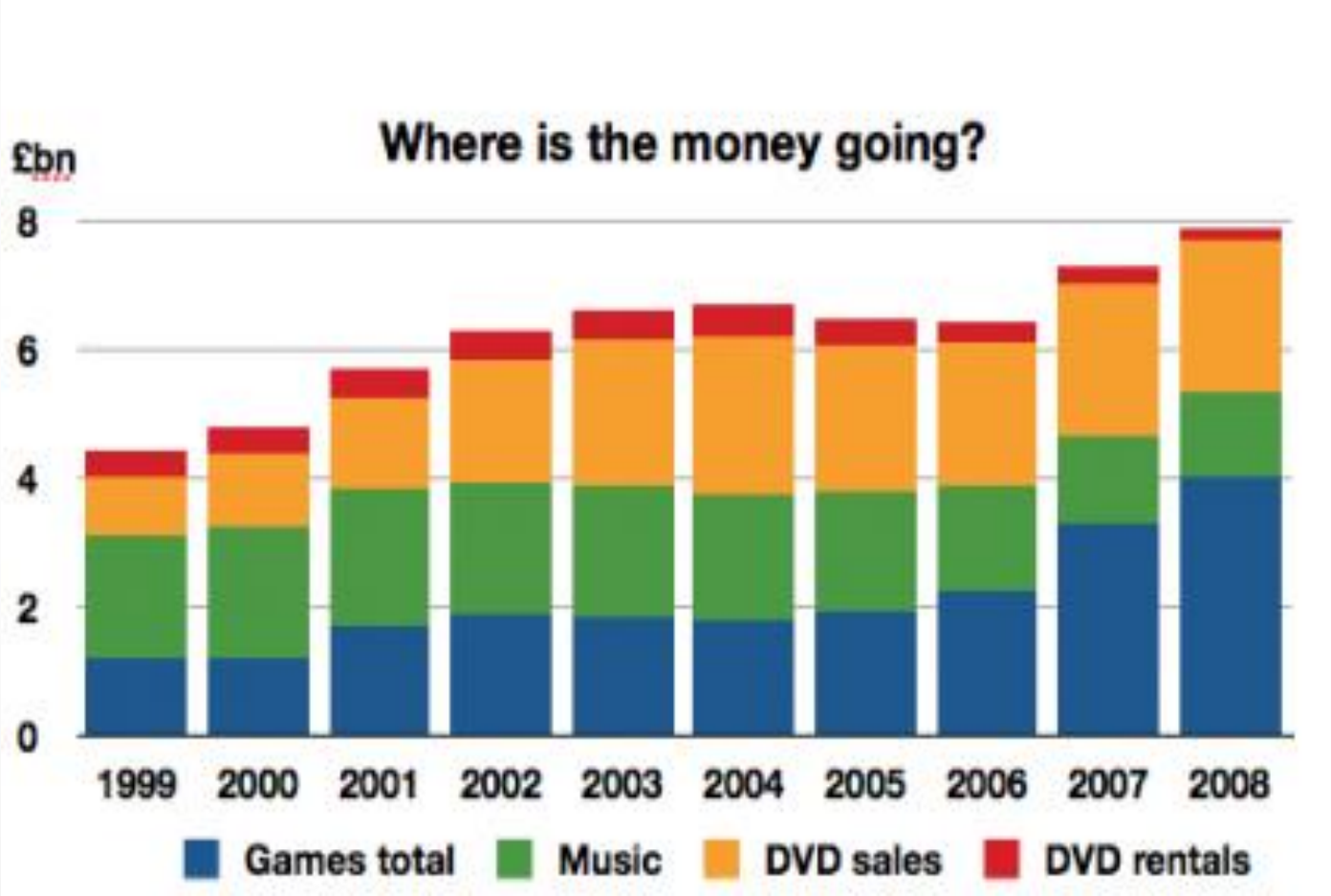

Department of Computer Science and Engineering

The Chinese University of Hong Kong

# Agenda

- Motivation
- Experiment to evaluate Mindset
- Game Engine - UDK
- UDK-Mindset Integration
- Demo Video
- Q&A

# Why BCI Games?




http://www.guardian.co.uk/news/datablog/2009/jun/09/games-dvd-music-downloads-piracy

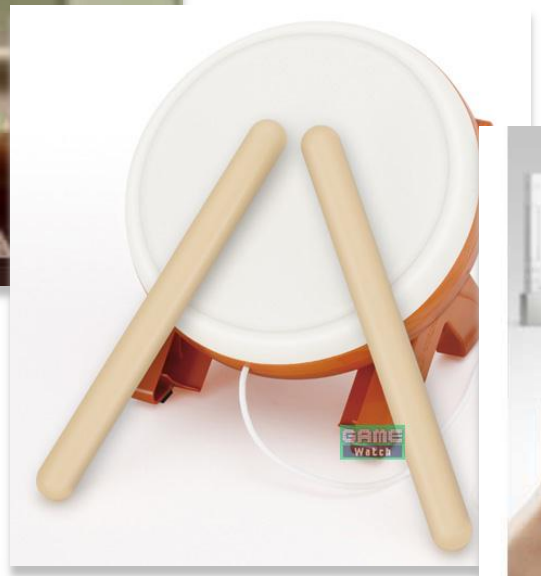
# Why BCI Games?

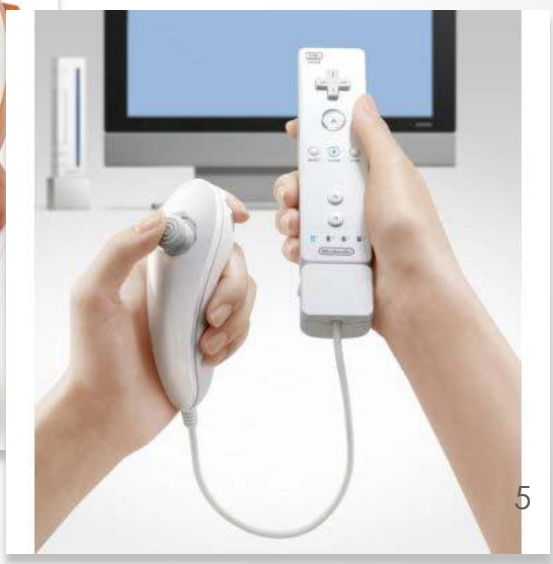



Keys

# Why BCI Games?

## Motion Detection

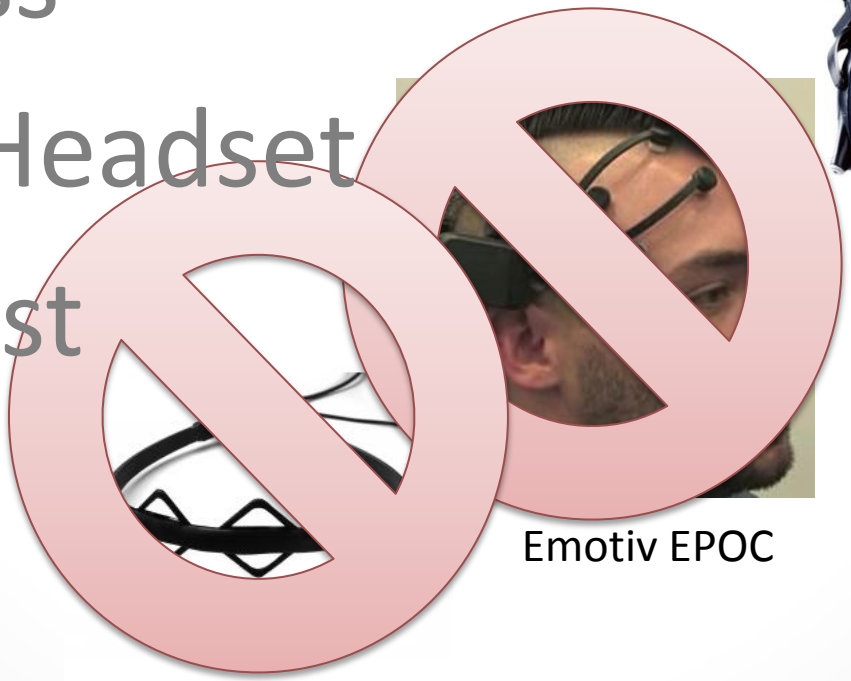
# Why BCI Games?

# Why BCI Games?

# Why Mindset?

- Dry sensor
- Wireless
- Music Headset
- Low Cost

Neurosky Mindset



Emotiv EPOC

NIA

# Validity of Neurosky Mindset

HUMAN-COMPUTER INTERACTION. NEW TRENDS
Lecture Notes in Computer Science, 2009, Volume 5610/2009, 149-158, DOI: 10.1007/978-3-642-02574-7_17


Assessing NeuroSky's Usability to Detect Attention Levels in an Assessment Exercise

Genaro Rebolledo-Mendez, Ian Dunwell, Erika A. Martínez-Mirón, María Dolores Vargas-Cerdán, Sara de Freitas, Fotis Liarokapis and Alma R. García-Gaona

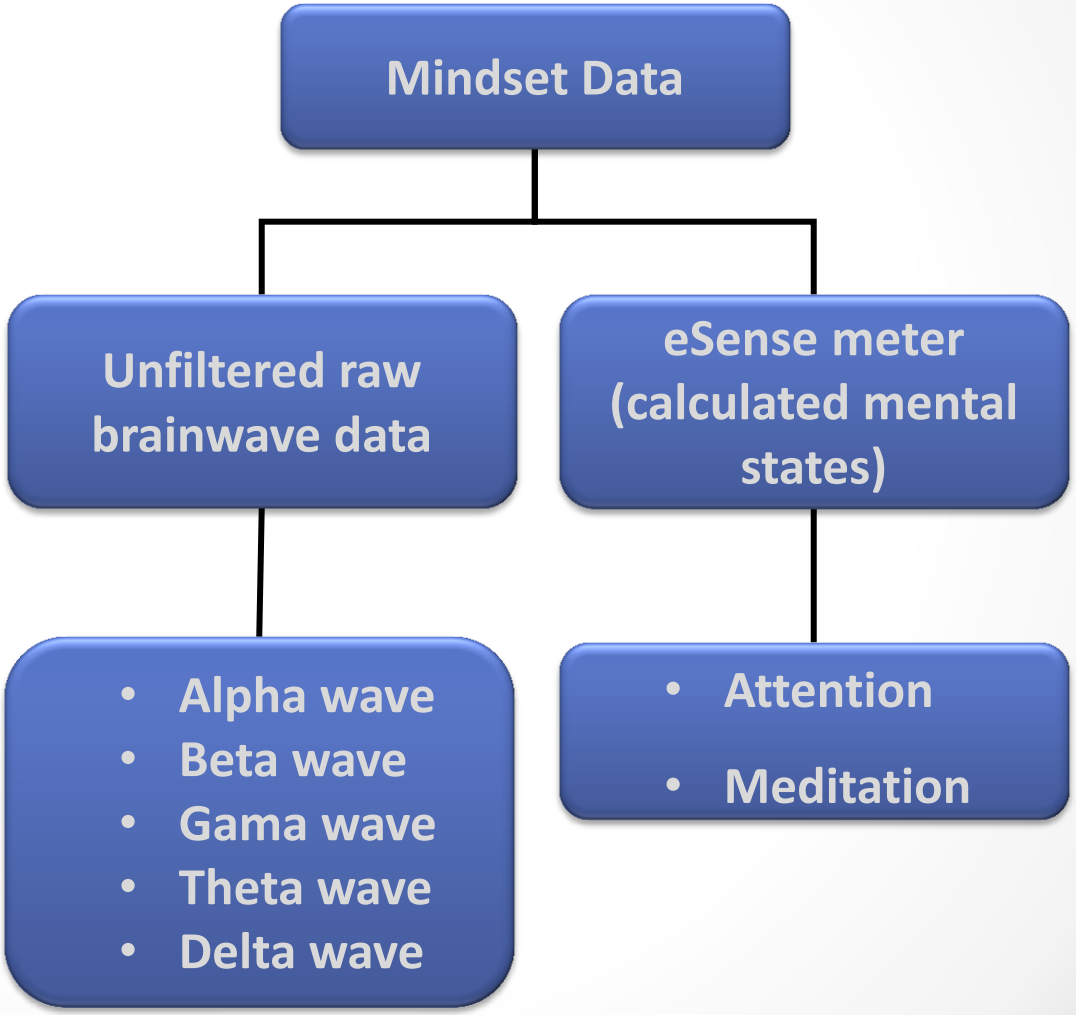
"Analyzes of individual showed the MB provides valid and constant data as expected."

http://www.springerlink.com/content/c471m5083xp905g6/

# Background – What can Mindset Do

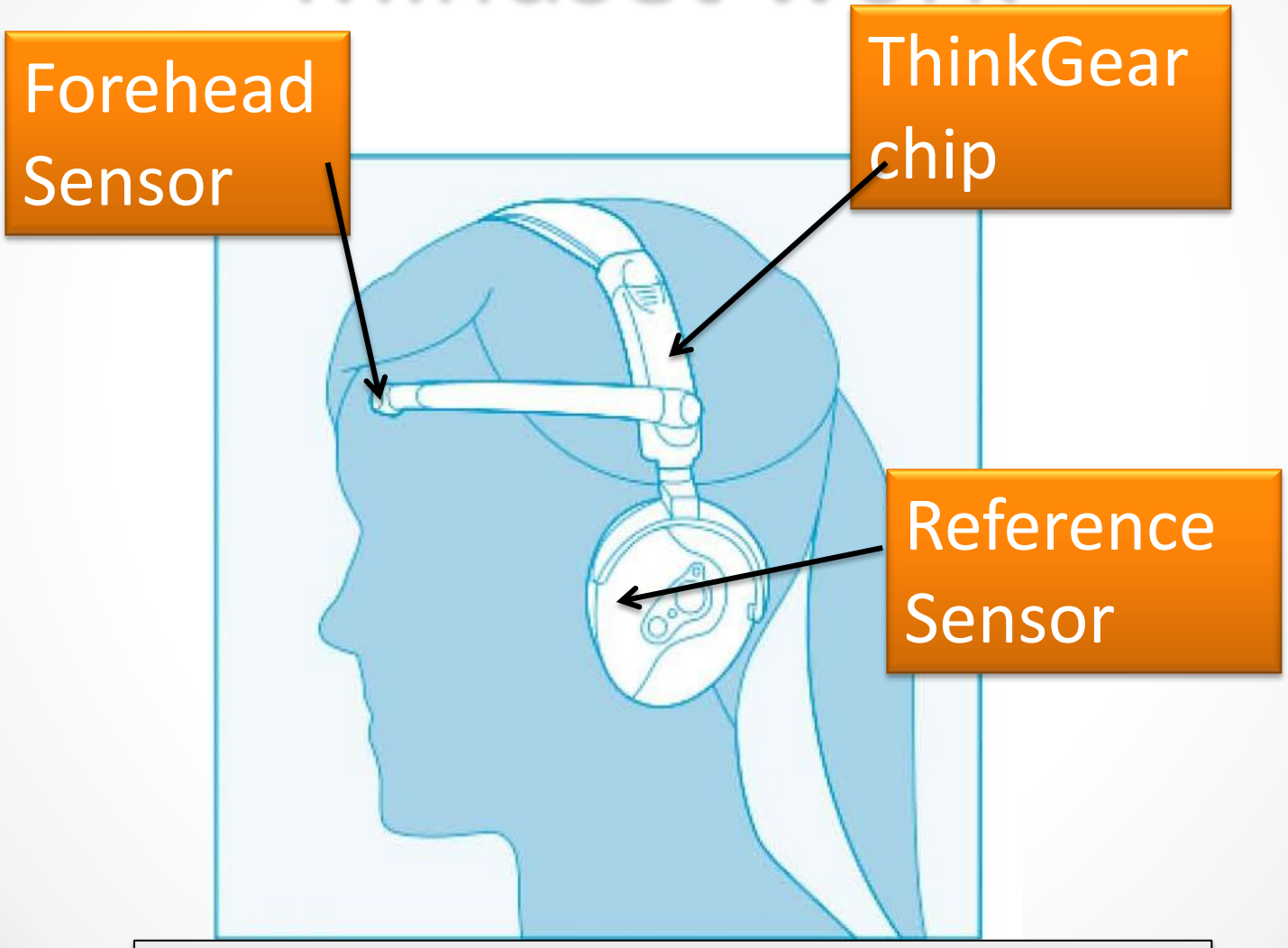
**Data Collection using**

**Mindset SDK**




Data that can be collected from Mindset

# Background – How does Mindset work




Key components of ThinkGear technology

# Background – How does Mindset work

- **ThinkGear**

  Interface wearer's brainwaves using ThinkGear chip.

- **eSense**

  NeuroSky's proprietary algorithm for characterizing mental states

# eSense Meter

- **Attention eSense**

  The intensity of a user's level of mental "focus" or "attention"

- **Meditation eSense**

  The level of a user's mental "calmness" or "relaxation"

# Experiment on eSense

- Objective

  Investigate the relation between eSense meter and mental states

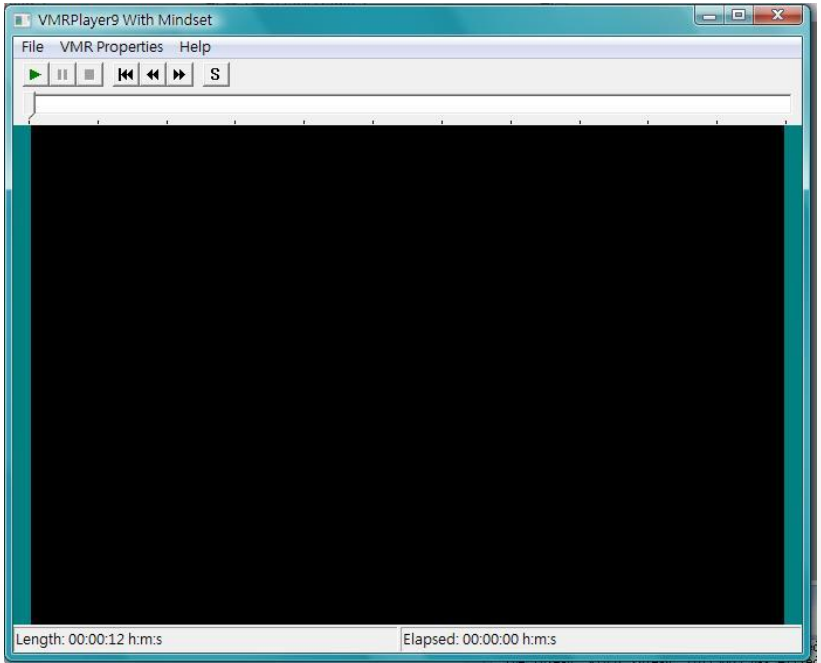
- Hypothesis

  eSense meter can reflect the existence or changes of some mental states

# Experiment on eSense - Methodology

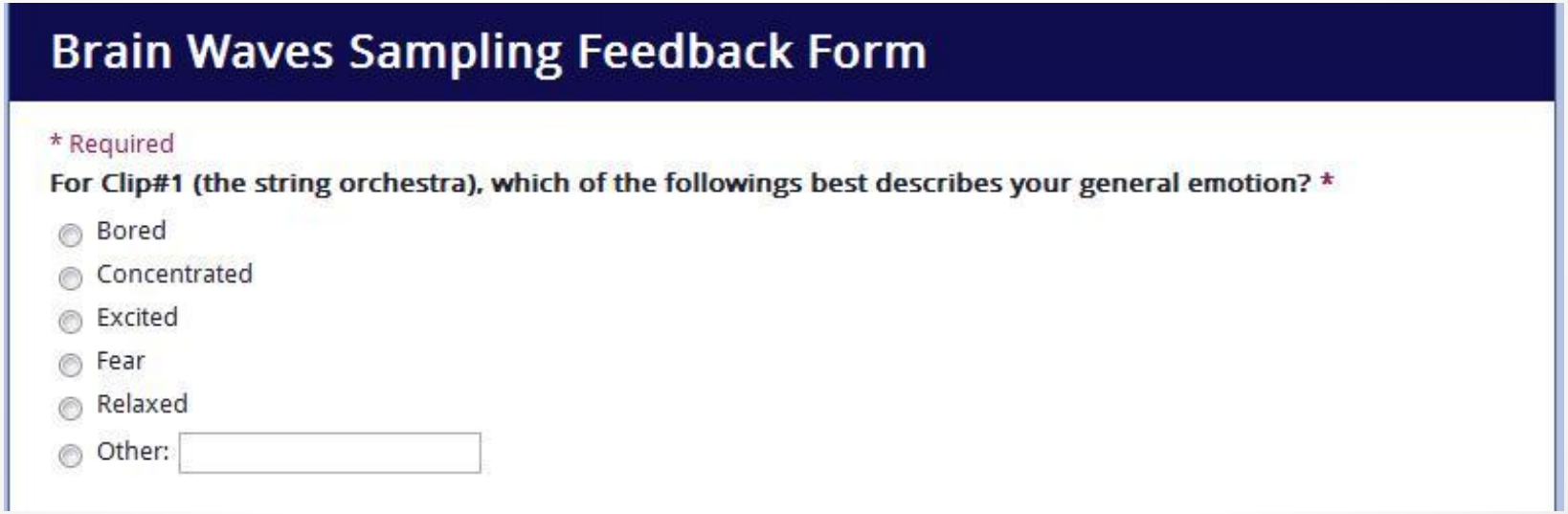
- **Collect the brainwave data while:**
  - Playing movies
  - Synchronizing with the movie

Our hacked VMRPlayer with Mindset



# Experiment on eSense - Methodology

- Identify the perceived mental states of the participants by questionnaire




Brainwaves sampling feedback form

# Experiment on eSense – Participants

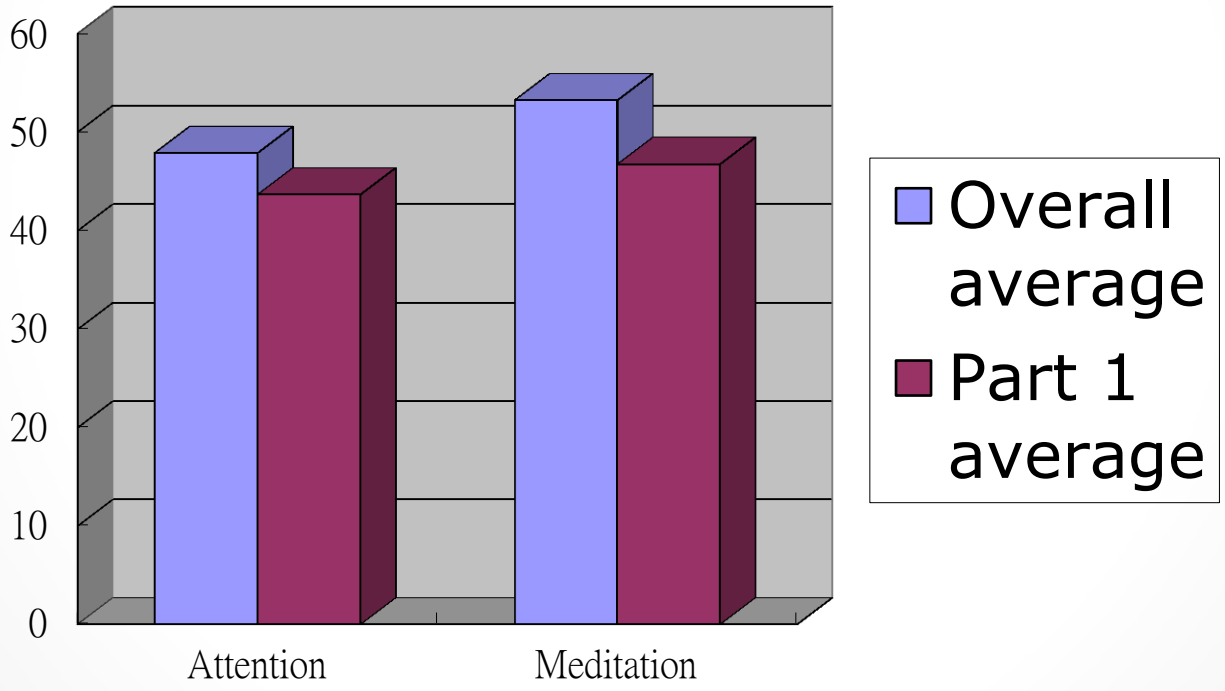
- **18 Participants**
  - 16 males
  - 2 females
- **Age:**
  - Around 20 years old

# Experiment on eSense - Movie

- **Part 1: String Orchestra, Symphony No. 94 in G Major**

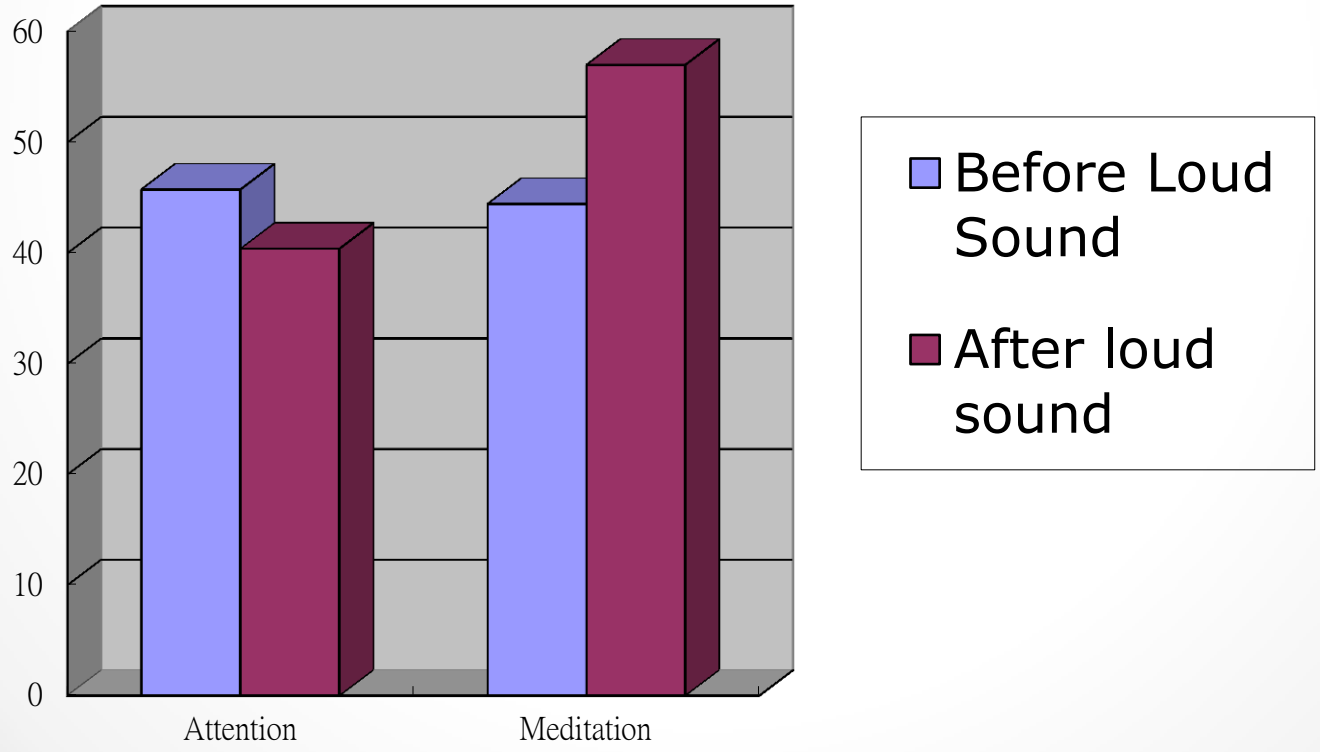
# Relaxed Participants

Comparing overall average eSense values and part 1 average values for relaxed participants



# A Strike of Loud Sound

Comparing eSense values before and after the strike of loud sound for participants who emotion changes from “relaxed” to “excited”



# Part 1 Result - Observation

The meditation value does not reflect the state “relaxed”

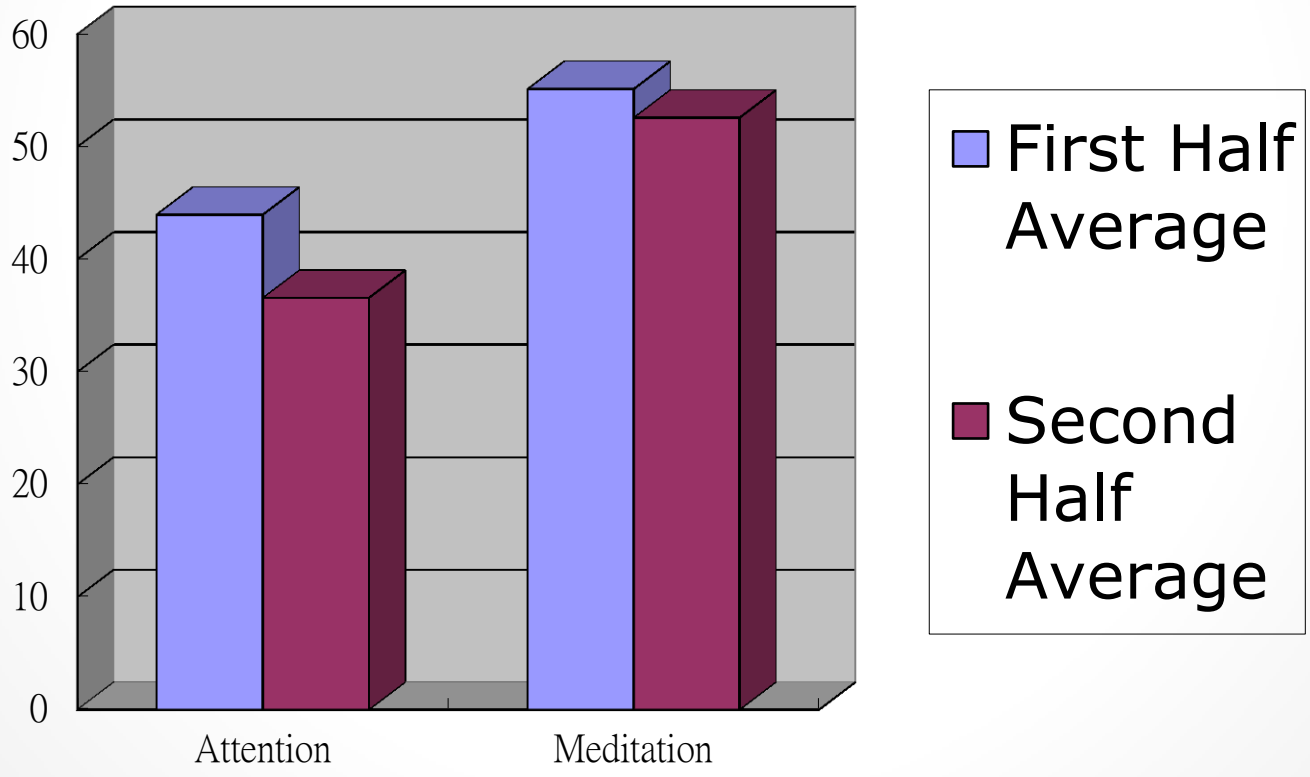
The meditation also did not reflect the change of mental states.

# Experiment on eSense - Movie

**Part 2: Speech of Pope Benedict XVI in Sistine Chapel**

# Bored Participants

Comparing eSense values between first half and second half for bored participants



# Part 2 Result - Observation

There is a correlation between attention and bored.

Attention value **decreases** when participants are bored.

# Experiment on eSense - Movie

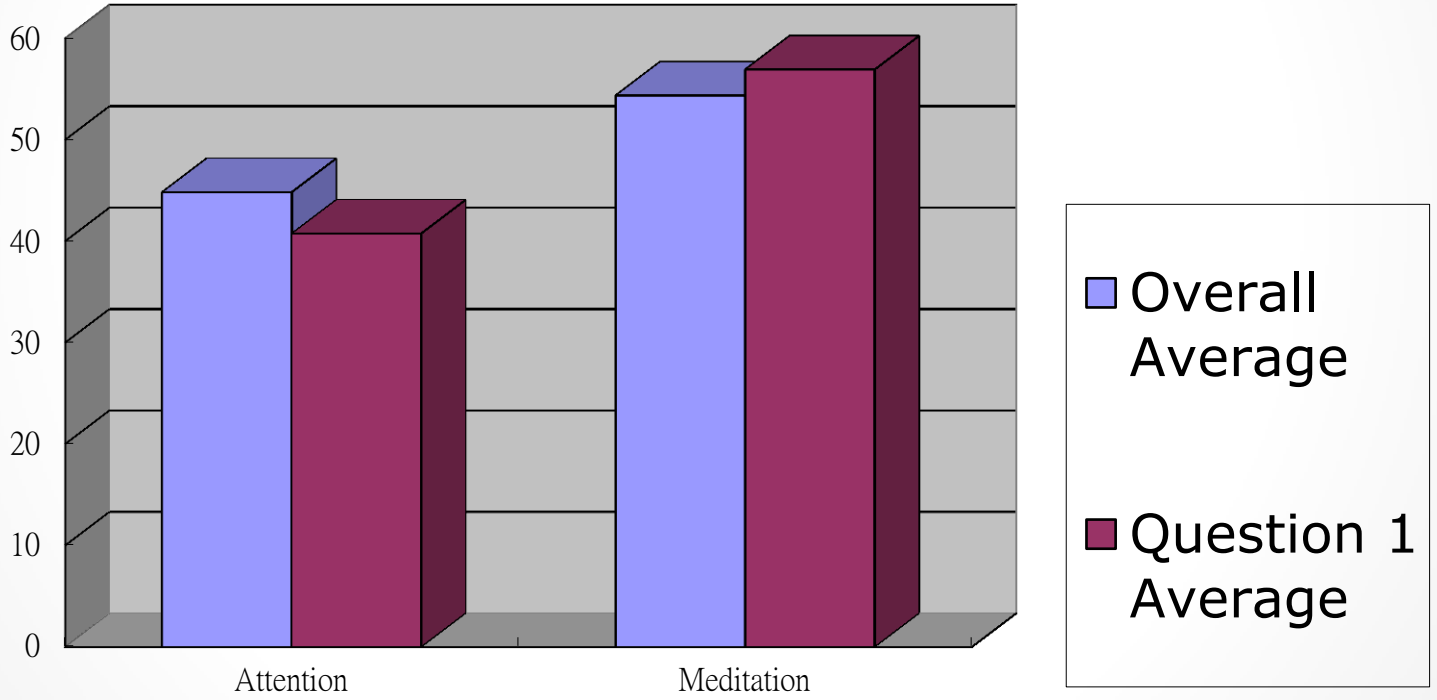
**Part 3: Don’t stare at bikini clip 1**

This box grows in the movie

Bikini and growing brown box

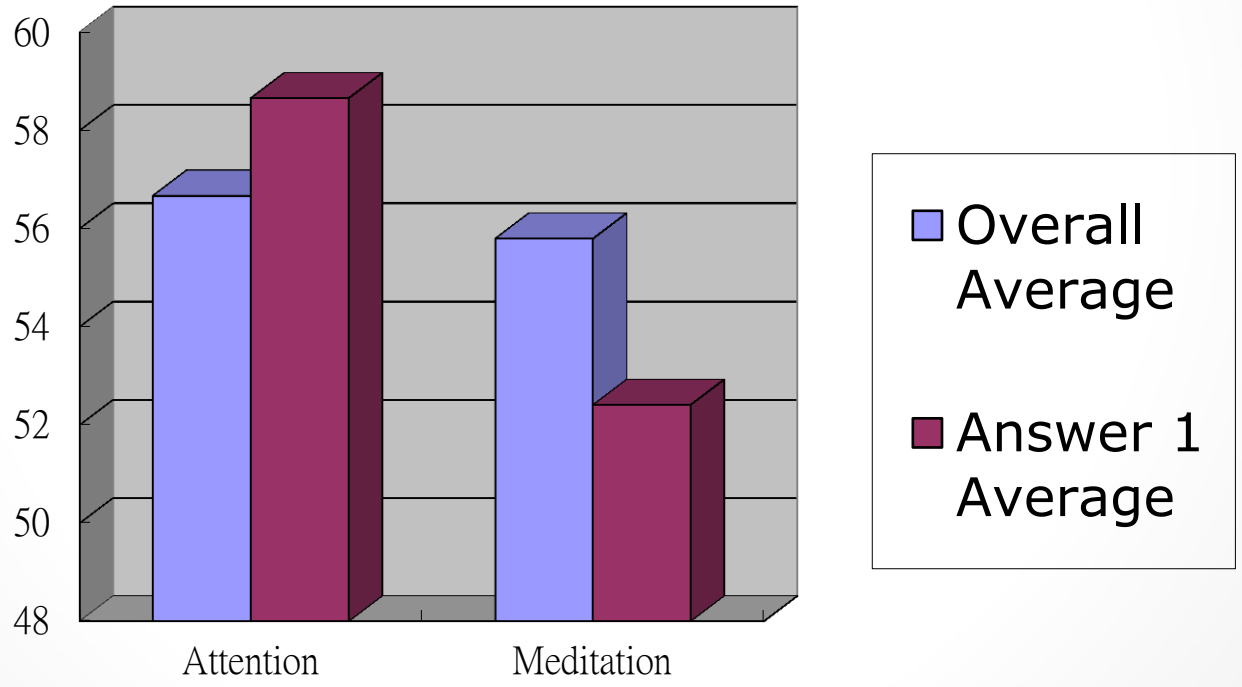
# Concentrated Participants – Question 1

Comparing overall average eSense values and part 3 average values for concentrated participants during question 1



# Concentrated Participants – Answer 1

Comparing overall average eSense values and part 3 average values for concentrated participants during answer 1



# Experiment on eSense - Movie

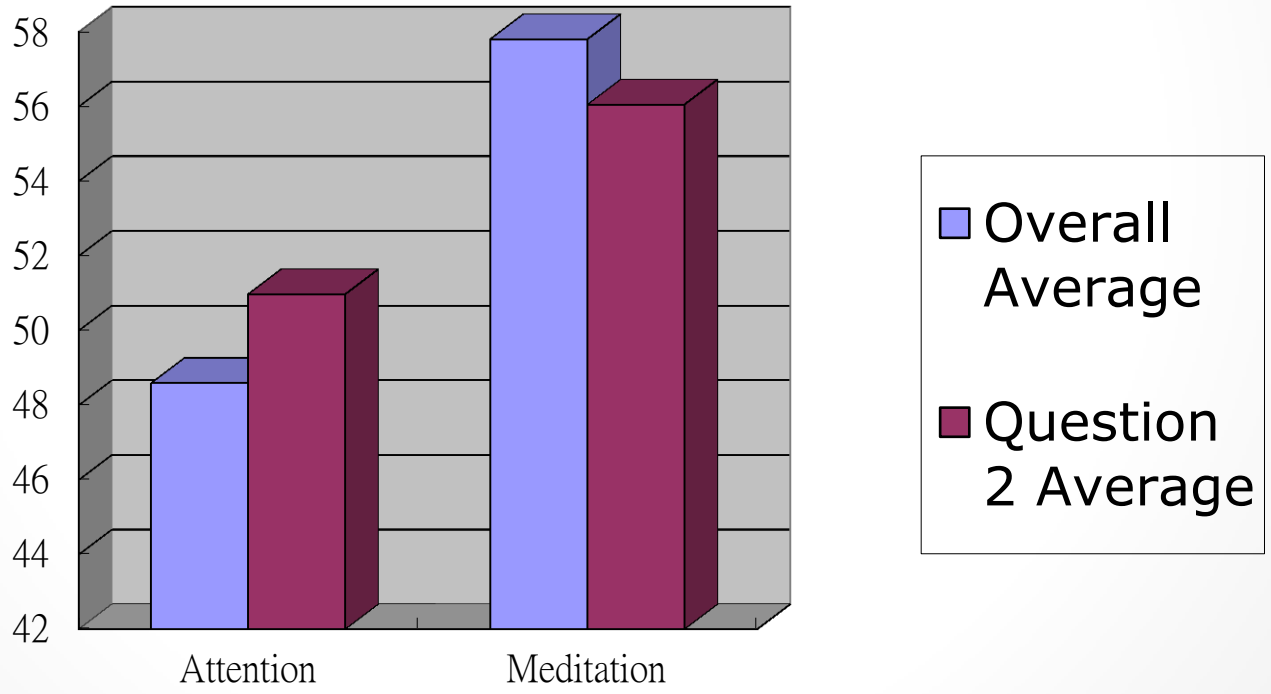
## Part 3: Don’t stare at bikini clip 2

The tires expands inward

Bikini and the expanding tires

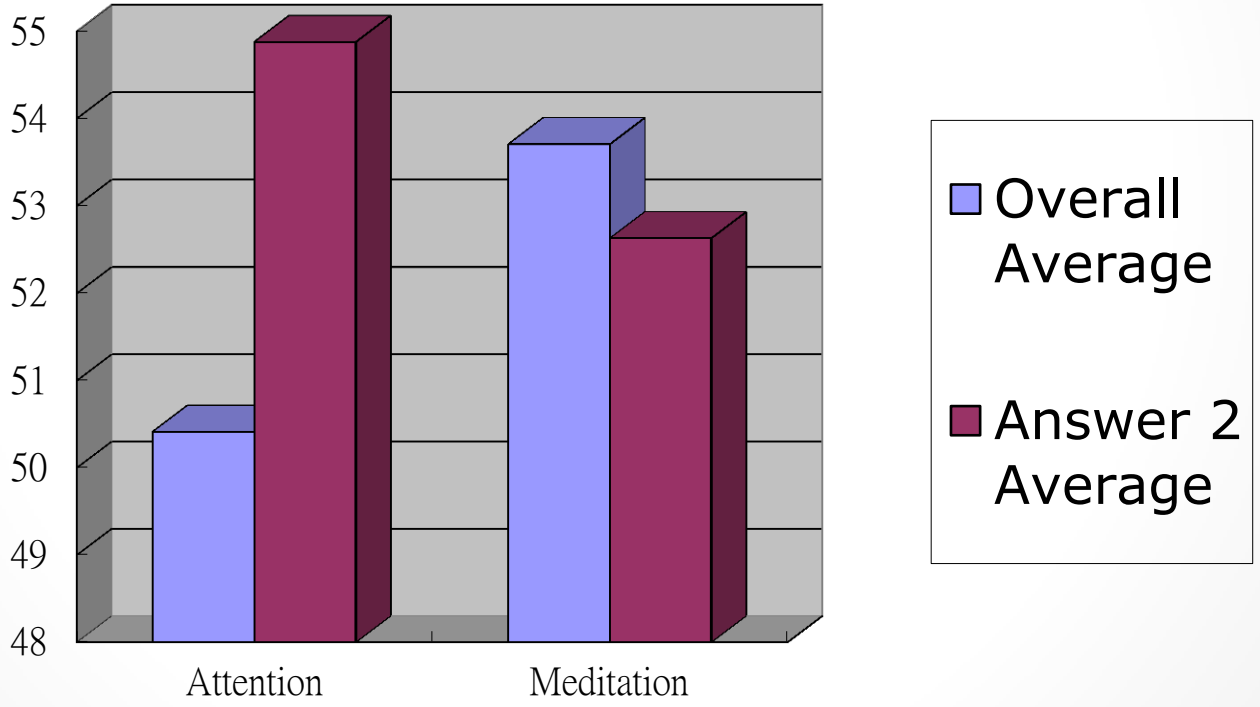
# Concentrated Participants – Question 2

Comparing overall average eSense values and part 3 average values for concentrated participants during question 2



# Concentrated Participants – Answer 2

Comparing overall average eSense values and part 3 average values for concentrated participants during answer 2



# Part 3 Result - Summary

| | Question 1 | Answer 1 | Question 2 | Answer 2 |
|---|---|---|---|---|
| **Overall Attention** | Q1 < Overall | A1 > Overall | Q2 > Overall | A2 > Overall |
| **Overall Meditation** | Q1 > Overall | A1 < Overall | Q2 < Overall | A2 < Overall |

General Trend:
High Attention and Low Meditation

# Part 3 Result - Observation

There is a correlation between attention and concentration.

Attention value is **higher** when wearer are concentrated.

# Experiment on eSense - Movie

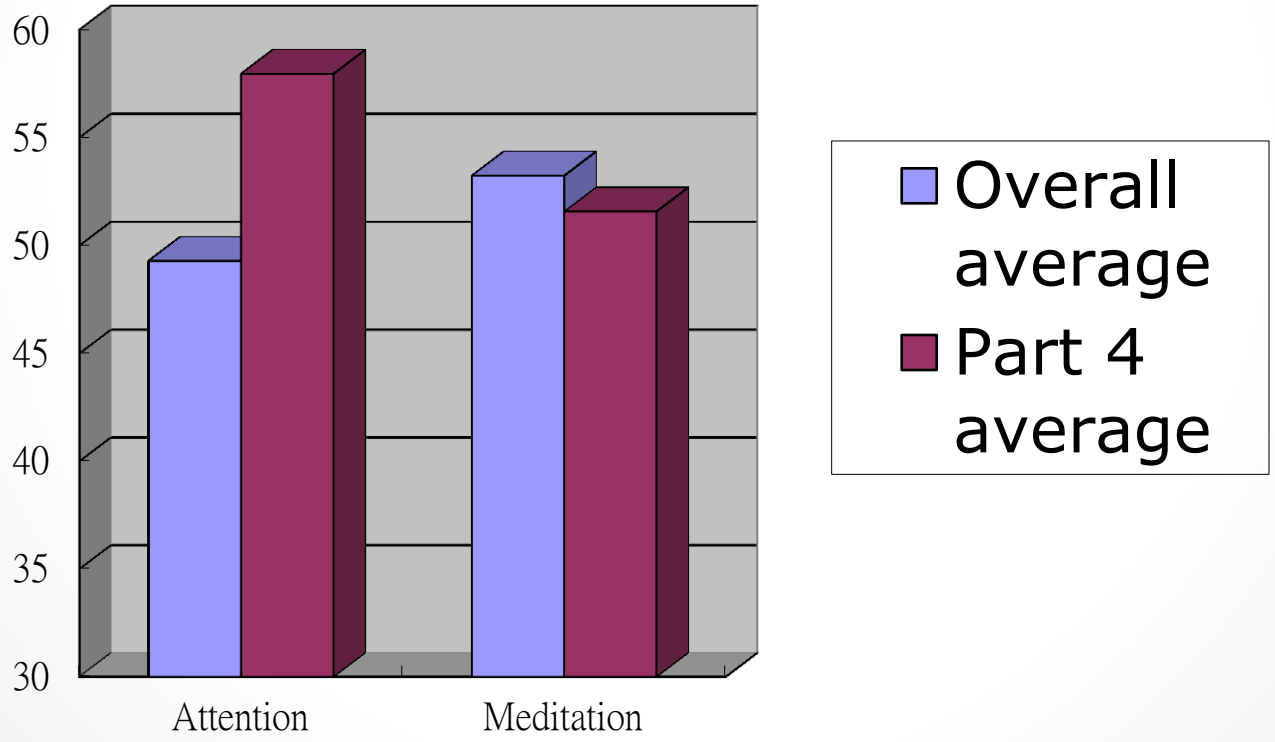
## Part 4: Ghost Pop-Up


Video clip before the ghost pop-up

The Ghost

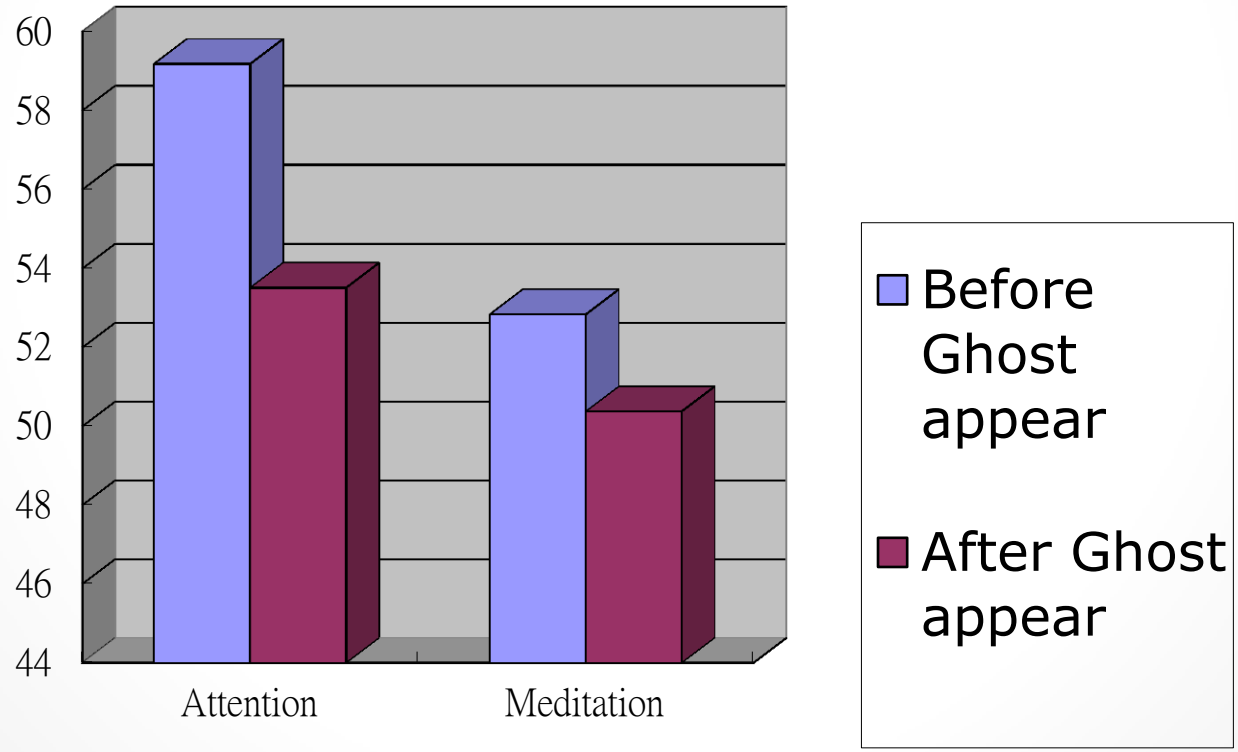
# Aware of Ghost

Comparing overall average eSense values and part 4 average values for all participants



# Ghost Pop-Up

Comparing attention and meditation values before and after the ghost pop up



# Part 4 Result - Observation

There are correlation between attention and concentration.

There are correlation between meditation and calmness.

# Experiment on eSense - Summary

The attention value can correlate to the mental states “concentrated” and “bored”

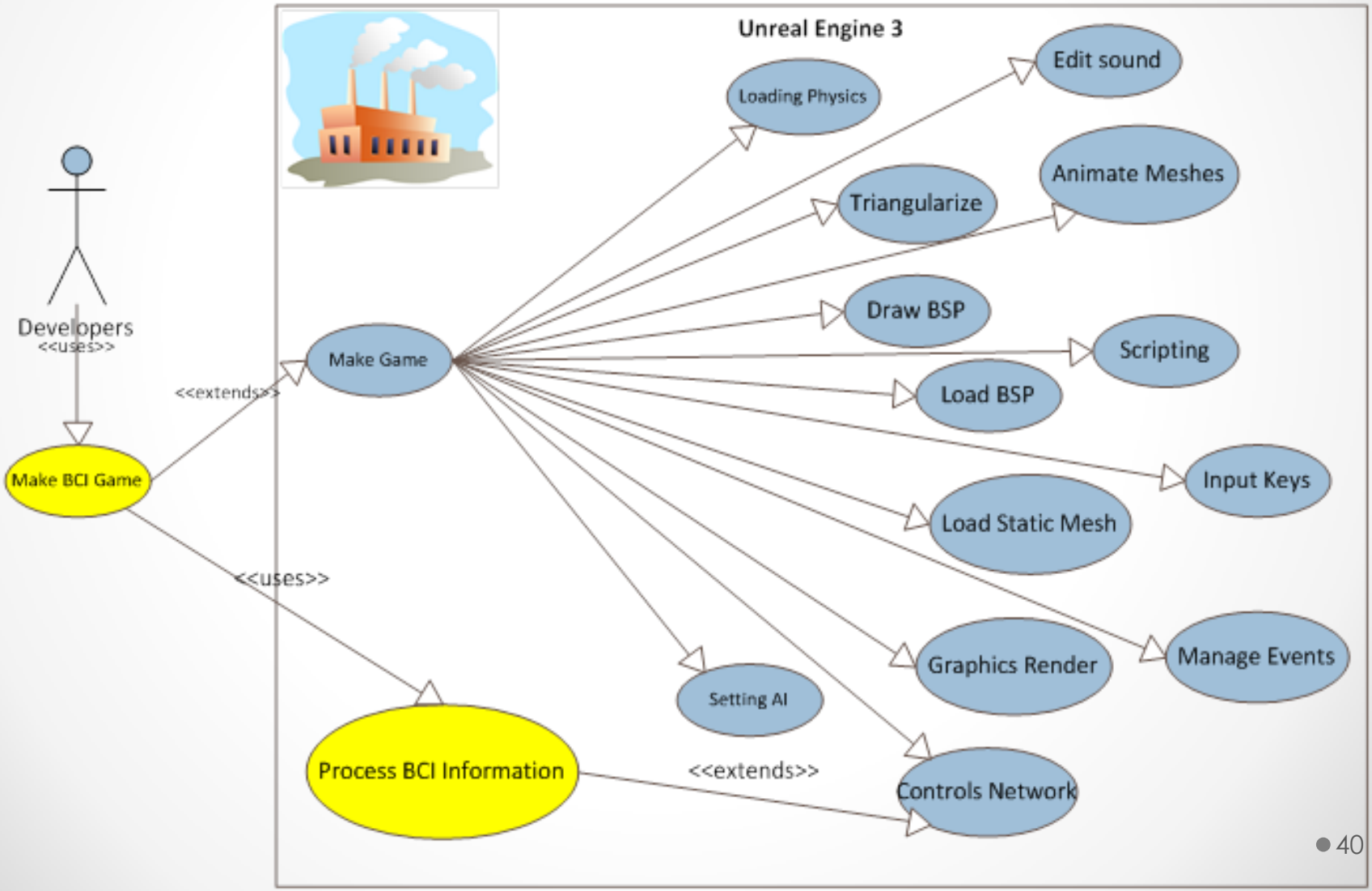
The relation between meditation value and mental states **is not conclusive**

# Why: Use a Game Engine?


711 lines of codes

# Why: Use a Game Engine?

# Why: Hack a Game Engine?



| | | Reality Factory | CryEngine | Unreal Engine 3 |
|---|---|---|---|---|
| **Platform** | Windows | Yes | Yes | Yes |
| | Linux | No | No | Yes |
| | Mac | No | No | Yes |
| | PS2 | No | Yes | Yes |
| | PS3 | No | Yes | Yes |
| | PSP | No | No | Yes |
| | Xbox | No | Yes | Yes |
| | Xbox360 | No | Yes | Yes |
| | Wii | No | No | Yes |
| **Cost** | License | Open-source | Commercial | Commercial |
| | Price | Free | Comes with Crysis | Free for Non-commercial |
| **Documentation** | Level Editor | Yes | Yes | Yes |
| | Asset Creation | Yes | Yes | Yes |
| | Programming | Yes | Yes | Yes |
| | Engine Architecture | No | No | Yes |
| | Knowledge Database | No | No | Yes |
| | Video Tutorials | No | No | Yes |
| | Demo w/ Source Codes | No | No | Yes |
| **Networking** | Client-Server | No | Yes | Yes |
| | Peer-to-Peer | Yes | No | Yes |
| **Graphics** | Hardware Acceleration | No | Yes | Yes |
| **Shadows** | Shadow Mapping | Yes | No | Yes |
| | Shadow Volume | No | Yes | Yes |
| | Projected Planar | No | No | Yes |
| **Texturing** | Multi-Texturing | Yes | Yes | Yes |
| | Bump mapping | Yes | Yes | Yes |
| | Mip mapping | Yes | Yes | Yes |
| **Animation** | Keyframe Animation | Yes | Yes | Yes |
| | Skeletal Animation | Yes | Yes | Yes |
| | Facial Animation | No | No | Yes |
| **Physics** | Collision Detection | Yes | Yes | Yes |
| | Rigid Body | Yes | Yes | Yes |
| | Vehicle Physics | No | Yes | Yes |
| **AI** | Pathfinding | Yes | Yes | Yes |
| | Scripted | Yes | Yes | Yes |
| | FSM | No | No | Yes |
| **Scene Management** | BSP | Yes | Yes | Yes |
| | Portals | Yes | Yes | Yes |
| | LOD | No | Yes | Yes |

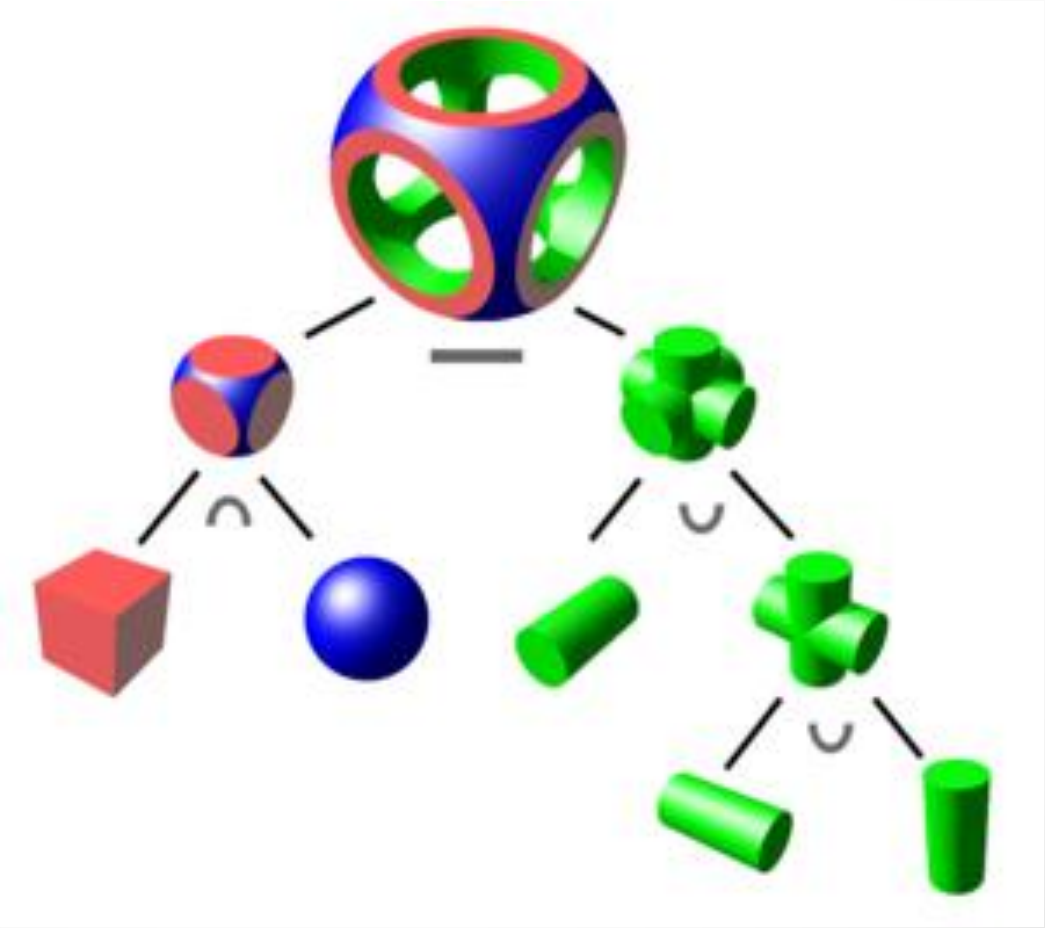
# Why UDK?

- ✓ Cross-platform
- ✓ Documentation
- ✓ Graphics
- ✓ Animation Control
- ✓ Game Physics
- ✓ AI Management
- ✓ Scene Management

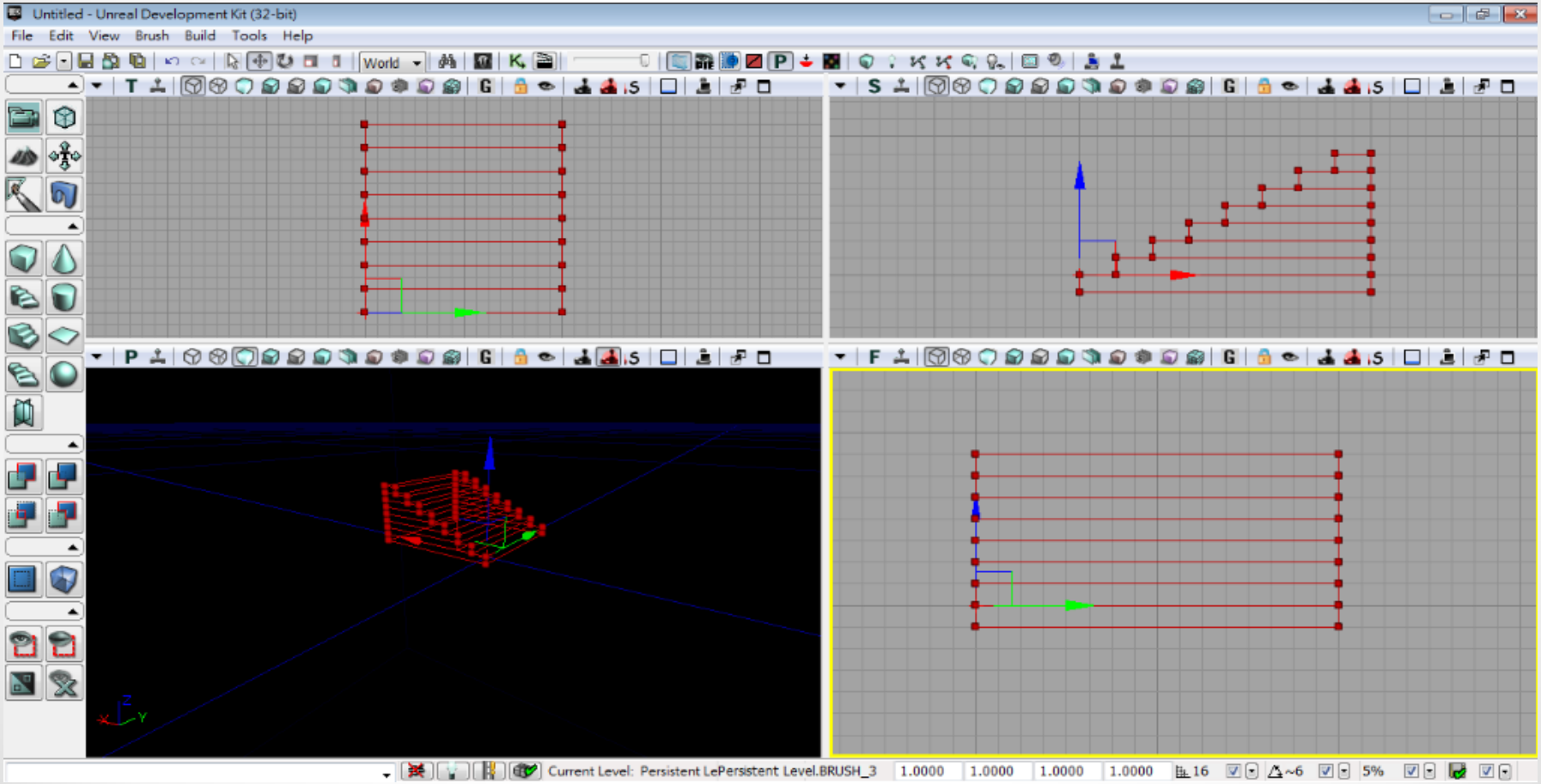

"Number 1 Game Engine"
Develop-online.net

# Game Creation in UDK

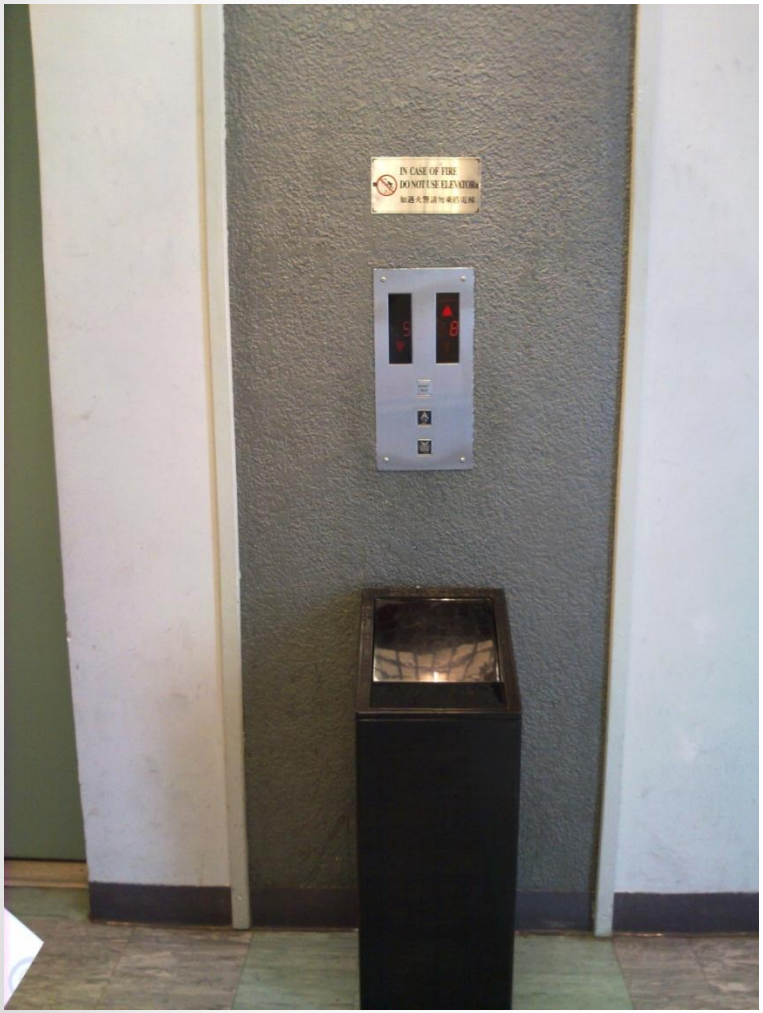
- Constructive Solid Geometry (CSG)

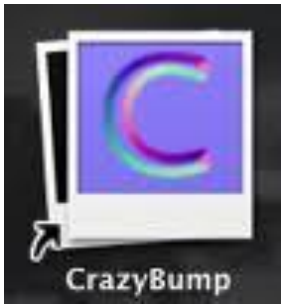


# Game Creation in UDK



# Game Creation in UDK

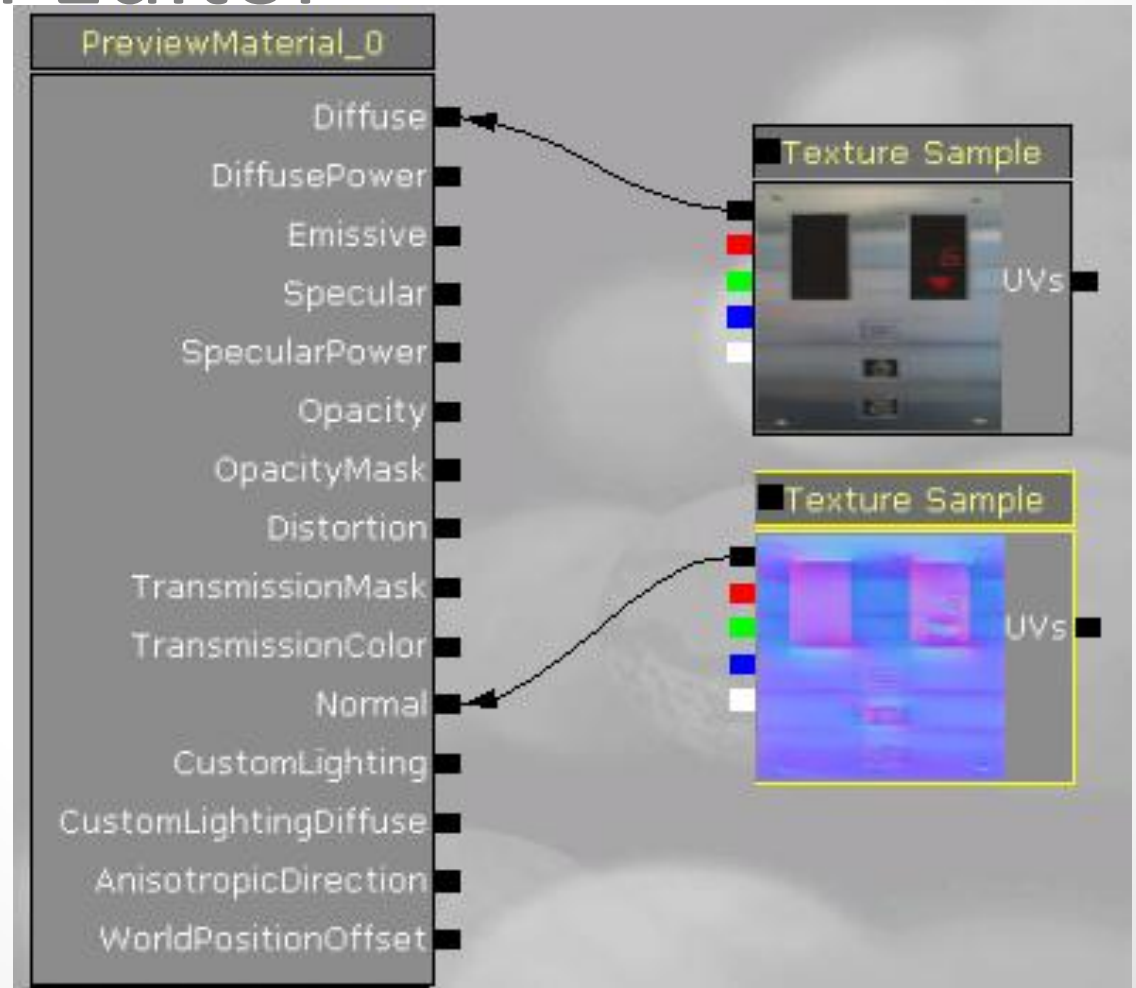


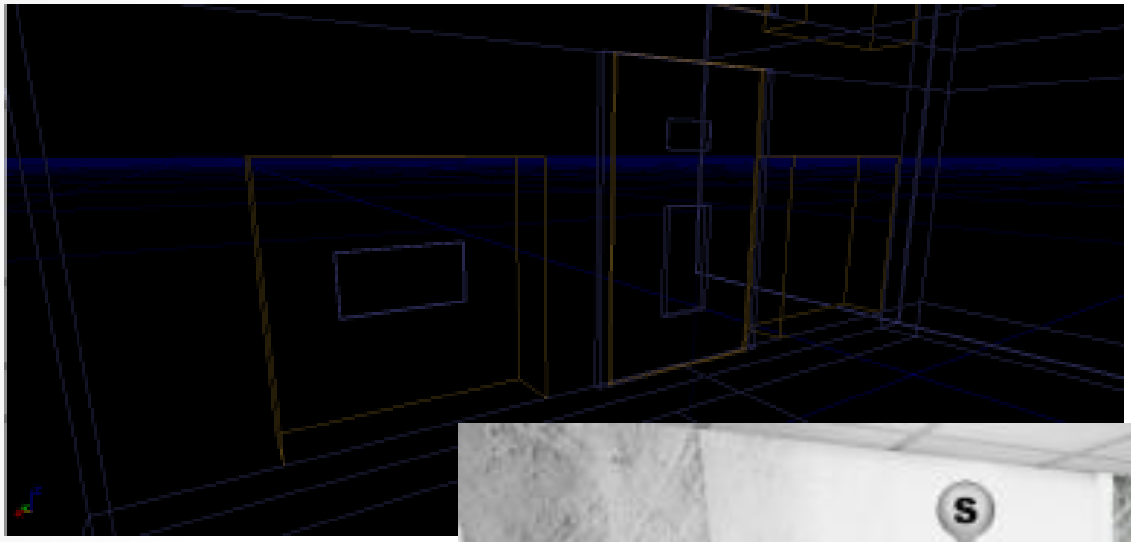

AND
Photo Editor

# Game Creation in UDK

- Material Editor

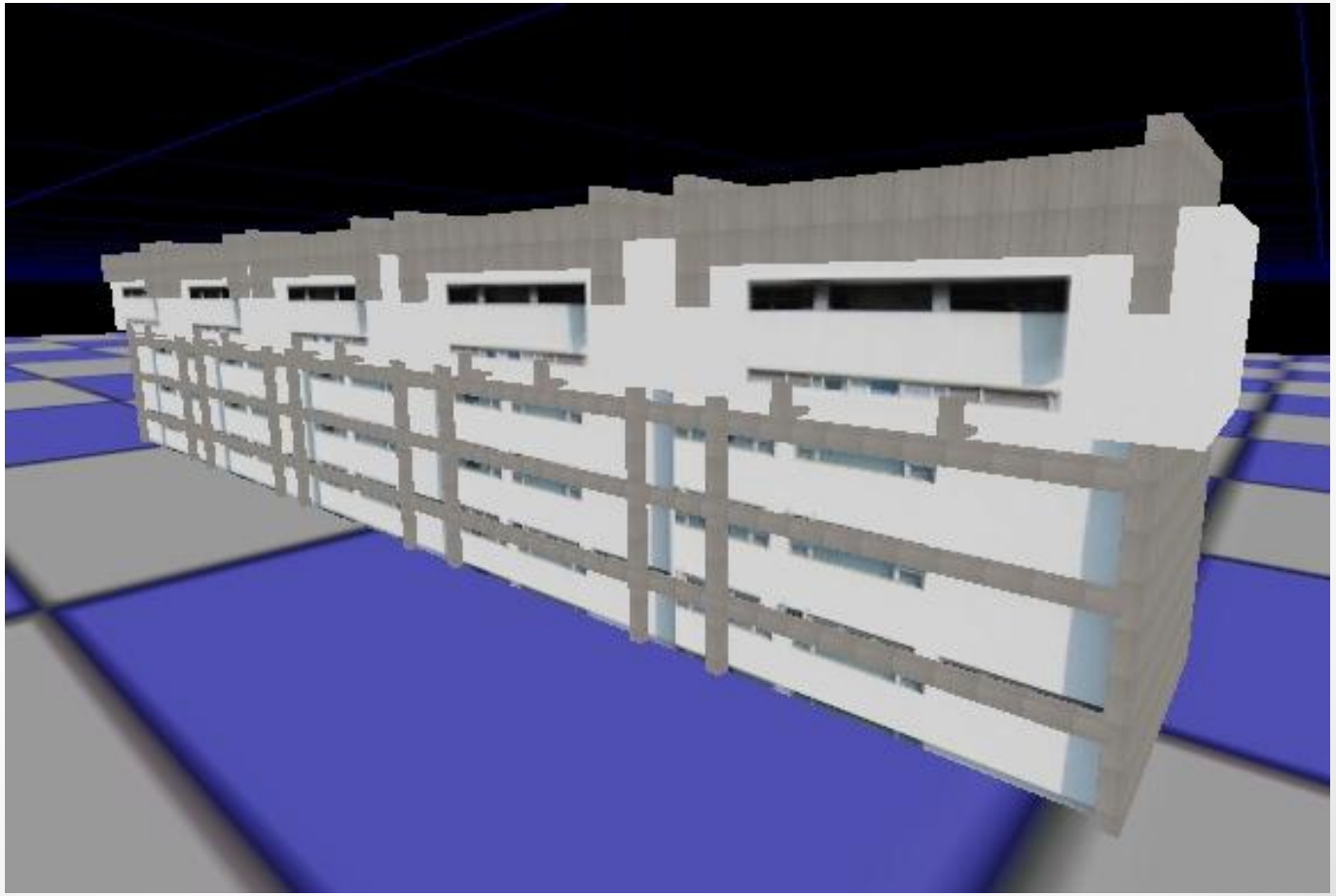


# Game Creation in UDK

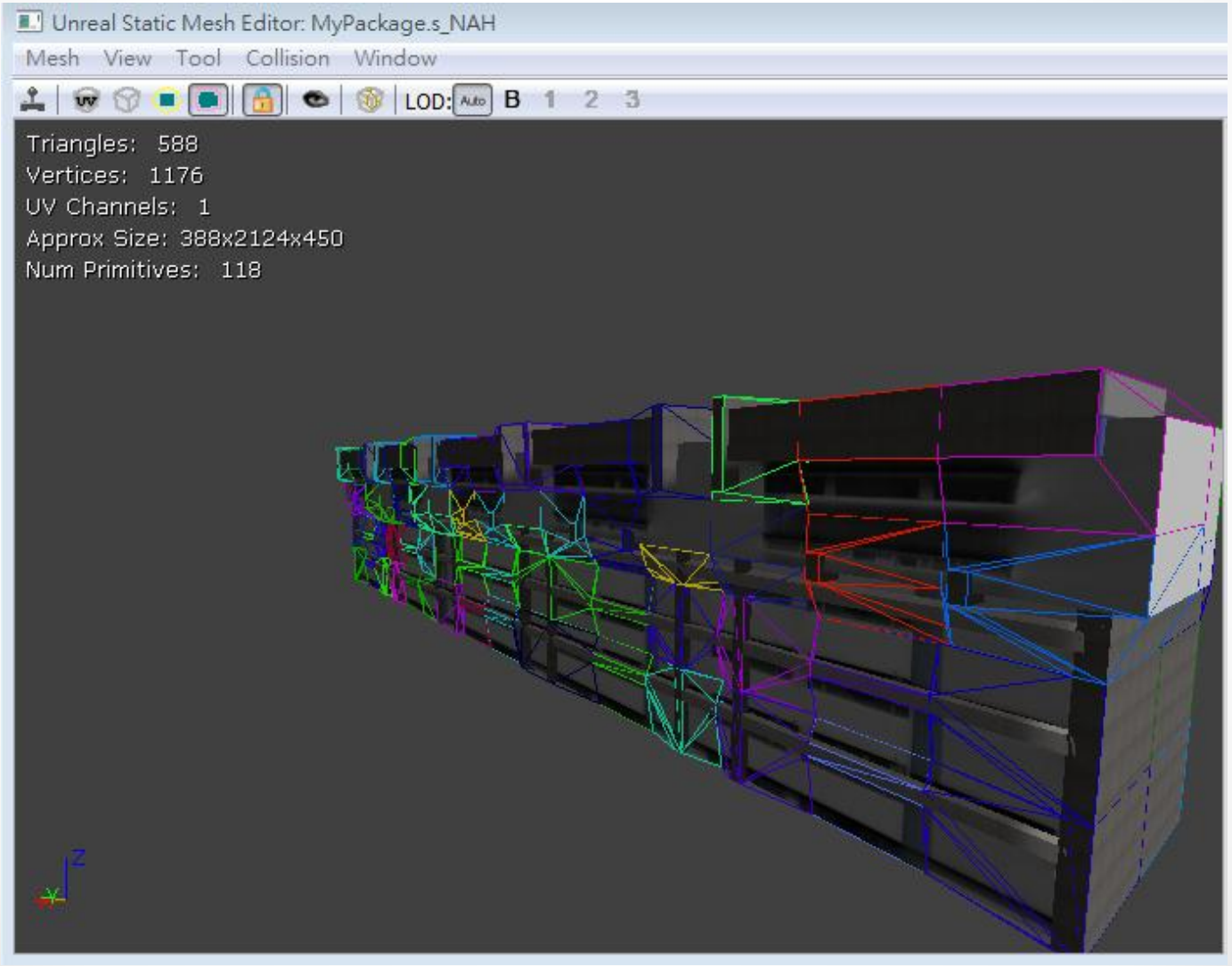


# Game Creation in UDK

- Static Mesh

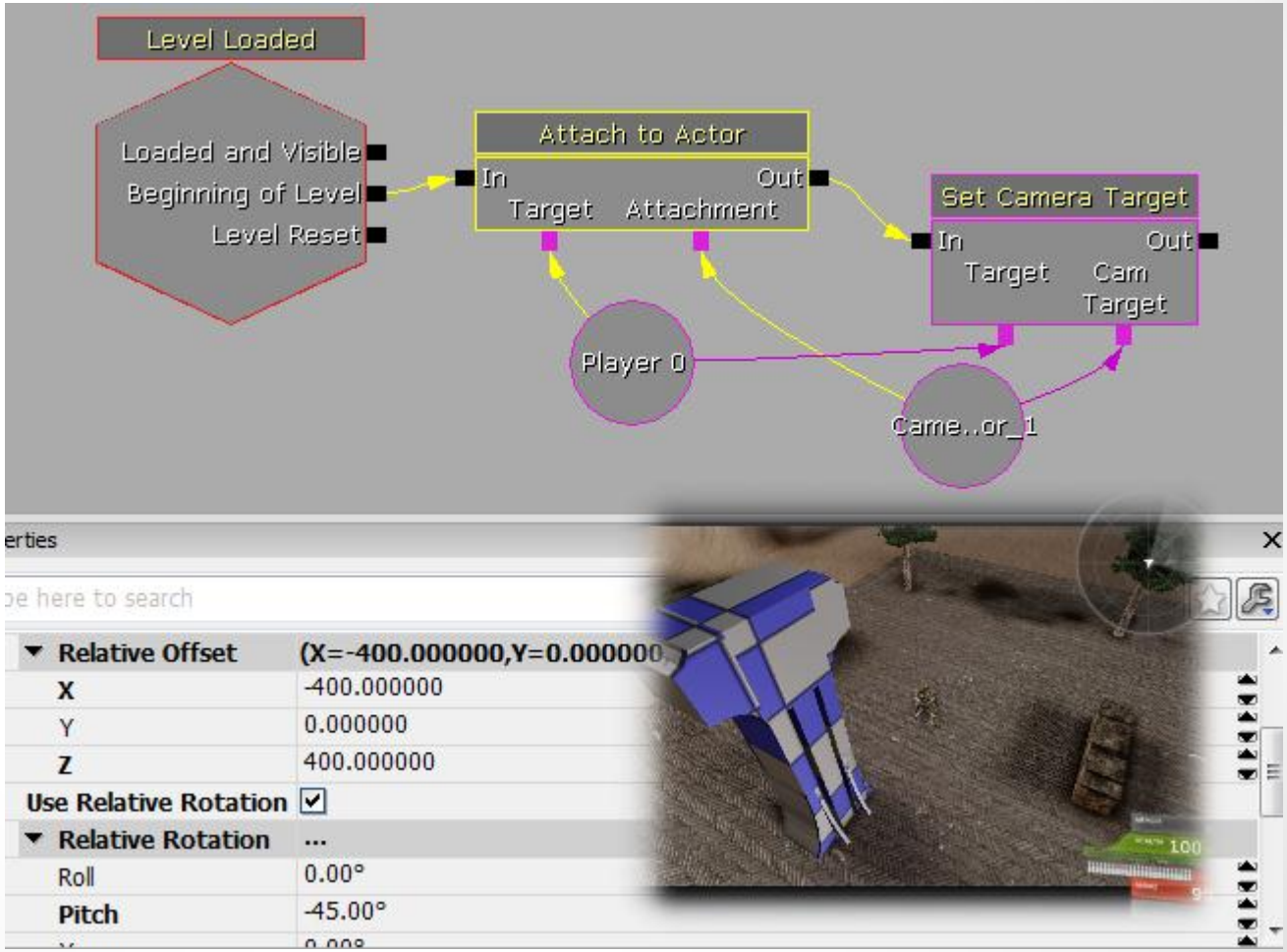


# Game Creation in UDK



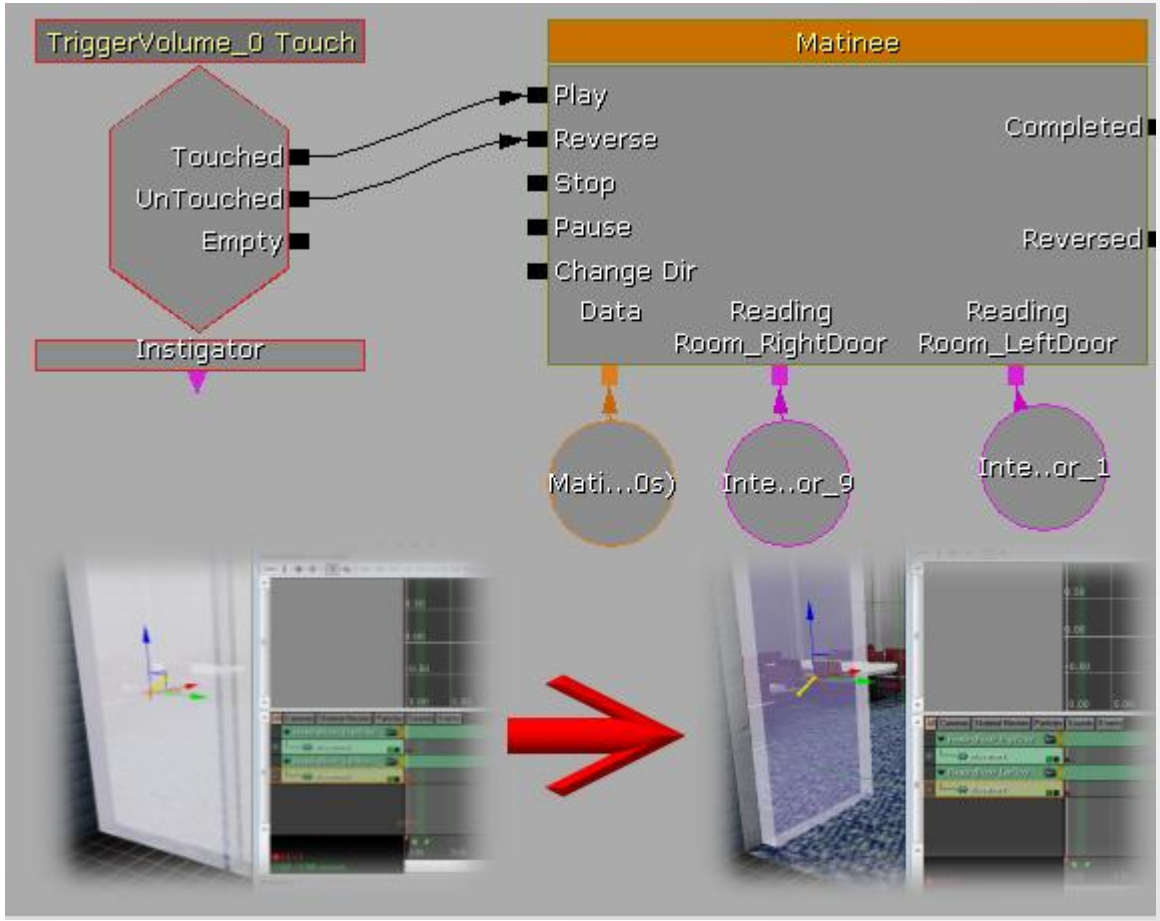
# Game Creation in UDK

- Kismet



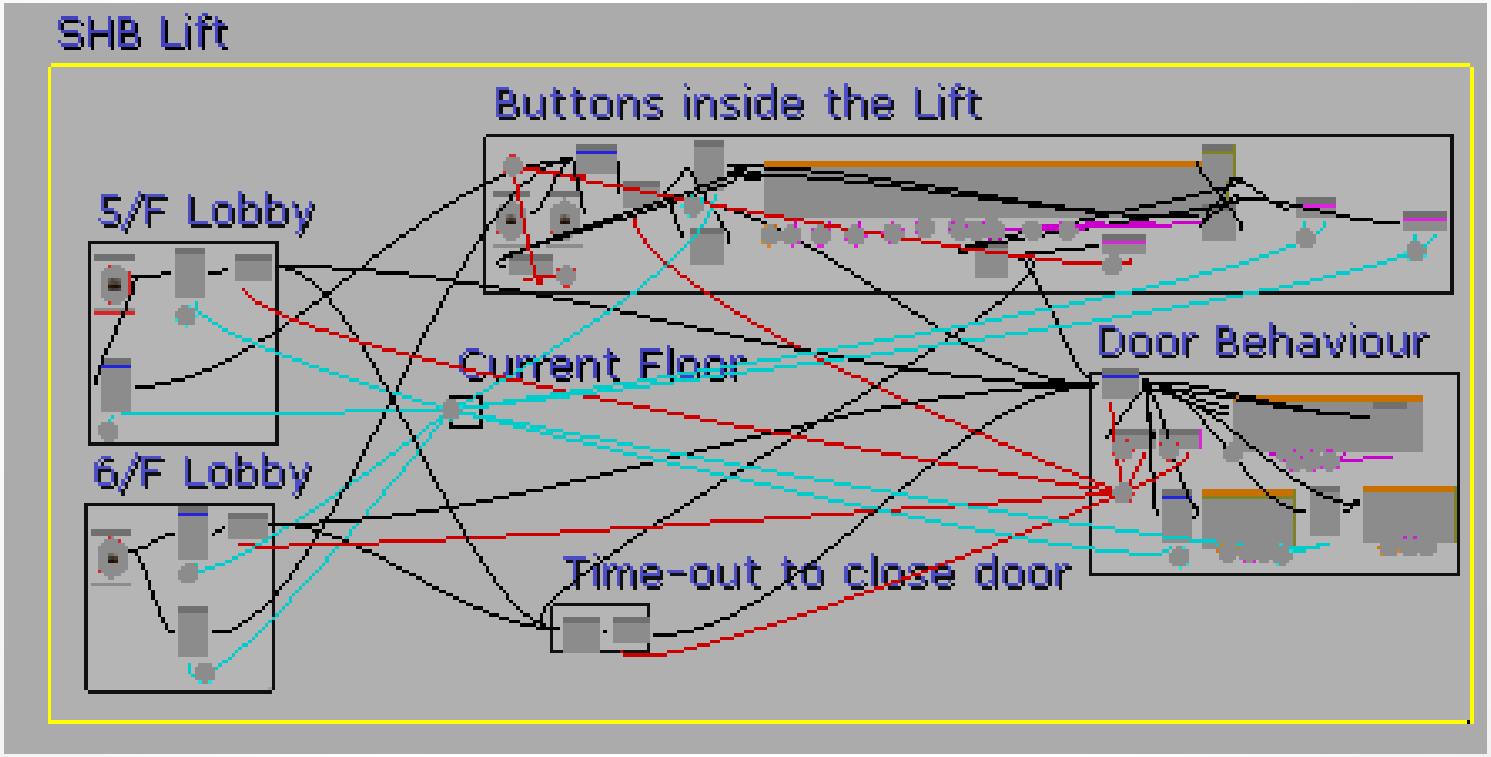
# Game Creation in UDK

- Kismet With Matinee



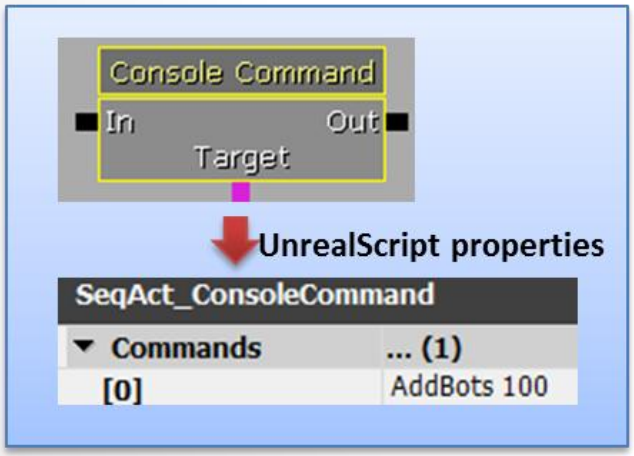
# Game Creation in UDK

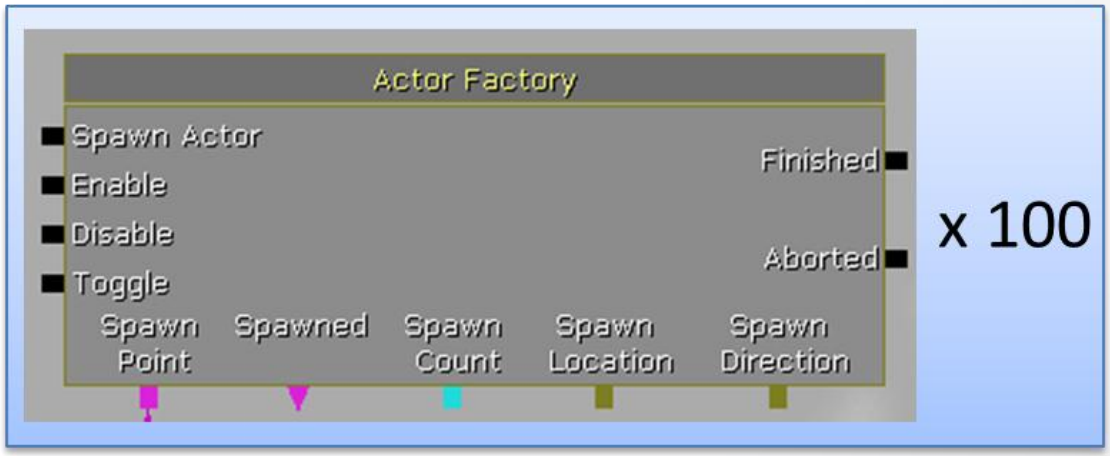
- Drawback of Kismet



# Game Creation in UDK

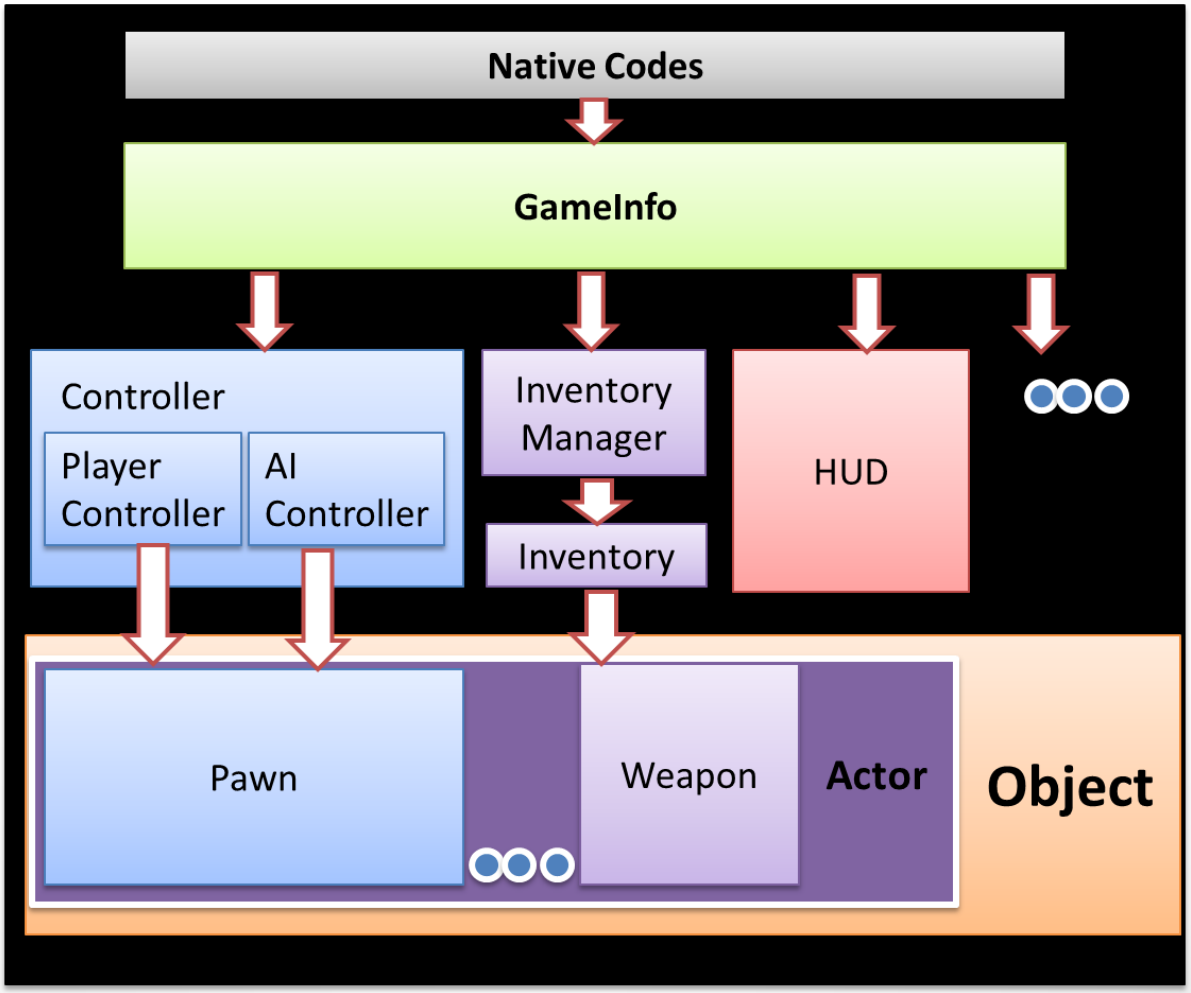
- Solution: UnrealScript



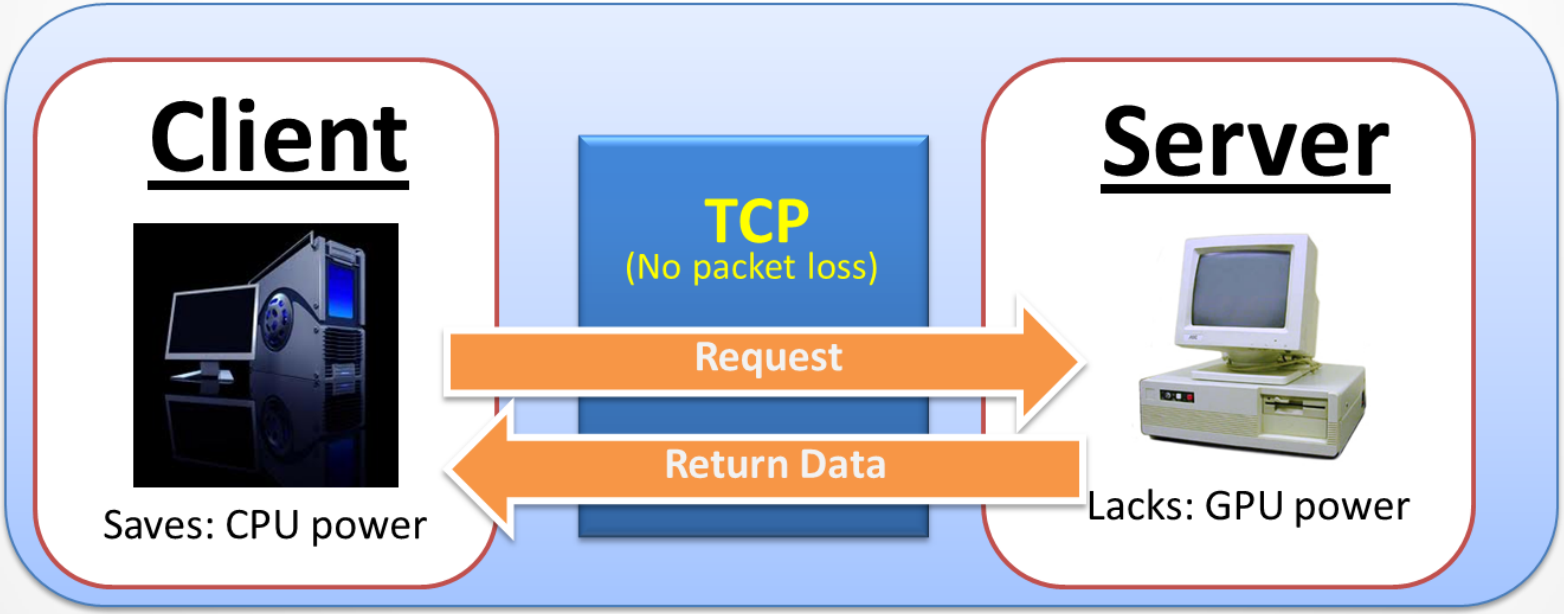



# UDK-Mindset Integration

- Abstract view on UnrealScript classes (total >2300)



# UDK-Mindset Integration



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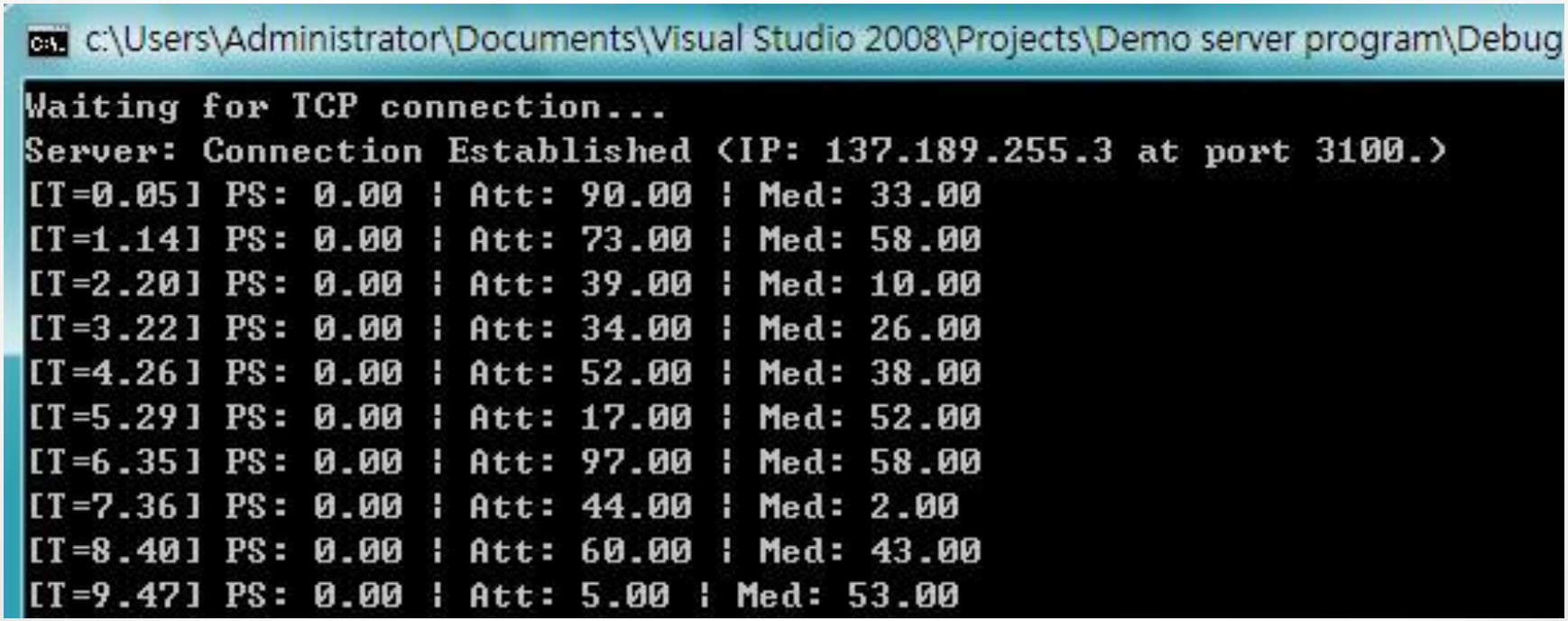

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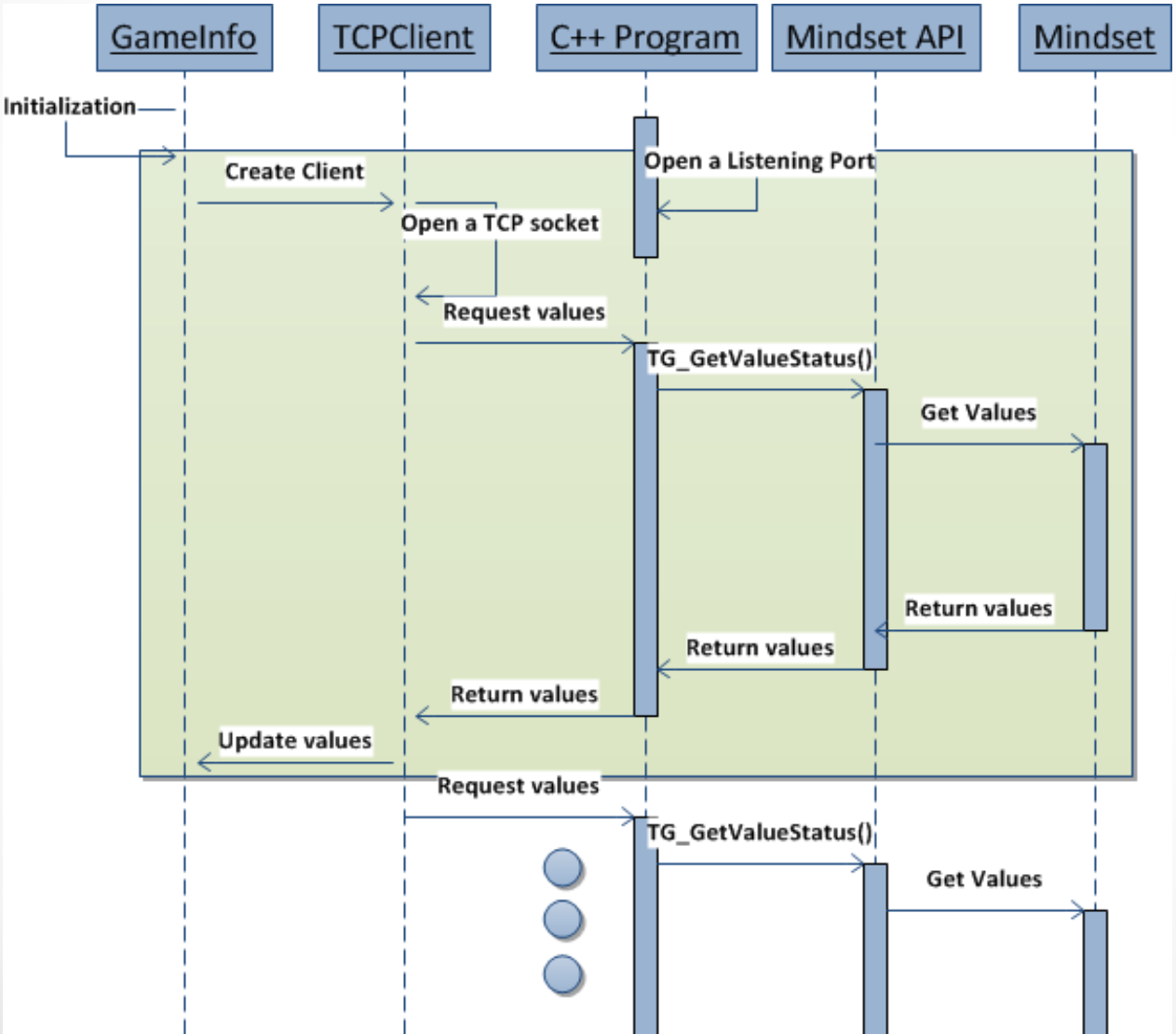

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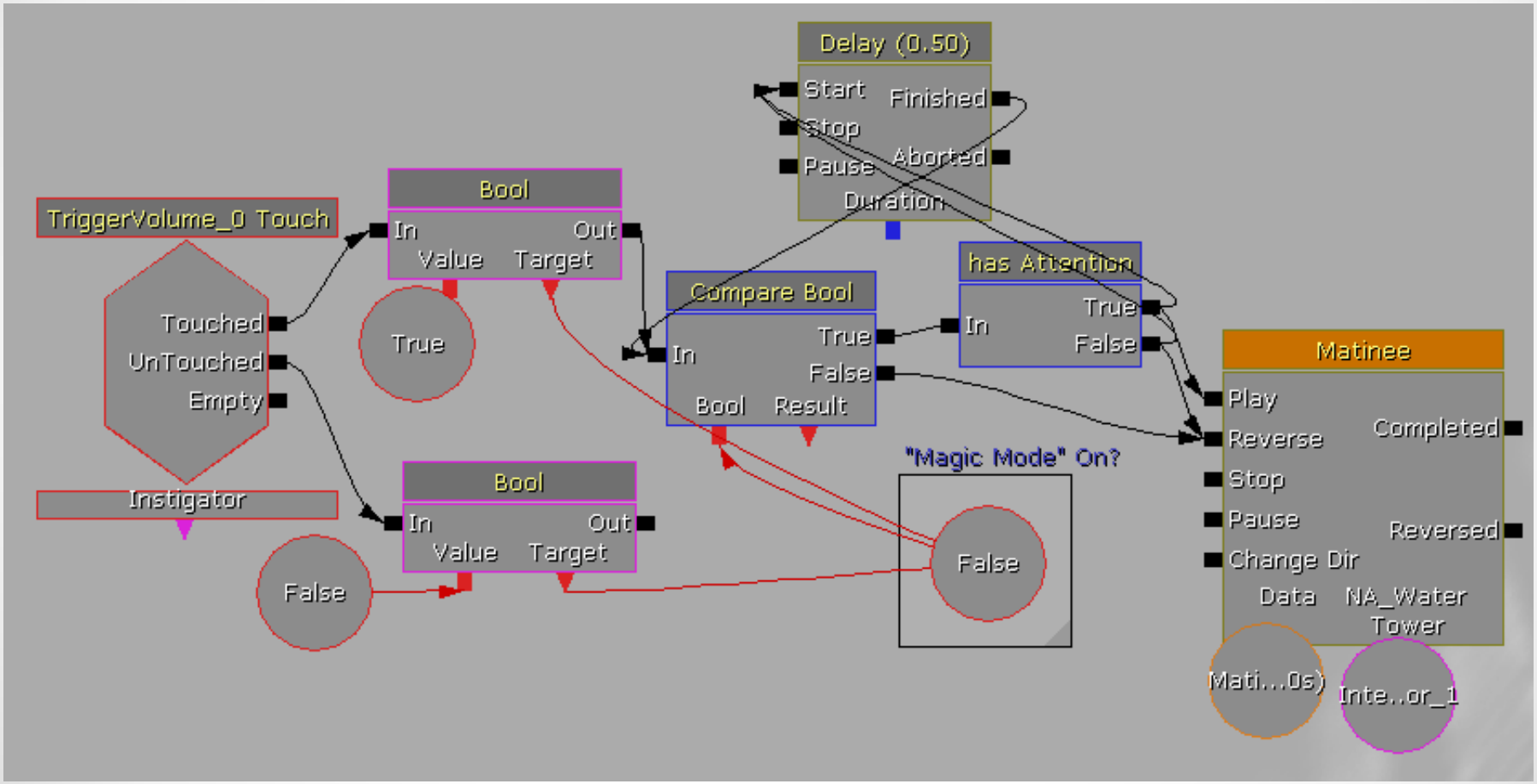

# UDK-Mindset Integration

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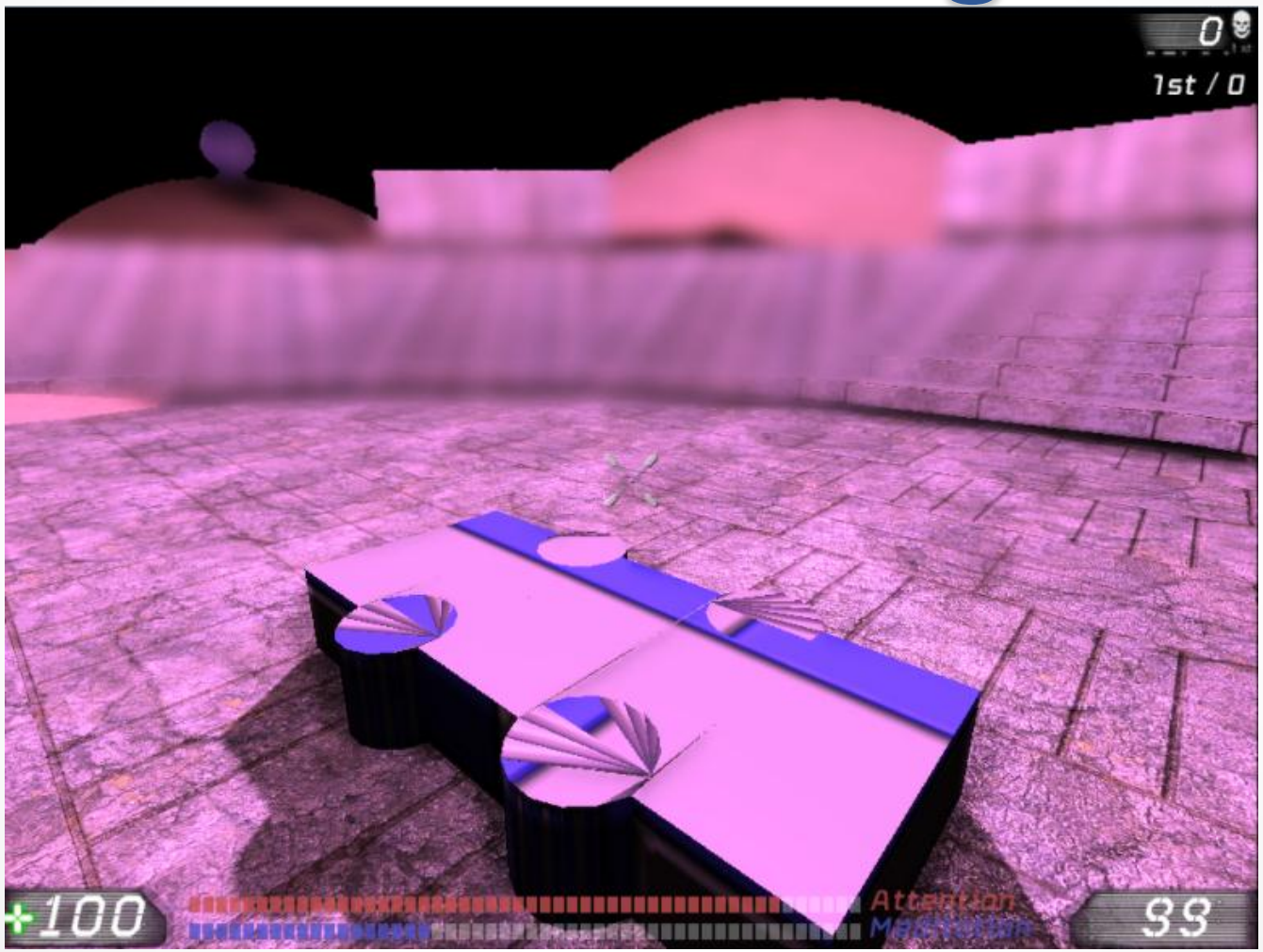
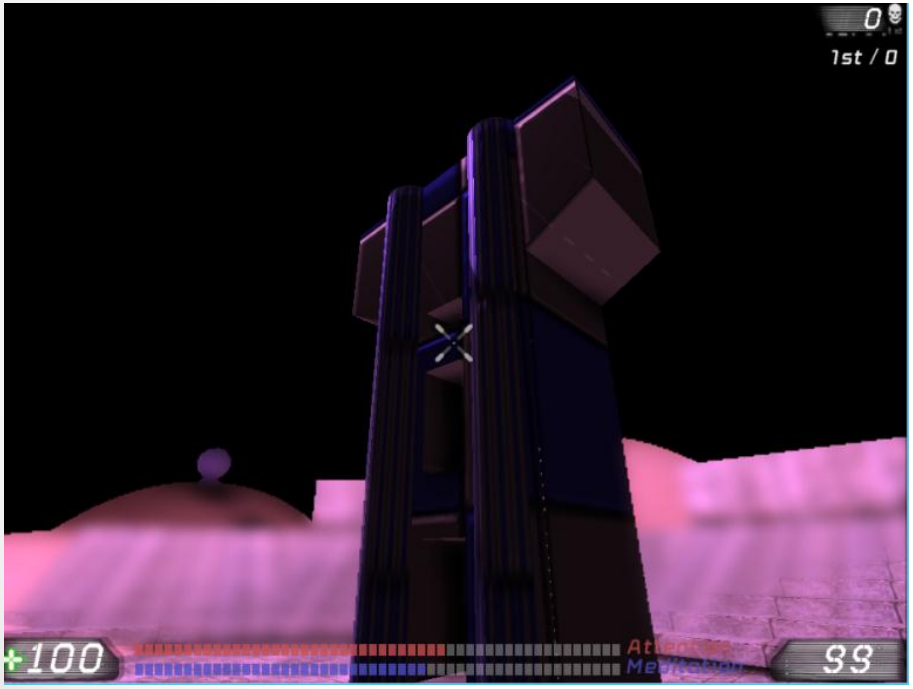
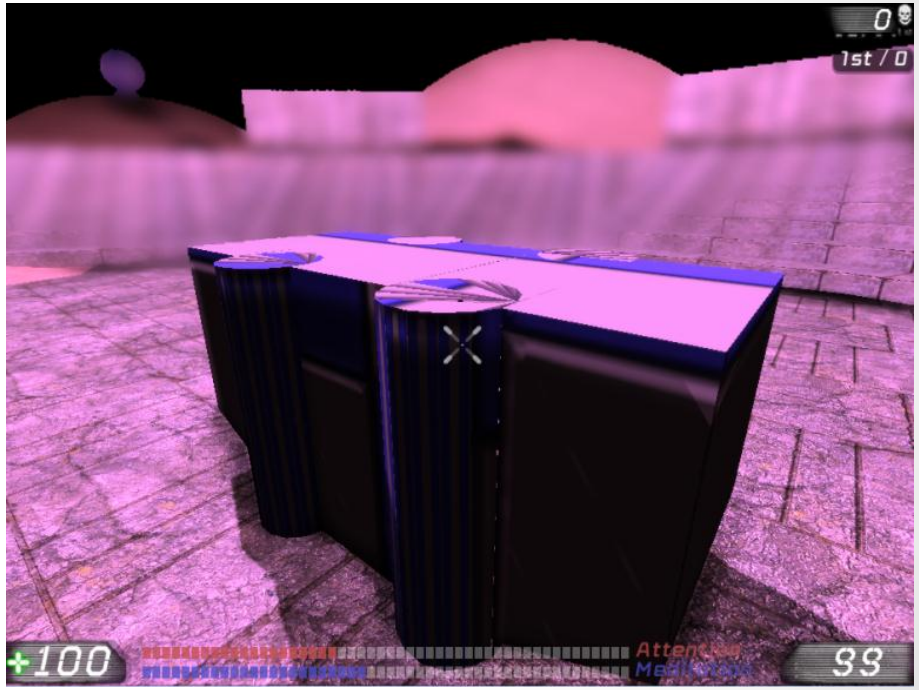


# UDK-Mindset Integration



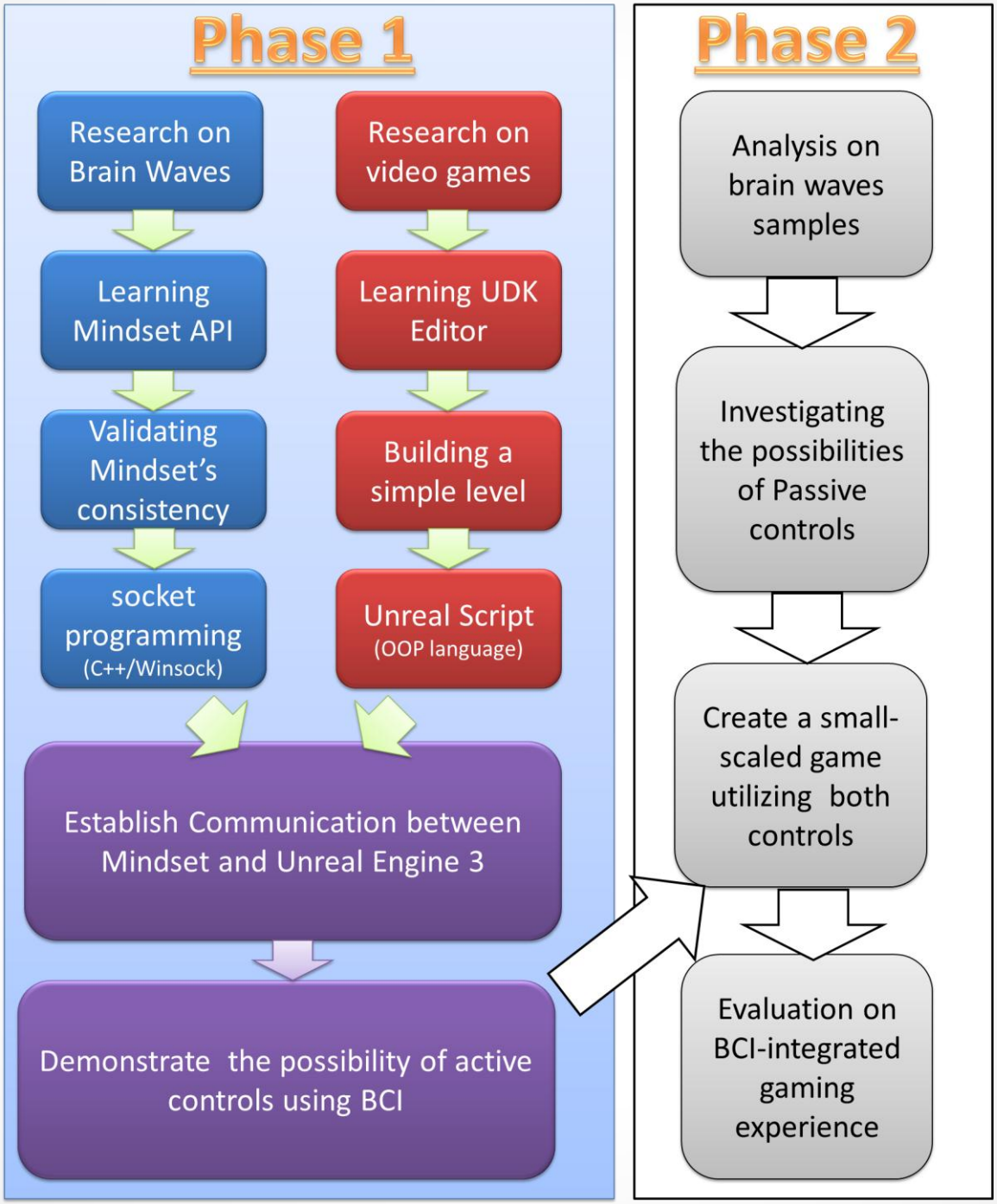




$$S_t = A_{t-1} + \frac{A_t - A_{t-1}}{T}$$

$(where\ S_t, S_{t-1}, A_t, A_{t-1}, T \in R)$

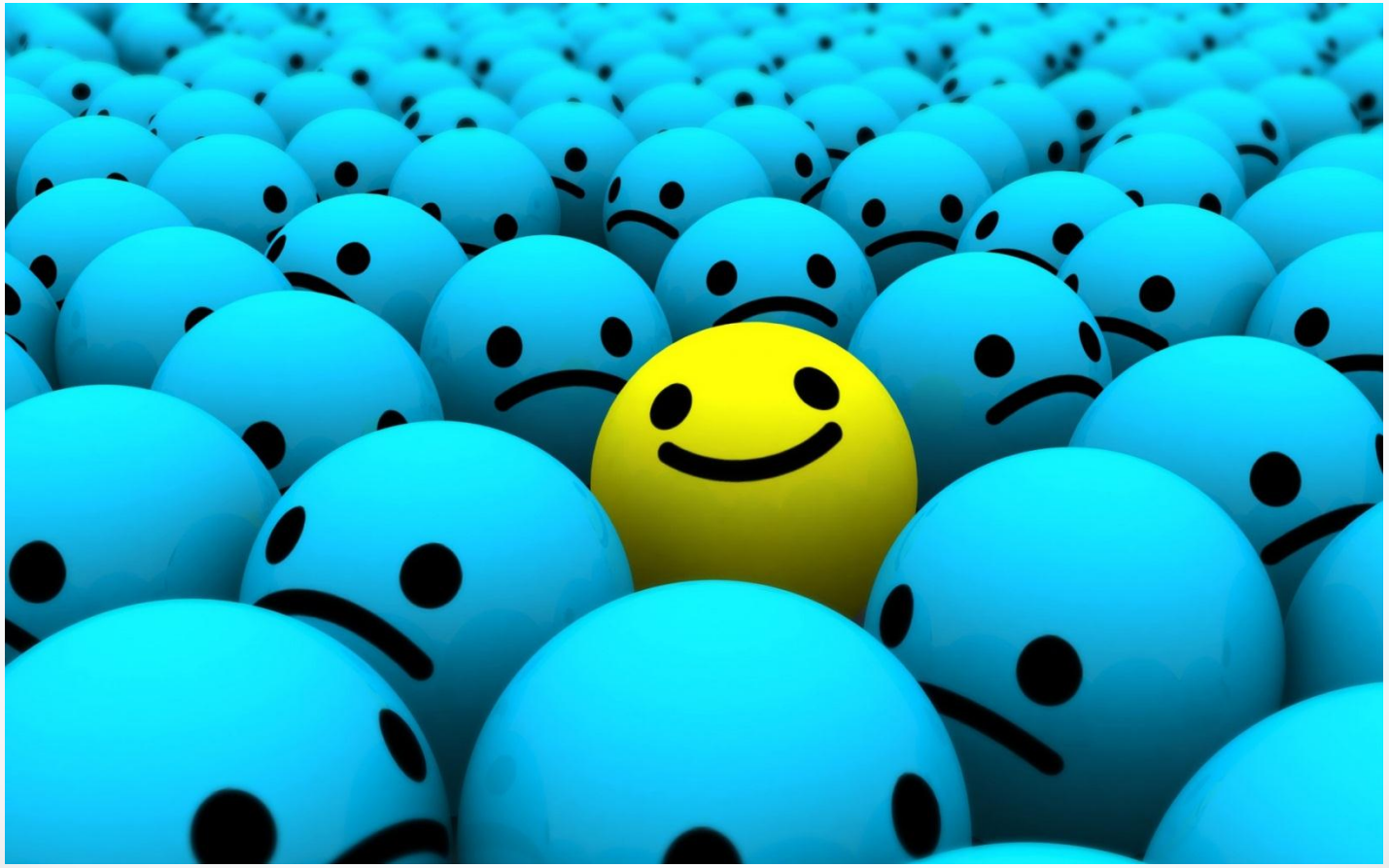
# Demo Video


http://www.youtube.com/watch?v=CgOkyTpS6FQ&hd=1


Phase 1
Research on Brain Waves
Research on video games
Learning Mindset API
Learning UDK Editor
Validating Mindset's consistency
Building a simple level
socket programming (C++/Winsock)
Unreal Script (OOP language)
Establish Communication between Mindset and Unreal Engine 3
Demonstrate the possibility of active controls using BCI
Phase 2
Analysis on brain waves samples
Investigating the possibilities of Passive controls
Create a small-scaled game utilizing both controls
Evaluation on BCI-integrated gaming experience

# Future Work

- Signal Processing



# Future Work

- Passive Control

# Future Work

- Small-scaled BCI game with evaluation