Unleashing Brain Powers

A Study on Development of BCI-Enhanced Computer Games

LYU1006 Fall Semester Presentation (2010-2011)

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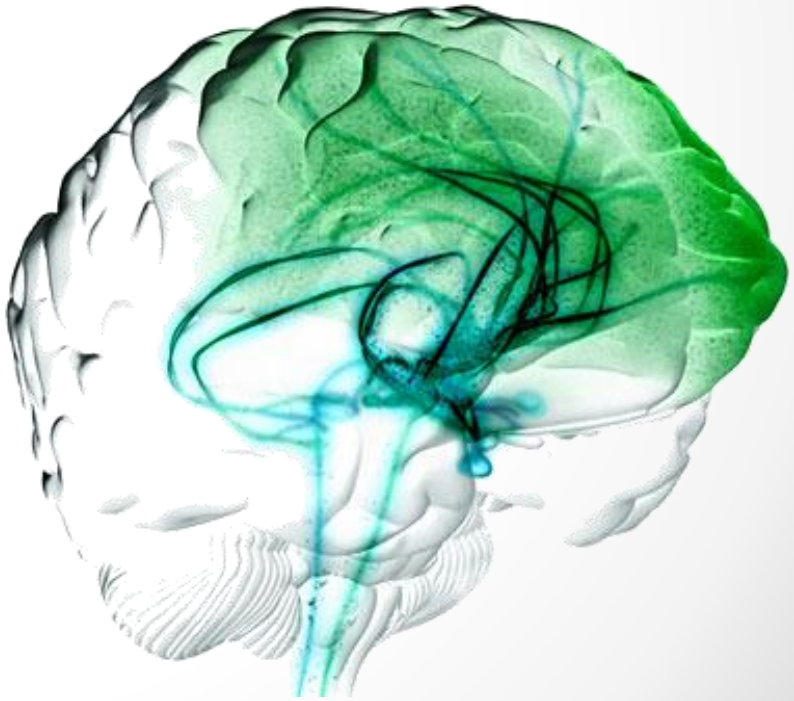


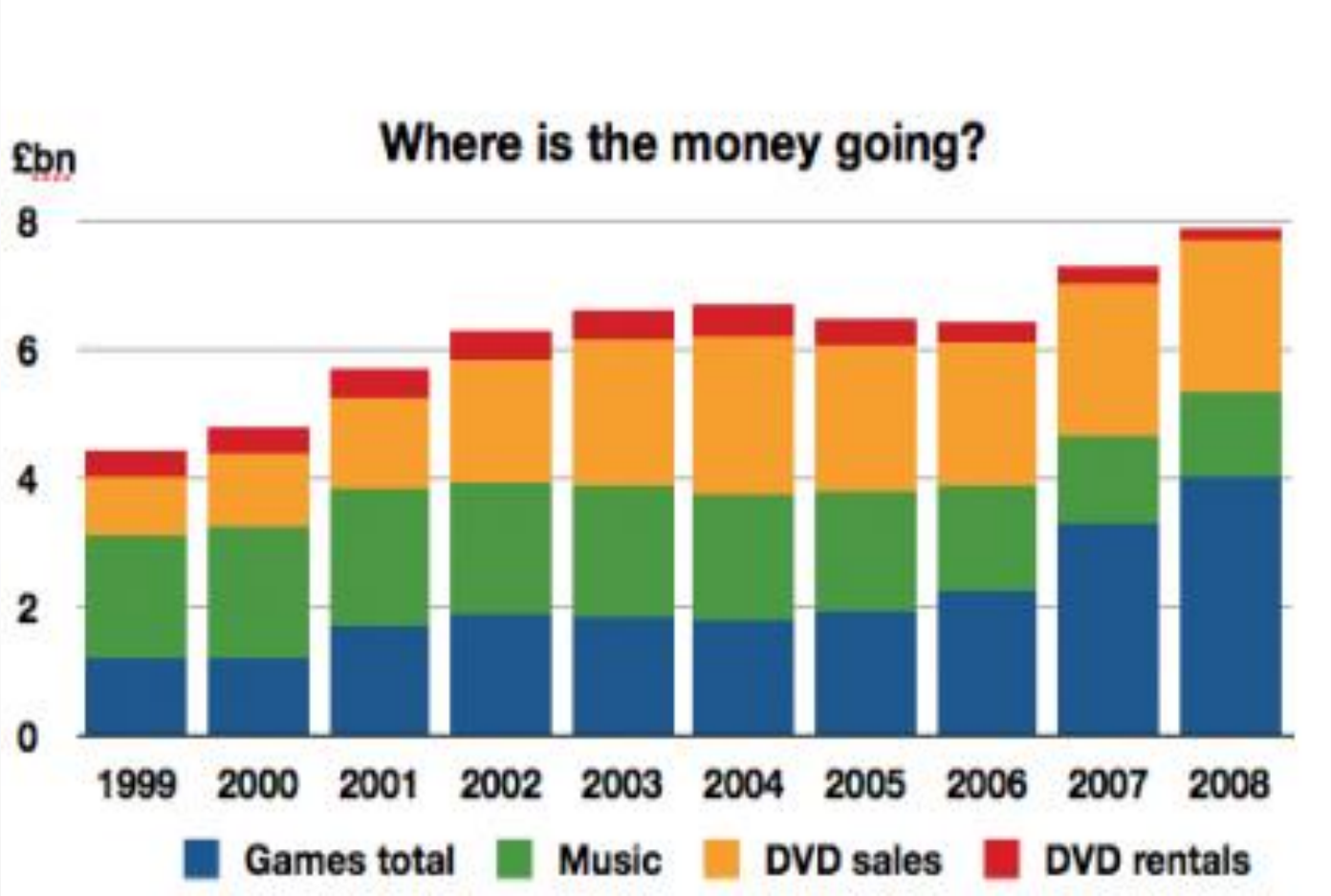
Department of Computer Science and Engineering

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?



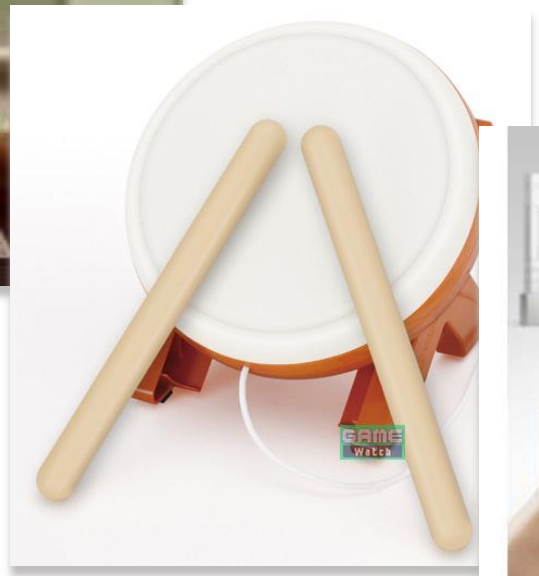
http://www.guardian.co.uk/news/datablog/2009/jun/09/games-dvd-music-downloads-piracy

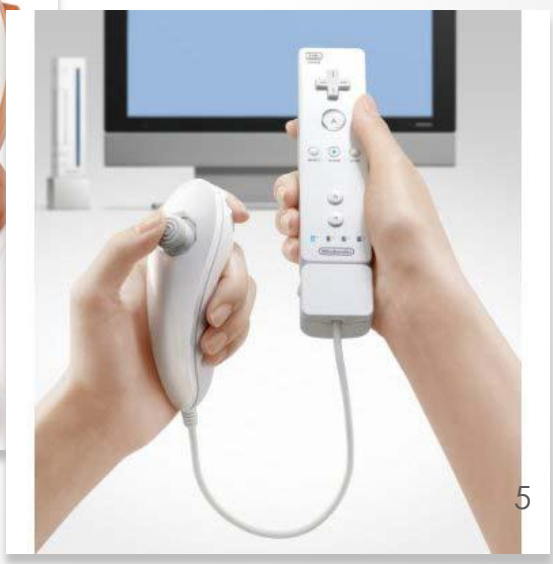
Why BCI Games?

Keys

Why BCI Games?

Motion Detection





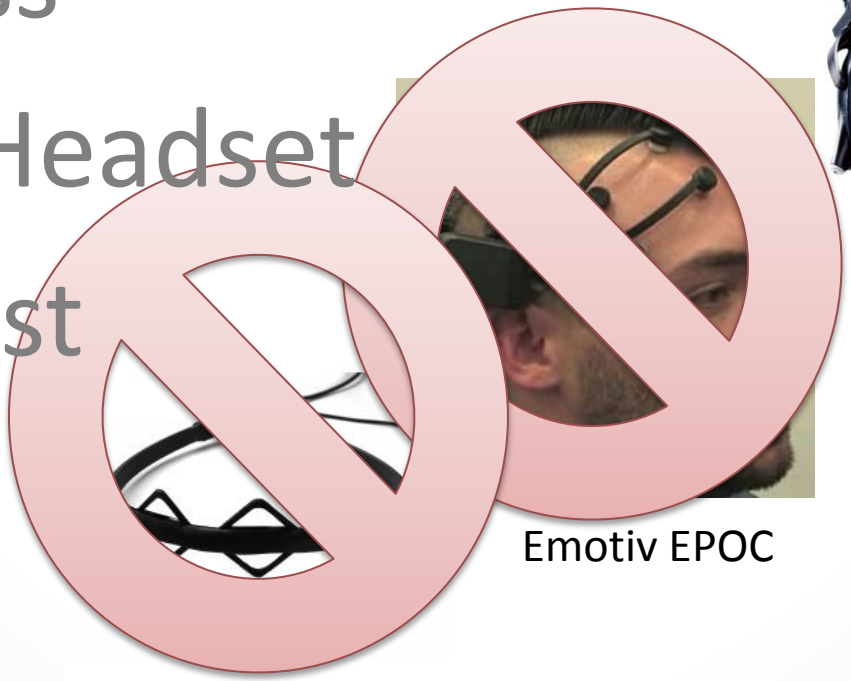
Why BCI Games?

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

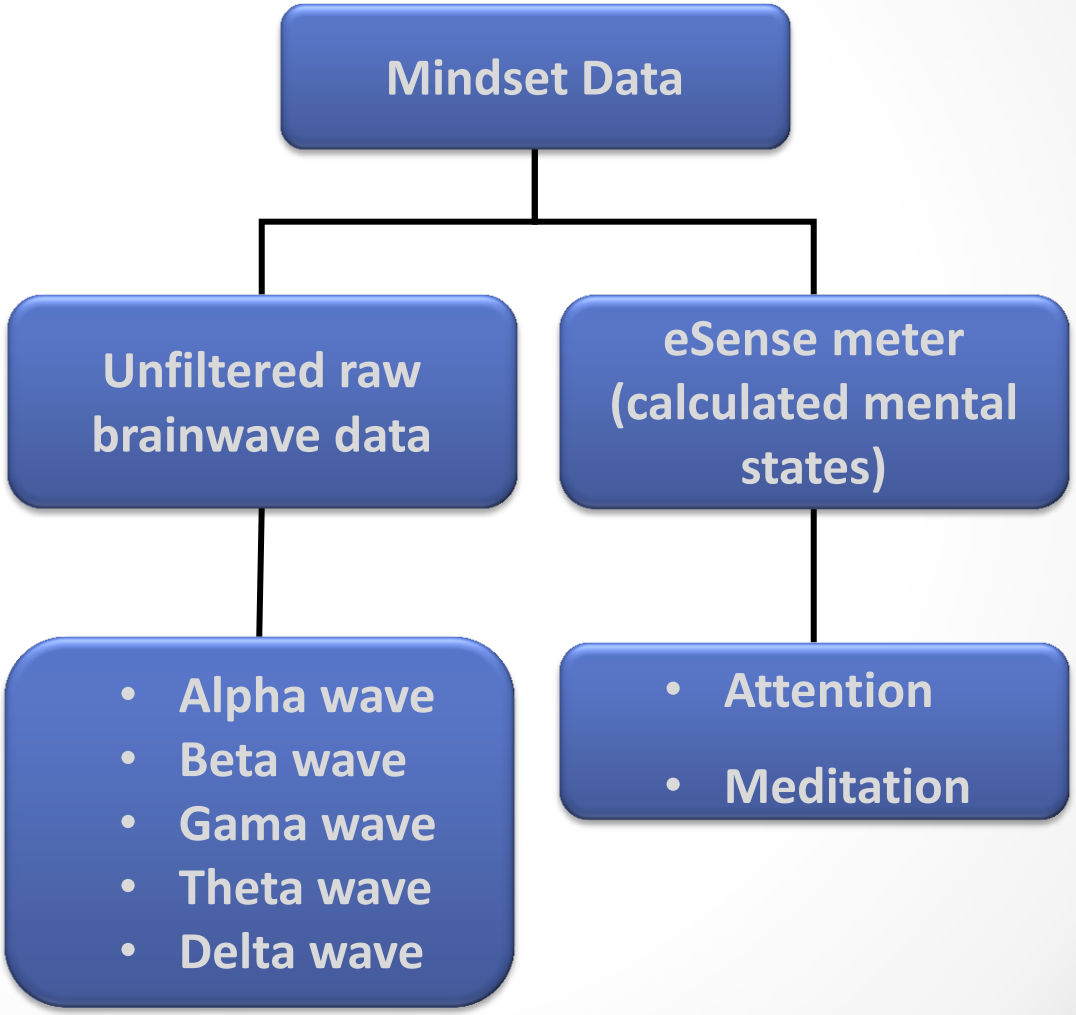
"Analyzes of individual showed the MB provides valid and constant data as expected."

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

Background – What can Mindset Do

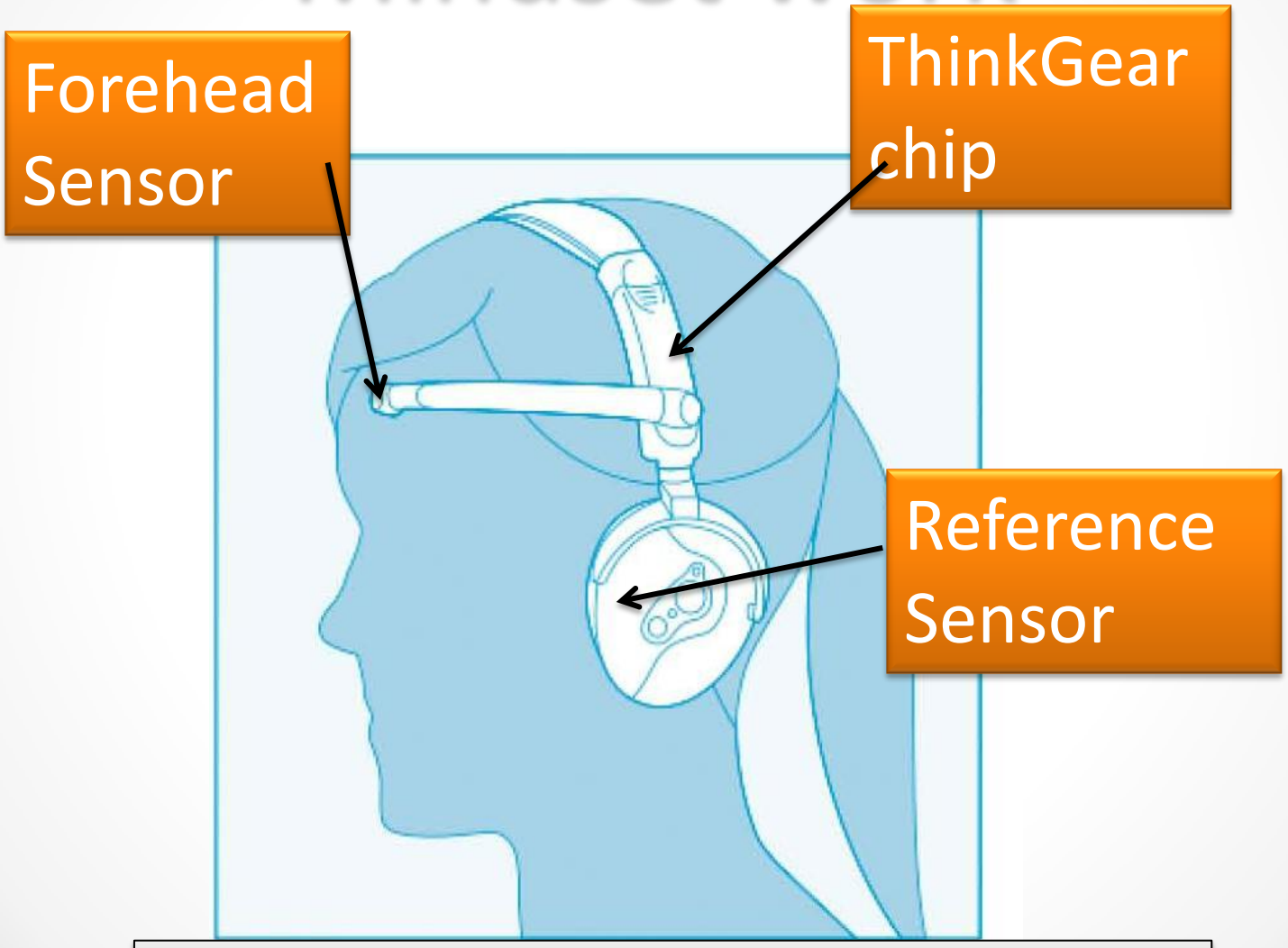
Data Collection using

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

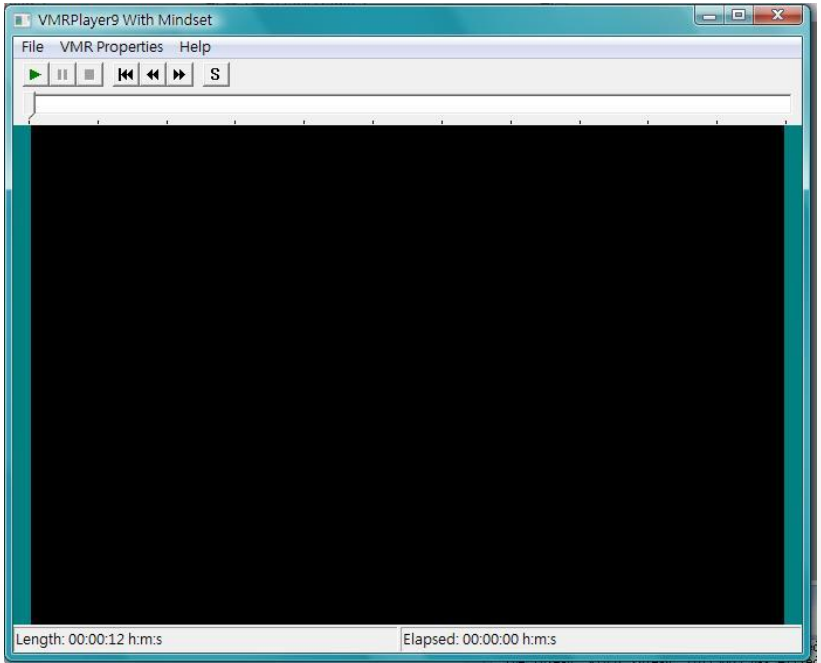
- Hypothesis

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

Experiment on eSense - Methodology

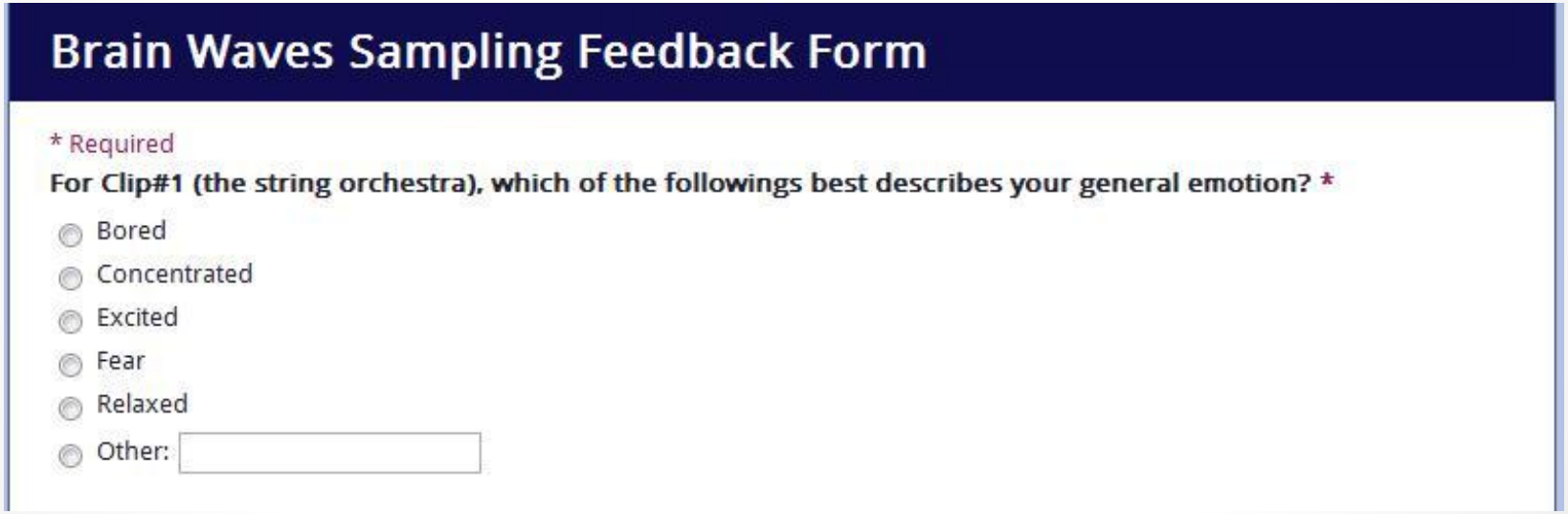
- **Collect the brainwave data while:**
  - Playing movies
  - Synchronizing with the movie

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

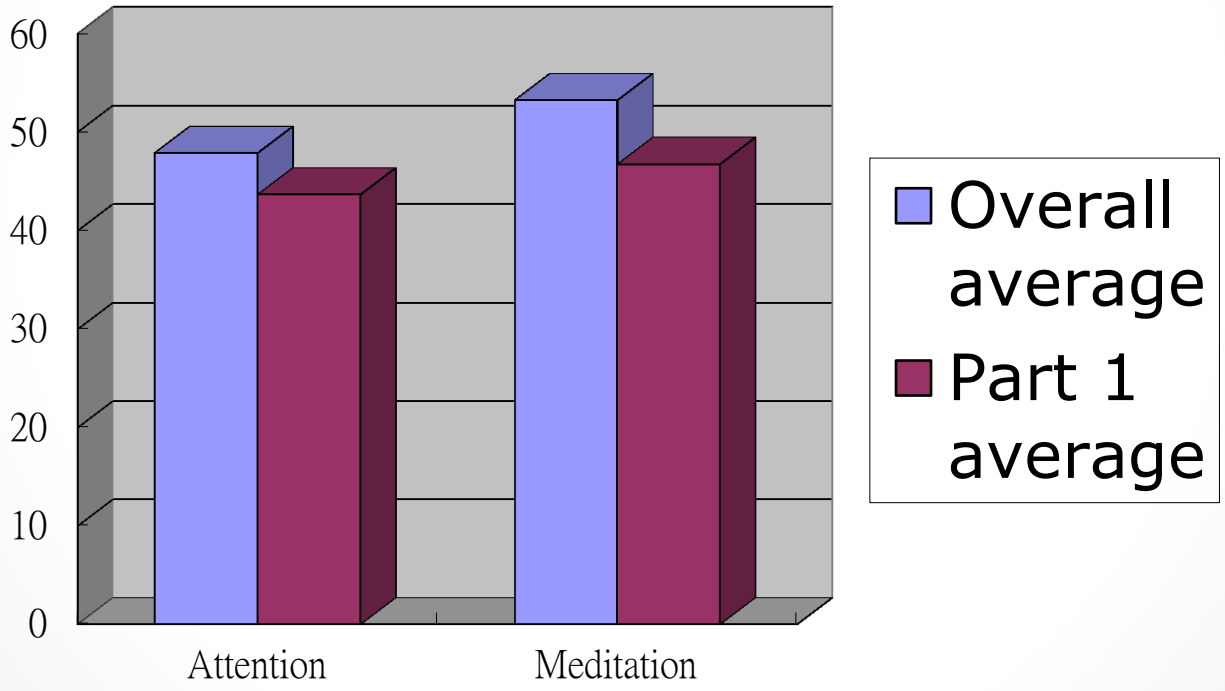
- **18 Participants**
  - 16 males
  - 2 females
- **Age:**
  - Around 20 years old

Experiment on eSense - Movie

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

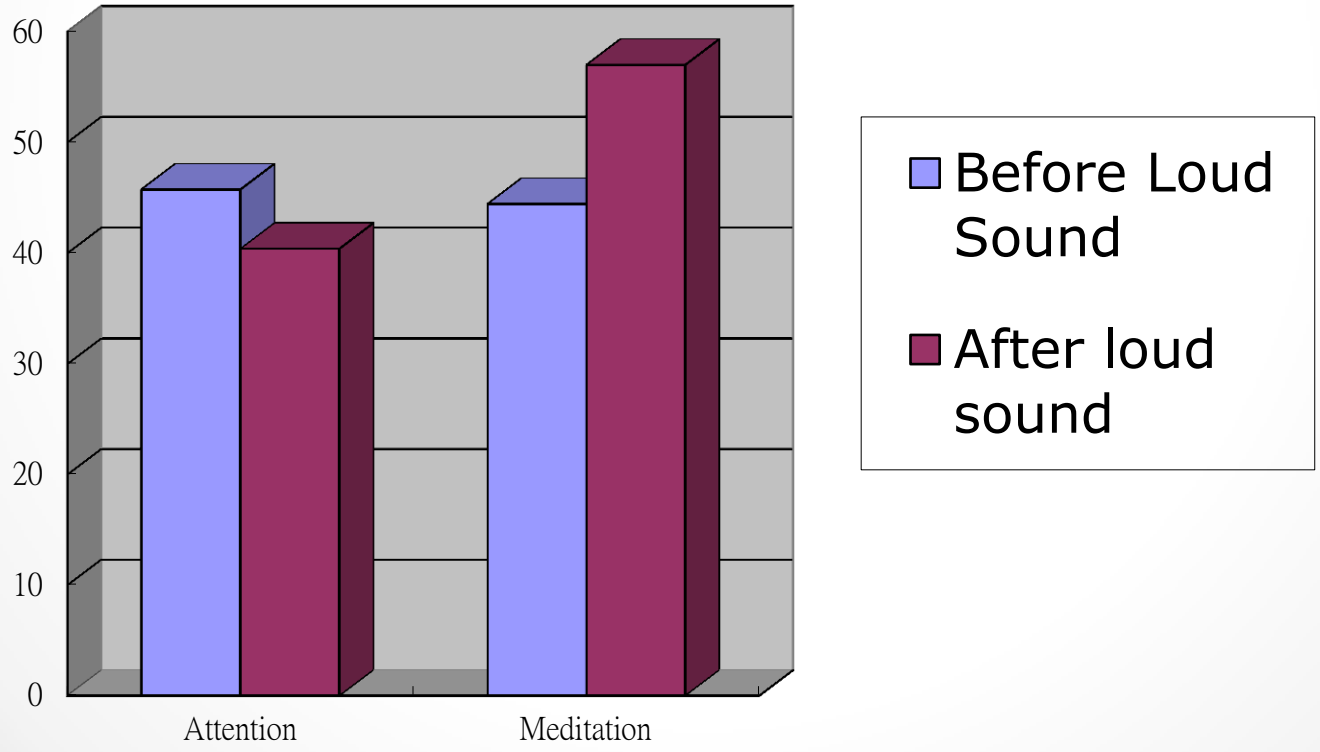
Relaxed Participants

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”

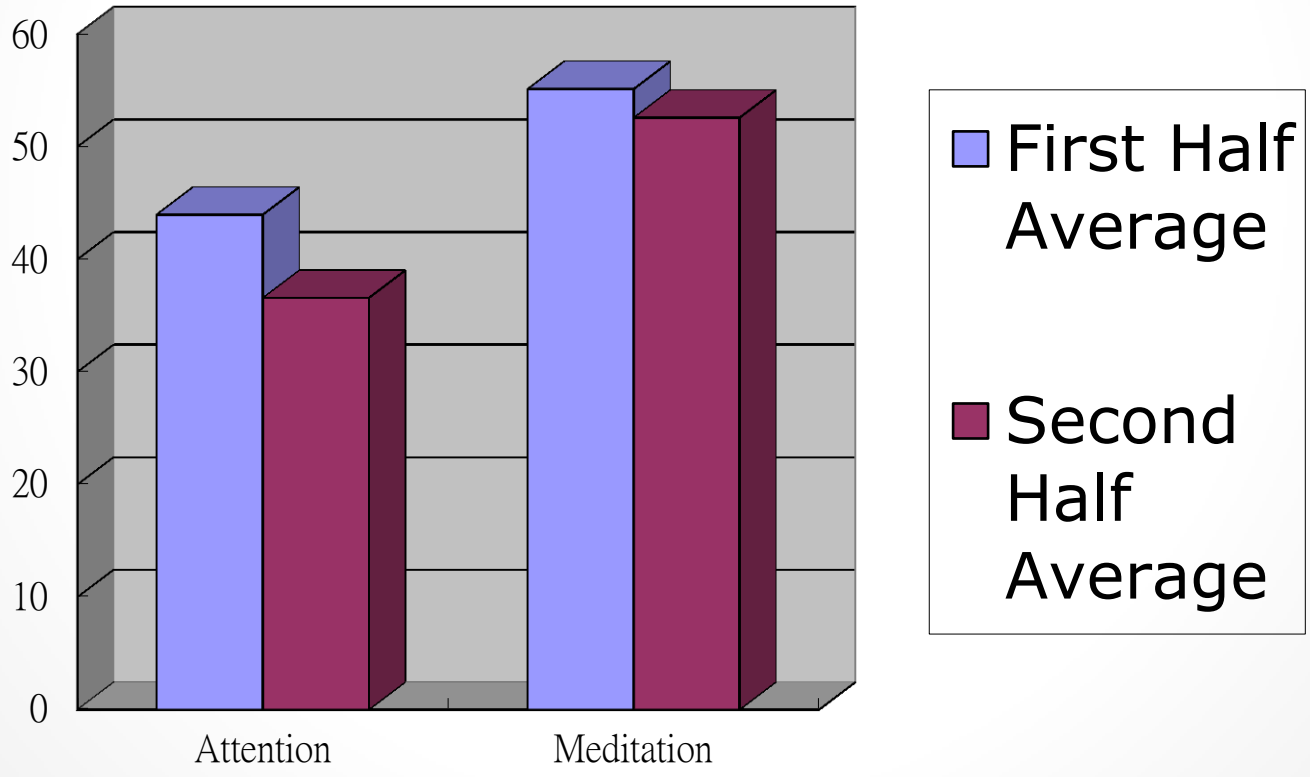
The meditation also did not reflect the change of mental states.

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

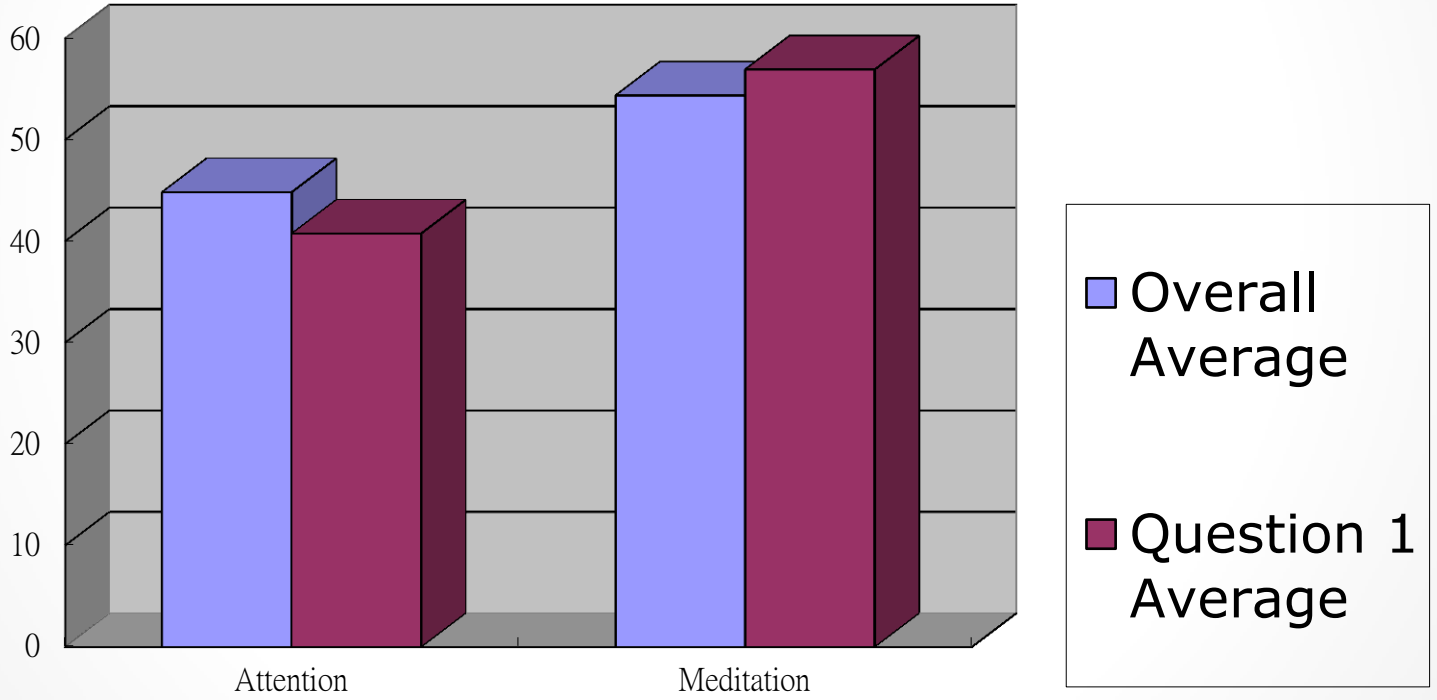
Part 3: Don’t stare at bikini clip 1

This box grows in the movie

Bikini and growing brown box

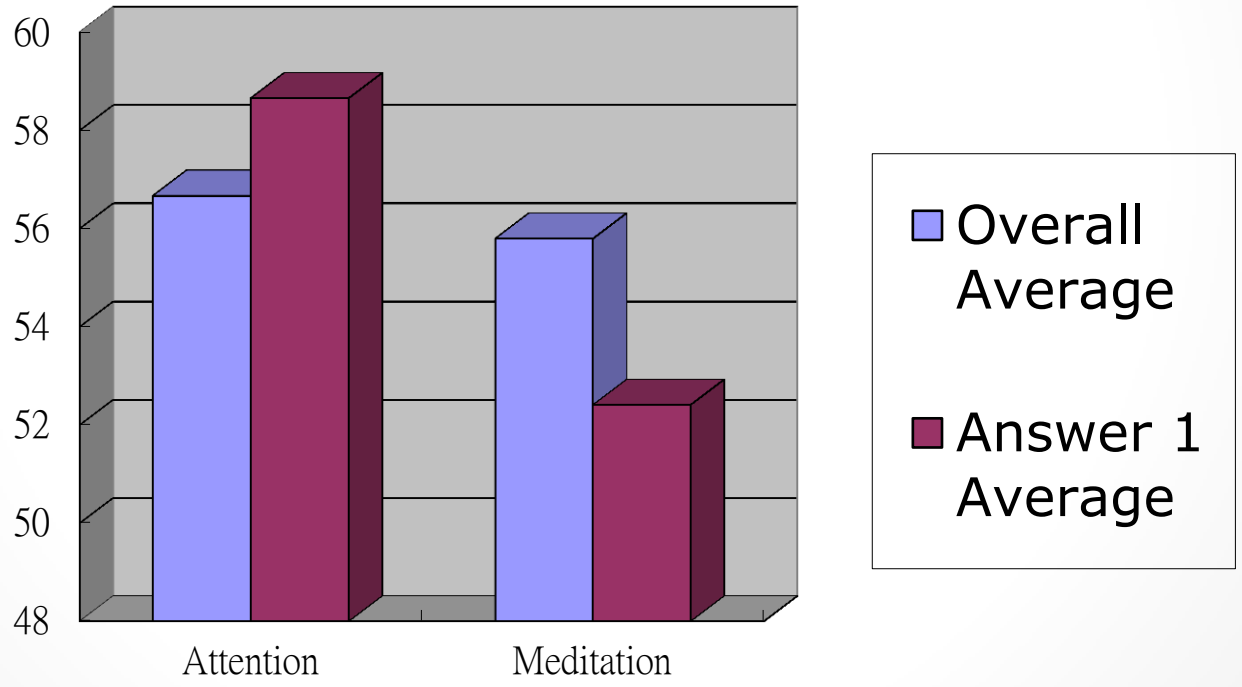
Concentrated Participants – Question 1

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

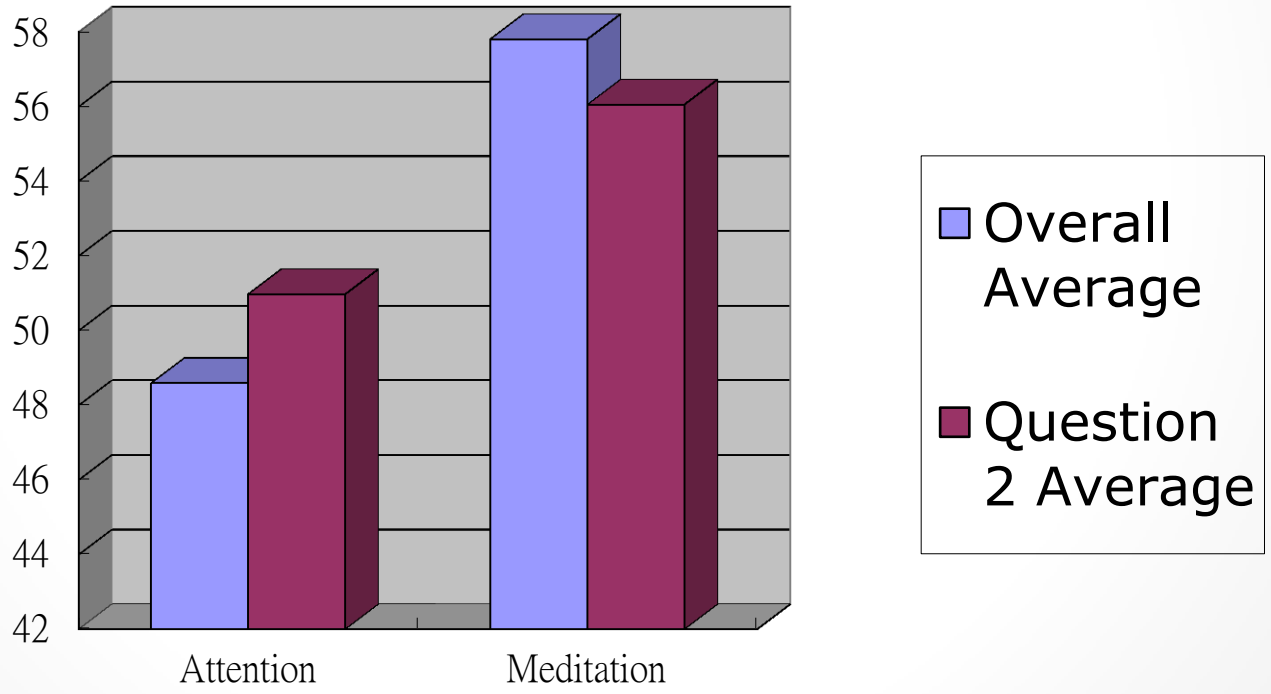
Part 3: Don’t stare at bikini clip 2

The tires expands inward

Bikini and the expanding tires

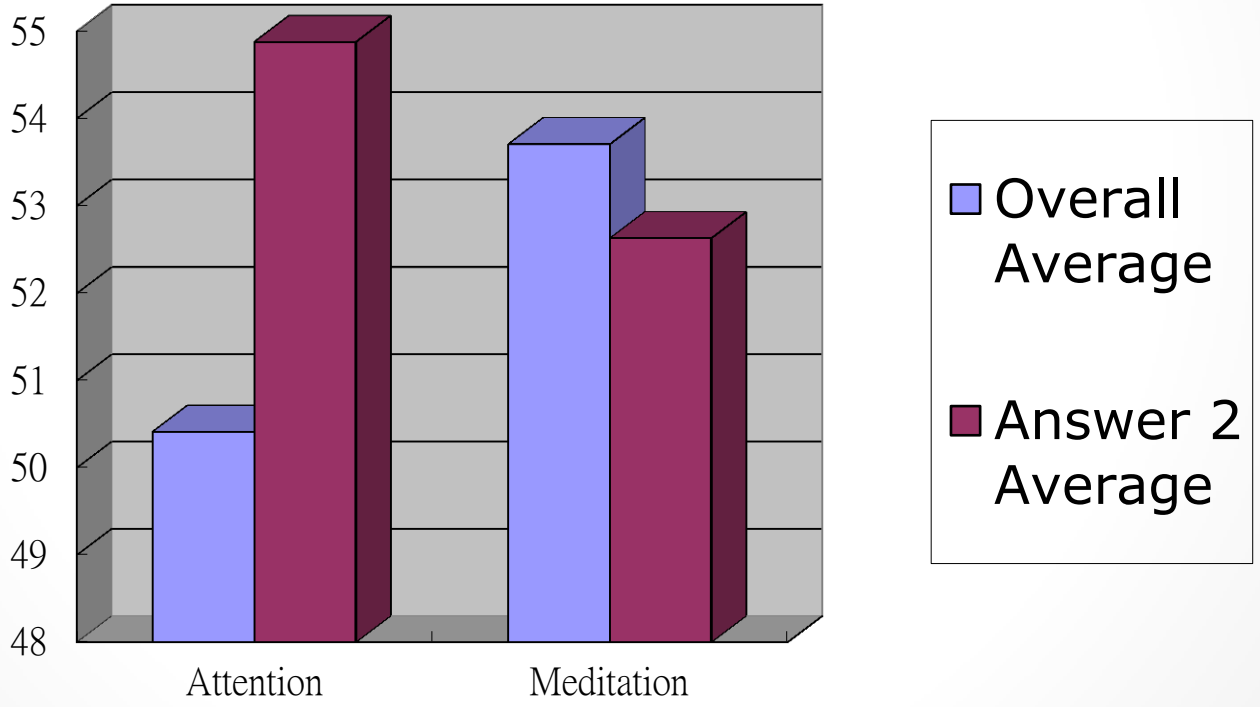
Concentrated Participants – Question 2

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

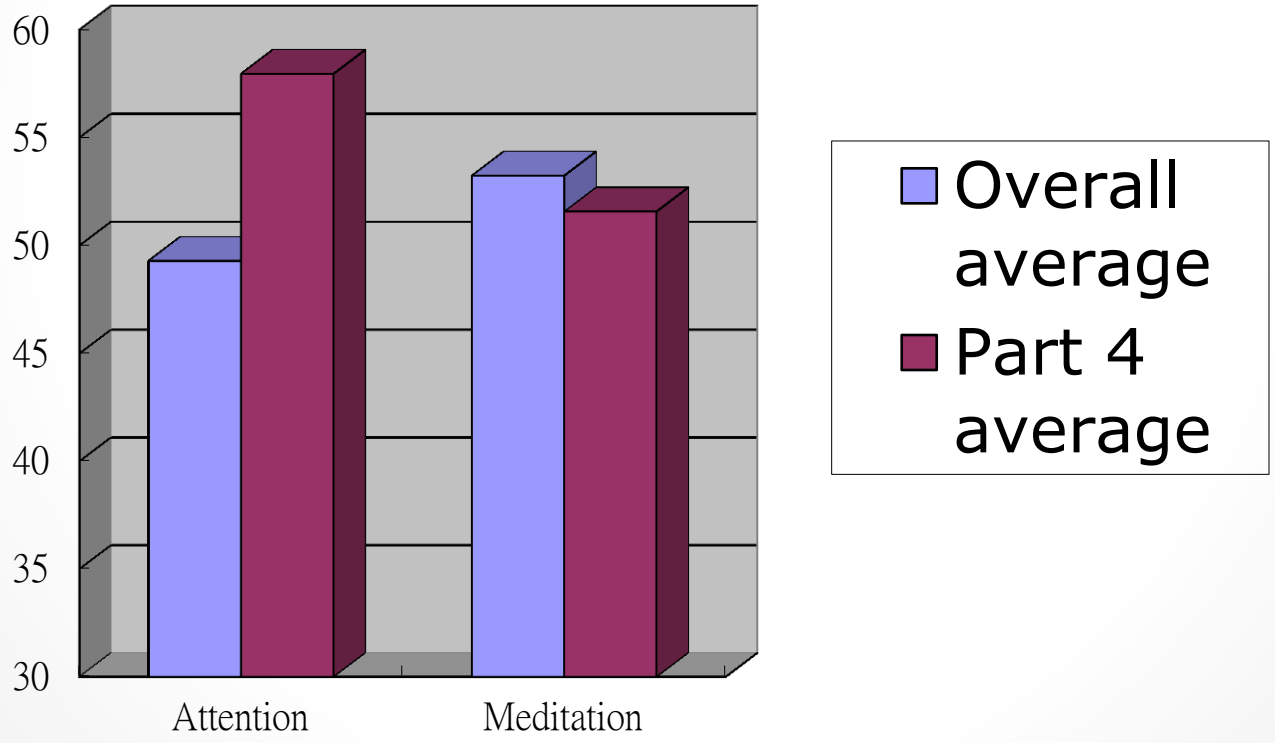
Part 4: Ghost Pop-Up

Video clip before the ghost pop-up

The Ghost

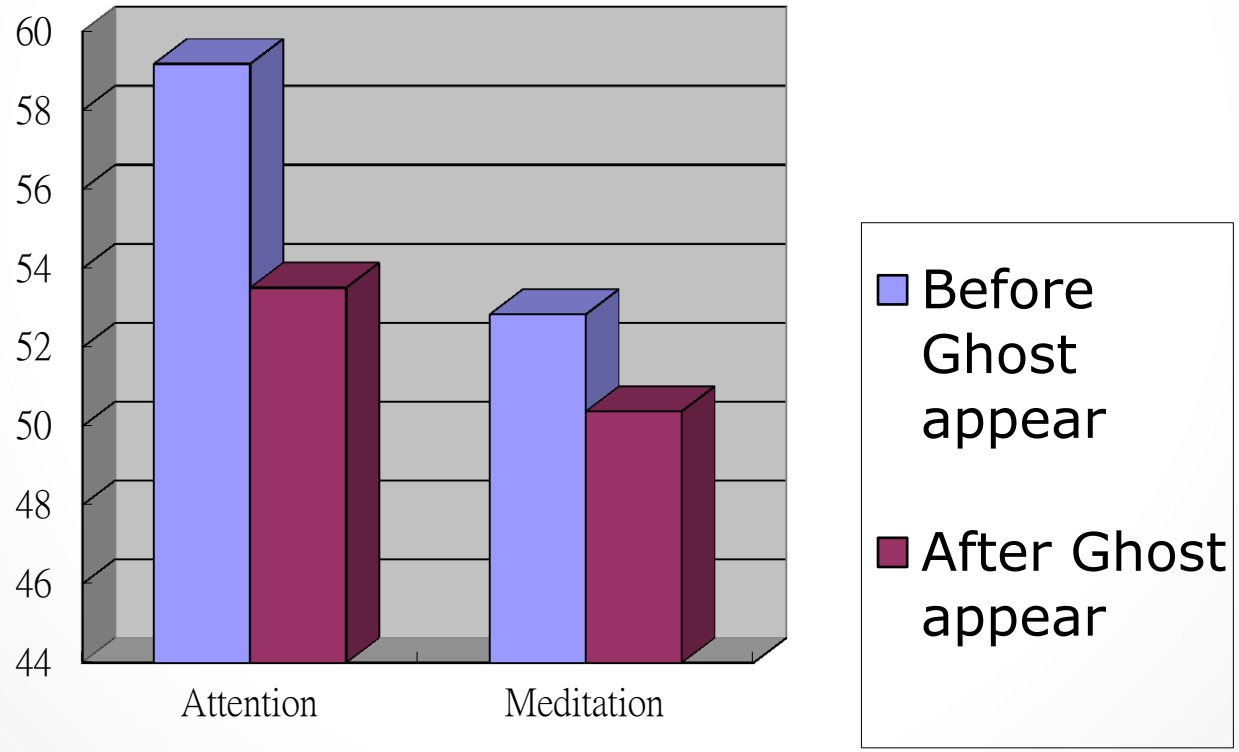
Aware of Ghost

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”

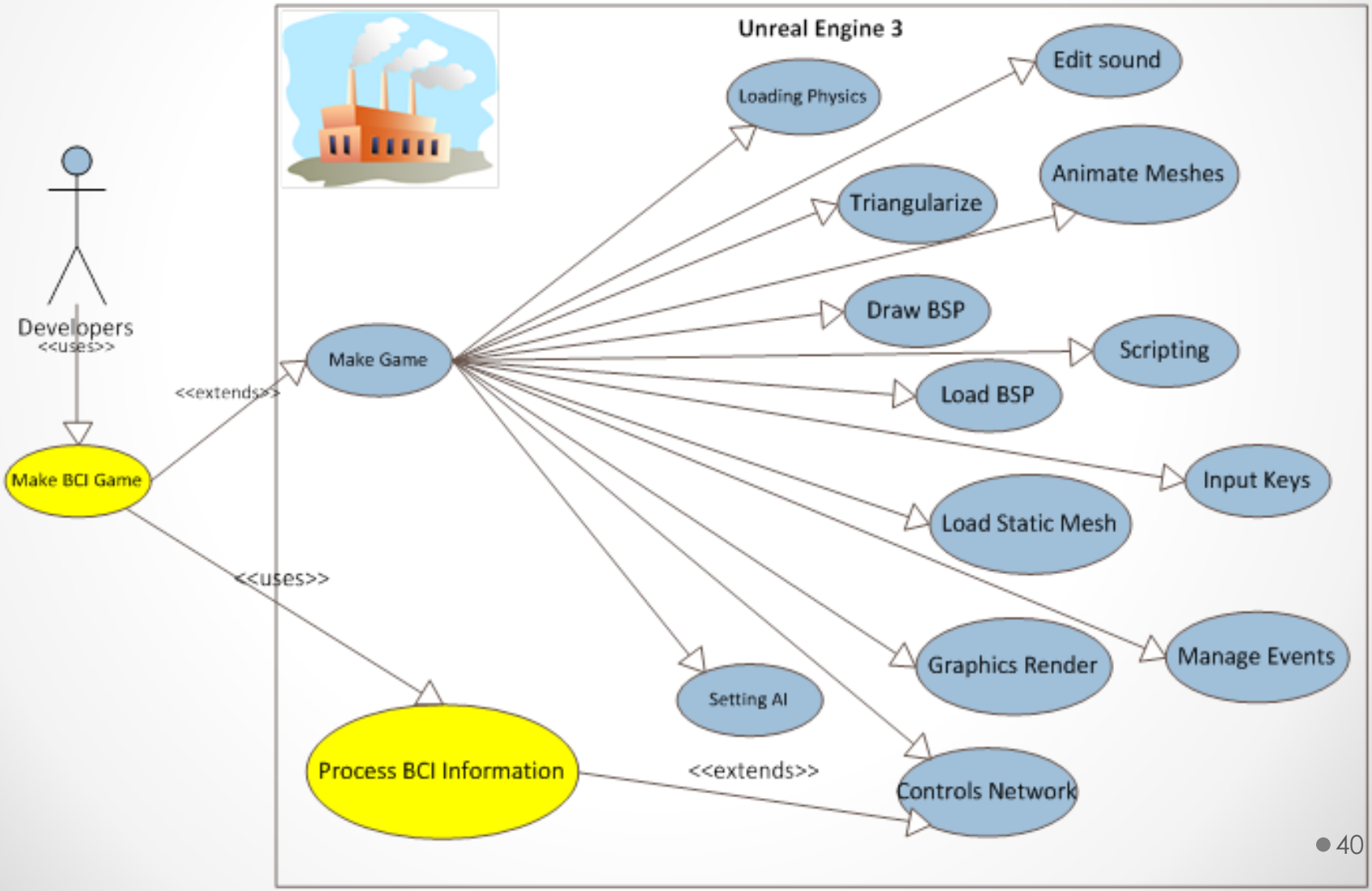
The relation between meditation value and mental states **is not conclusive**

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

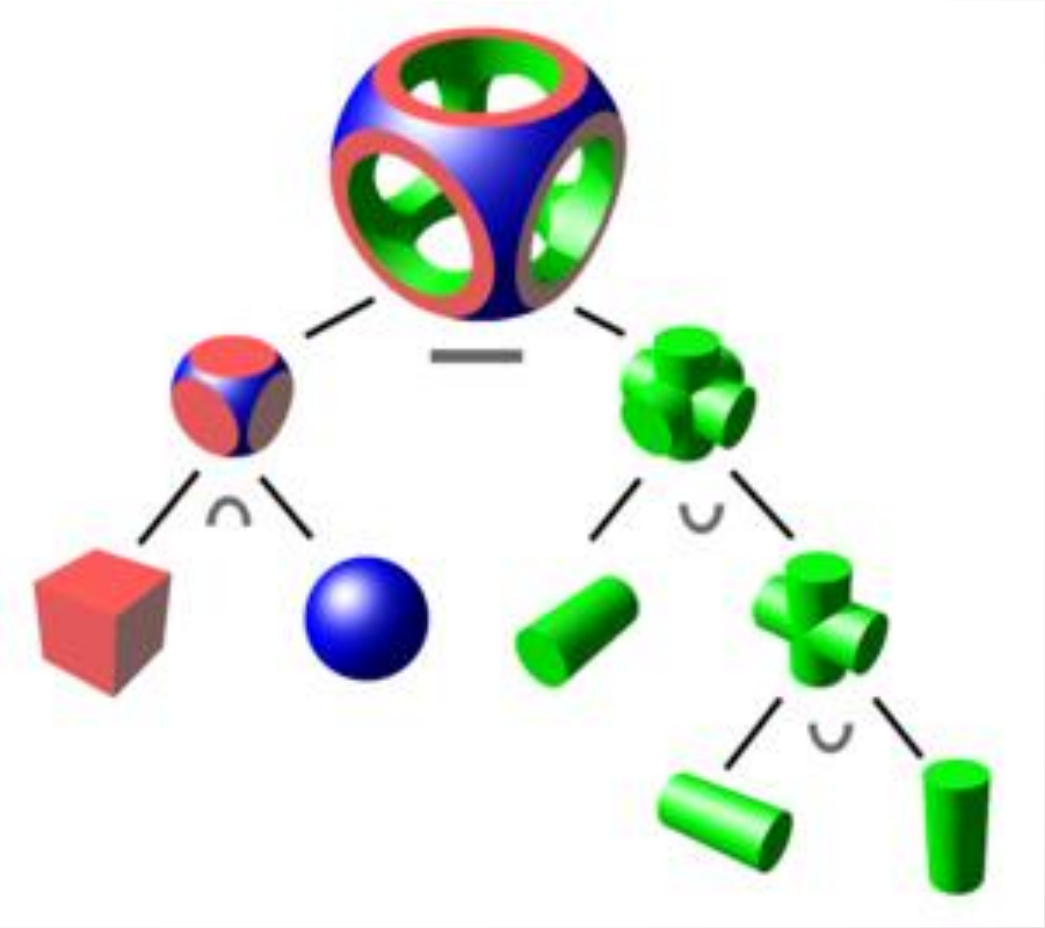
Why UDK?

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

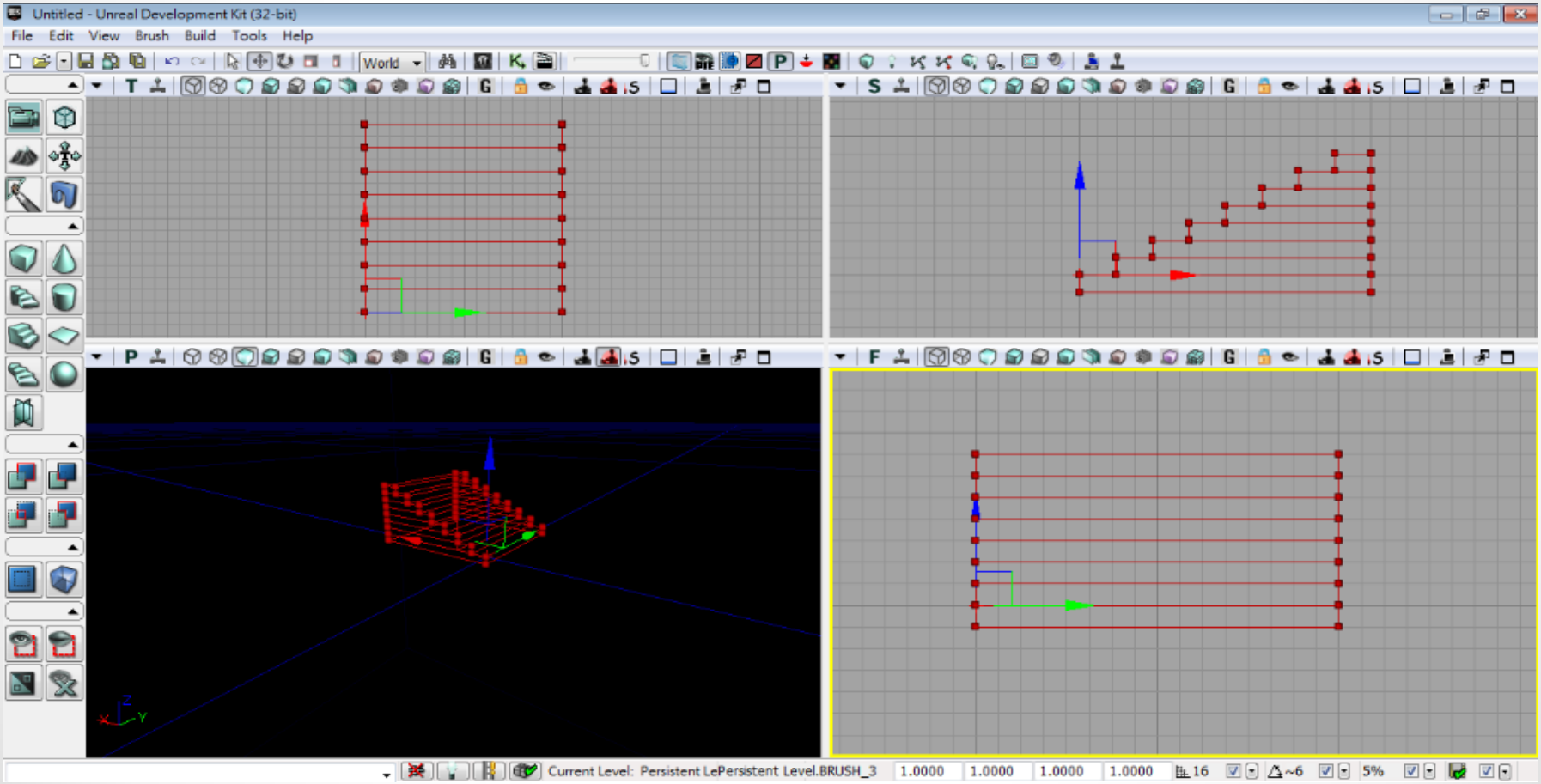
"Number 1 Game Engine"
Develop-online.net

Game Creation in UDK

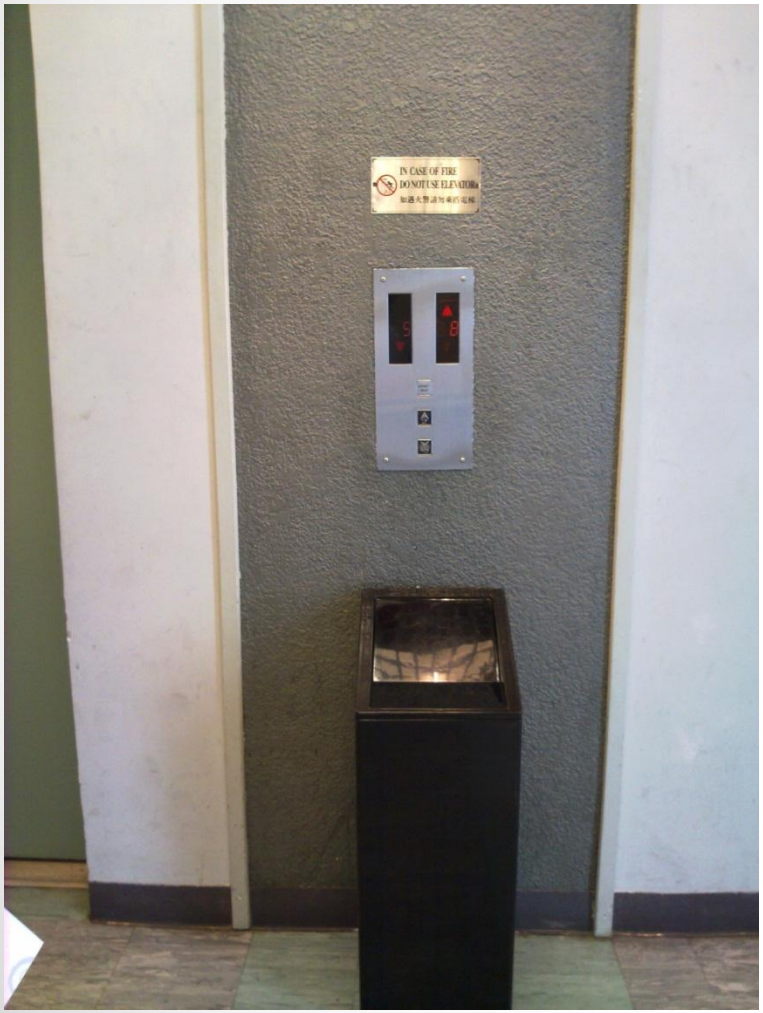
- Constructive Solid Geometry (CSG)



Game Creation in UDK



Game Creation in UDK

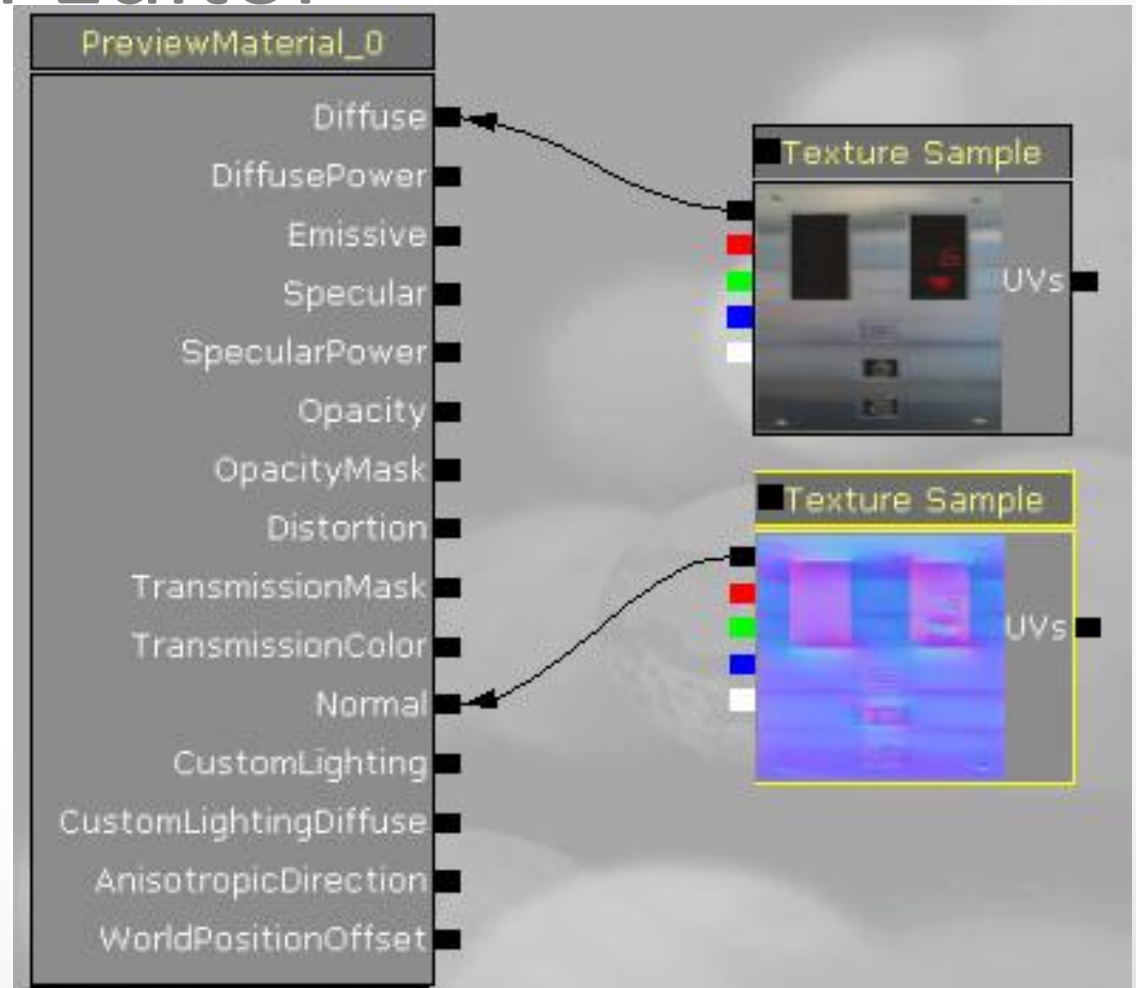


CrazyBump

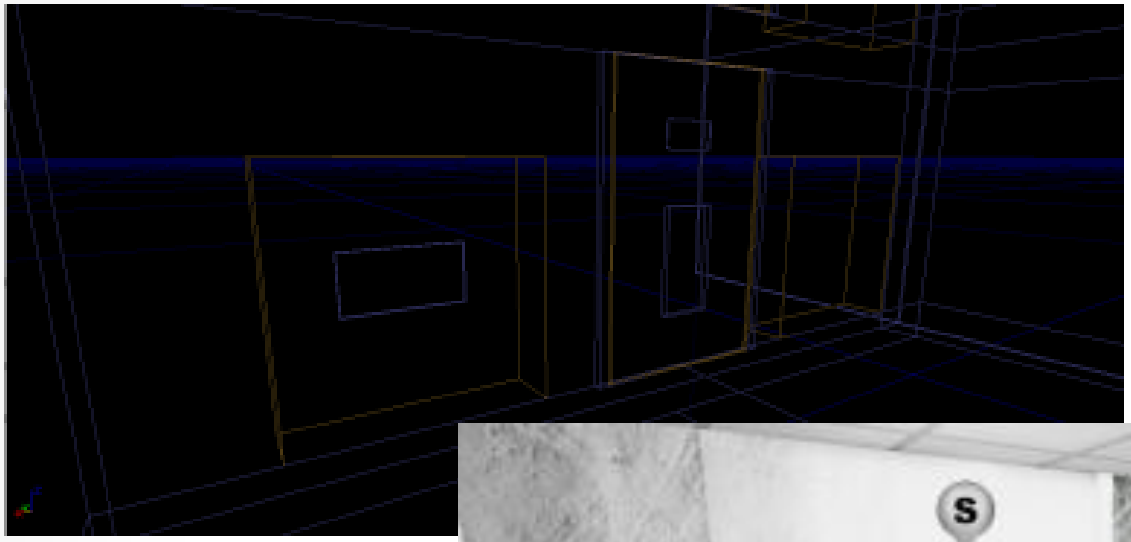
AND
Photo Editor

Game Creation in UDK

- Material Editor

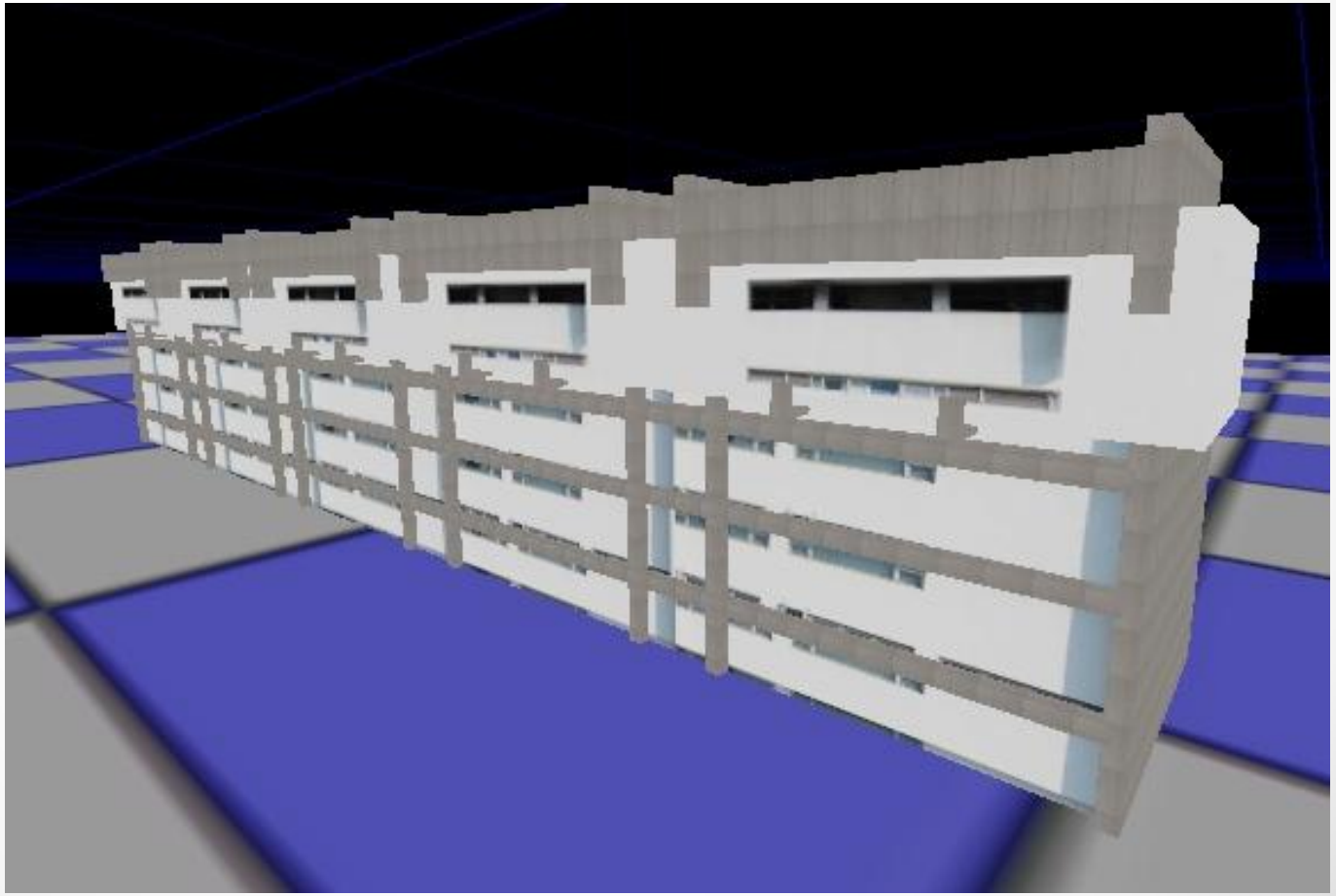


Game Creation in UDK

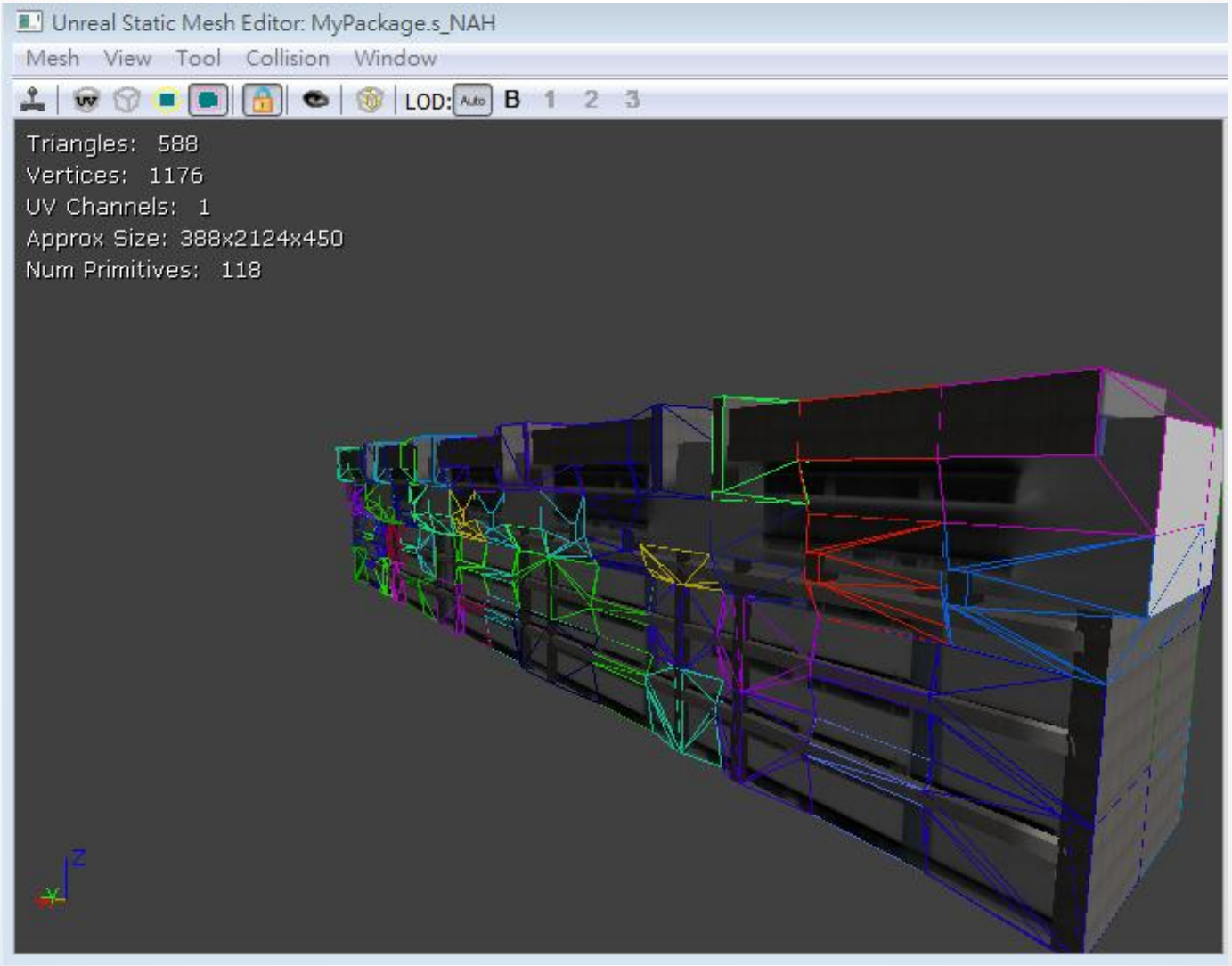


Game Creation in UDK

- Static Mesh

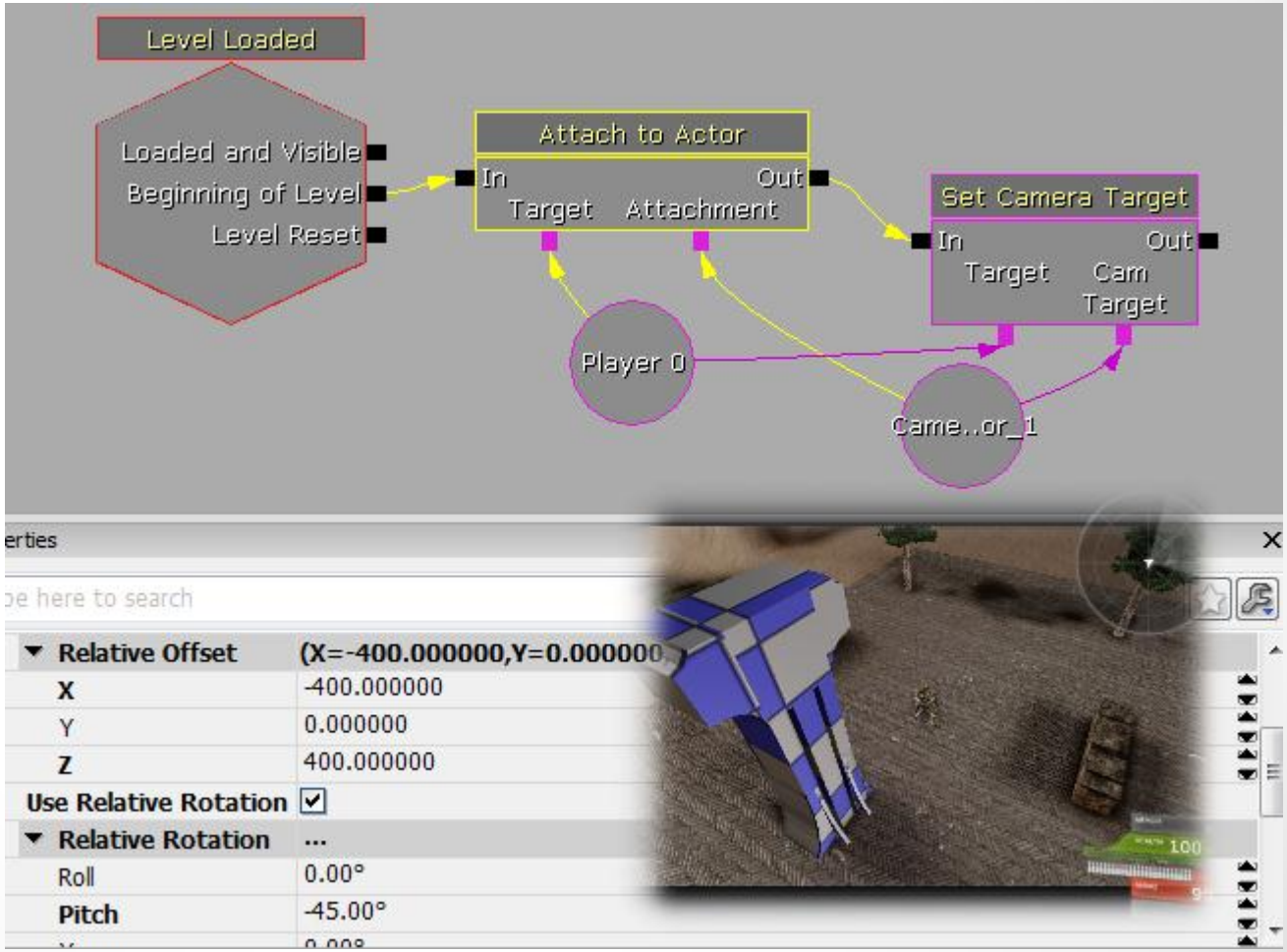


Game Creation in UDK



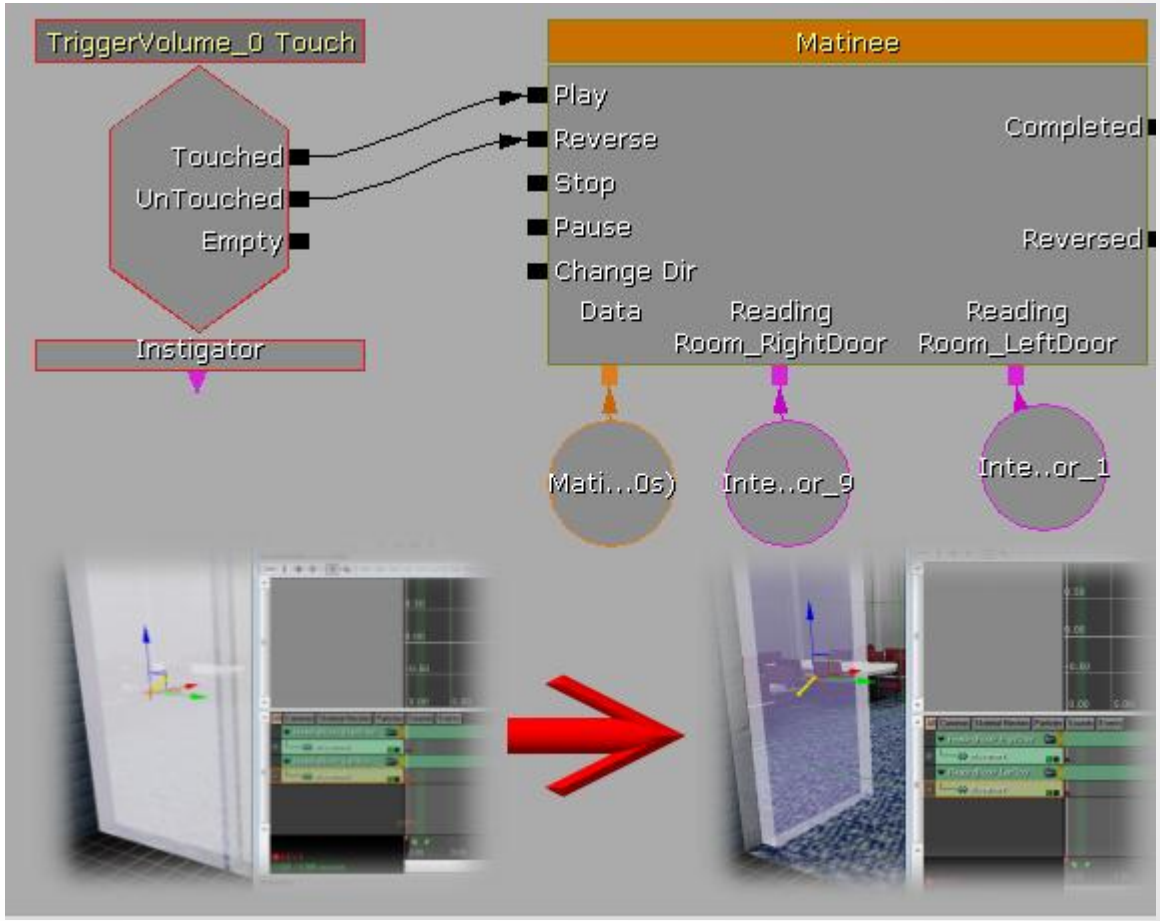
Game Creation in UDK

- Kismet



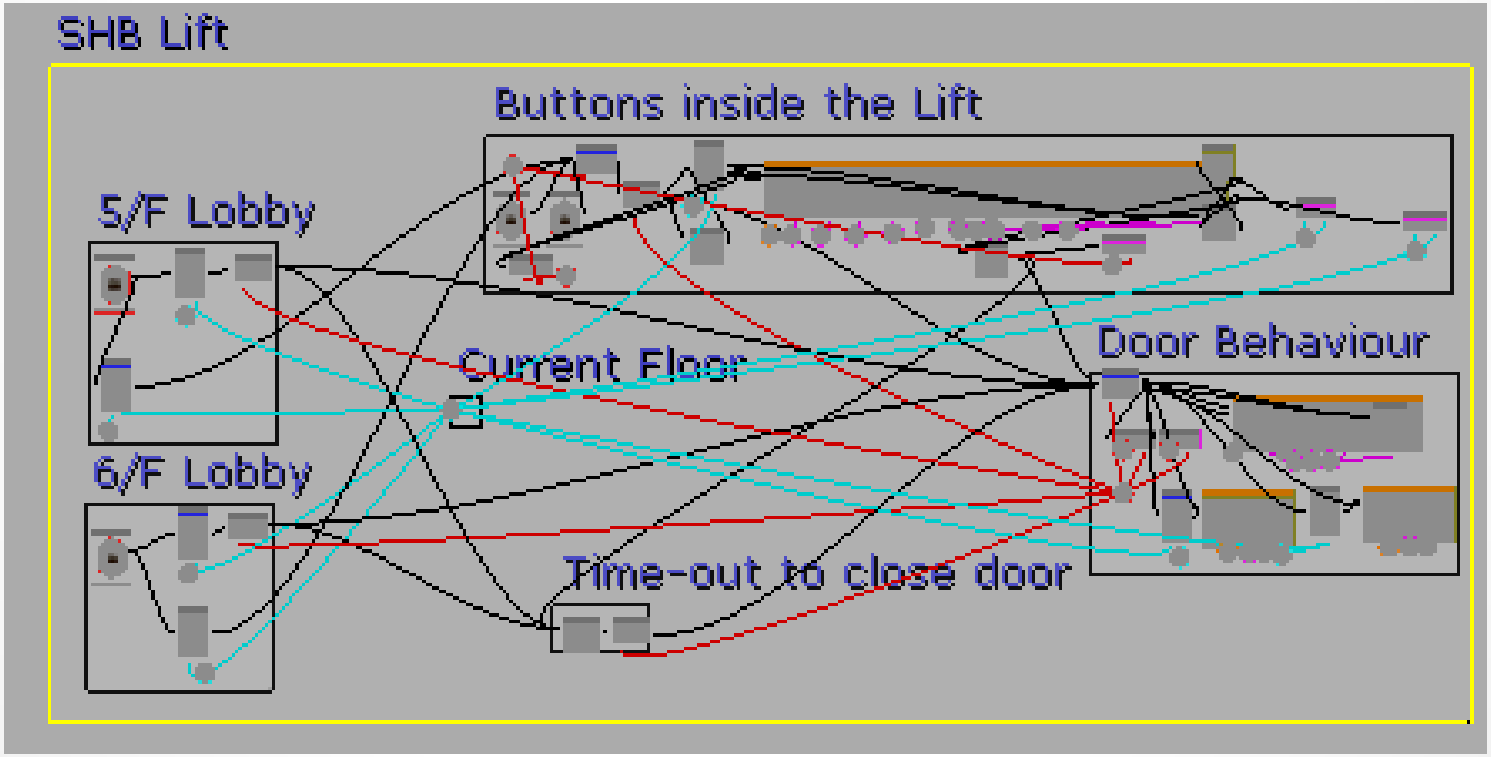
Game Creation in UDK

- Kismet With Matinee



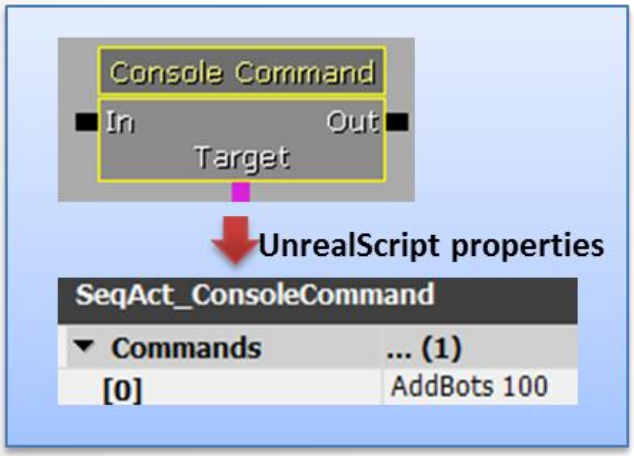
Game Creation in UDK

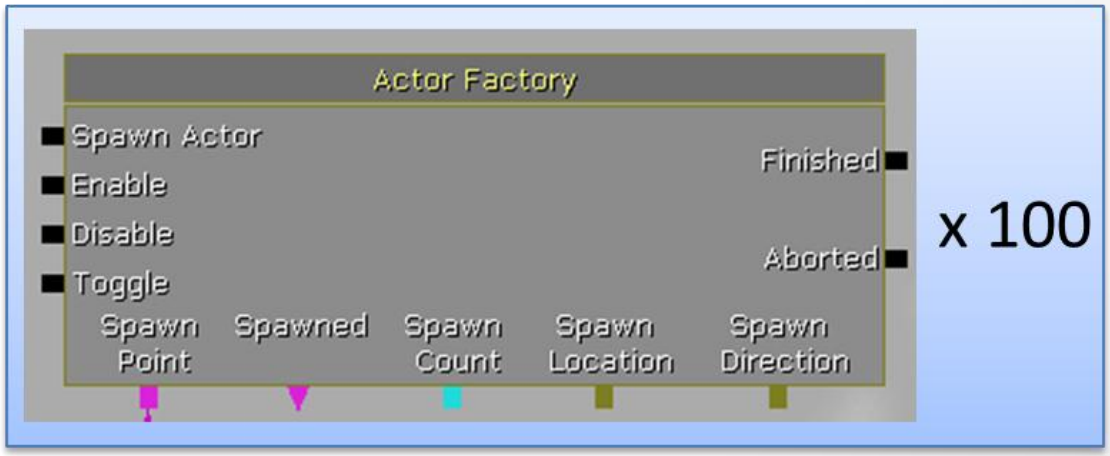
- Drawback of Kismet



Game Creation in UDK

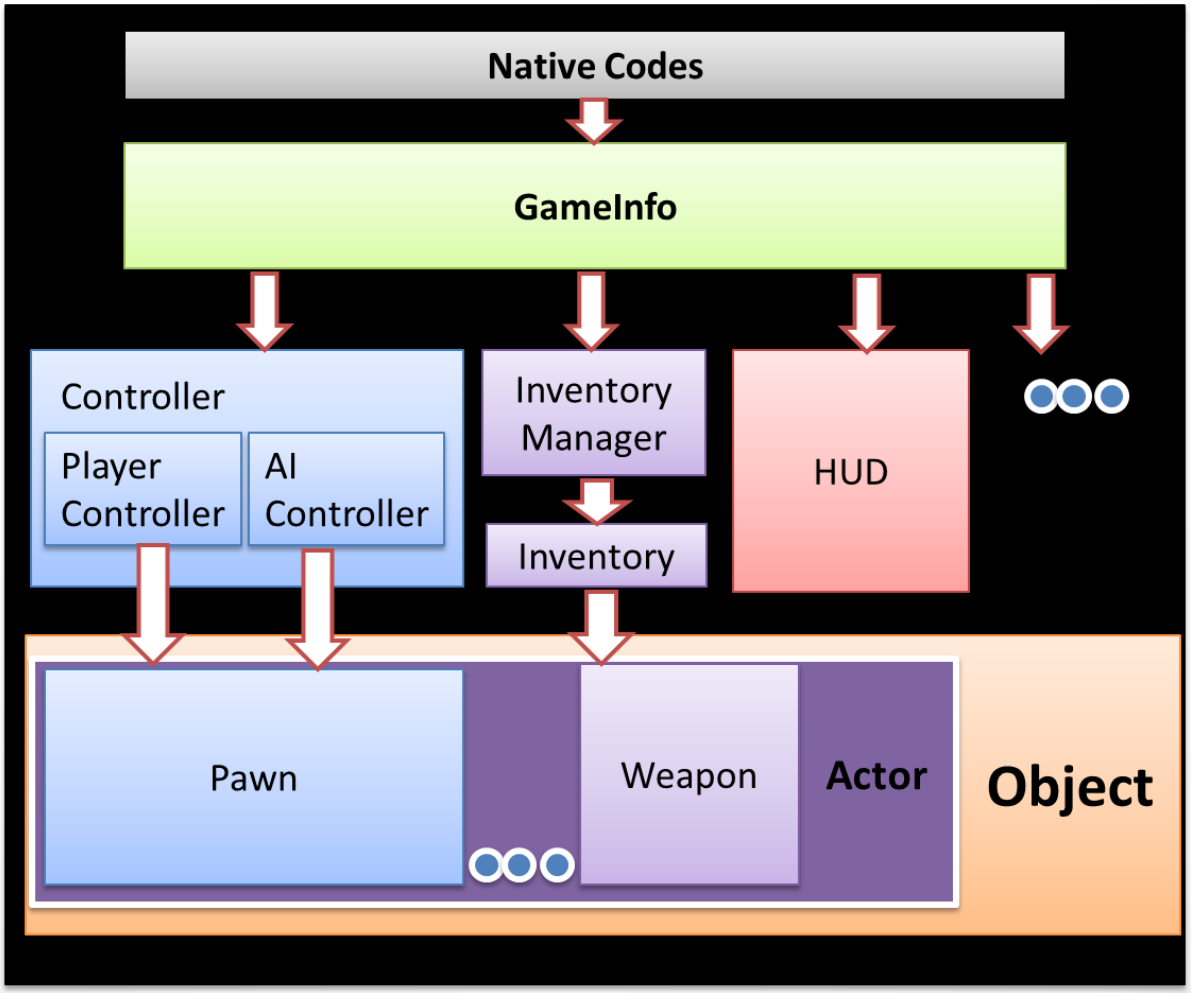
- Solution: UnrealScript



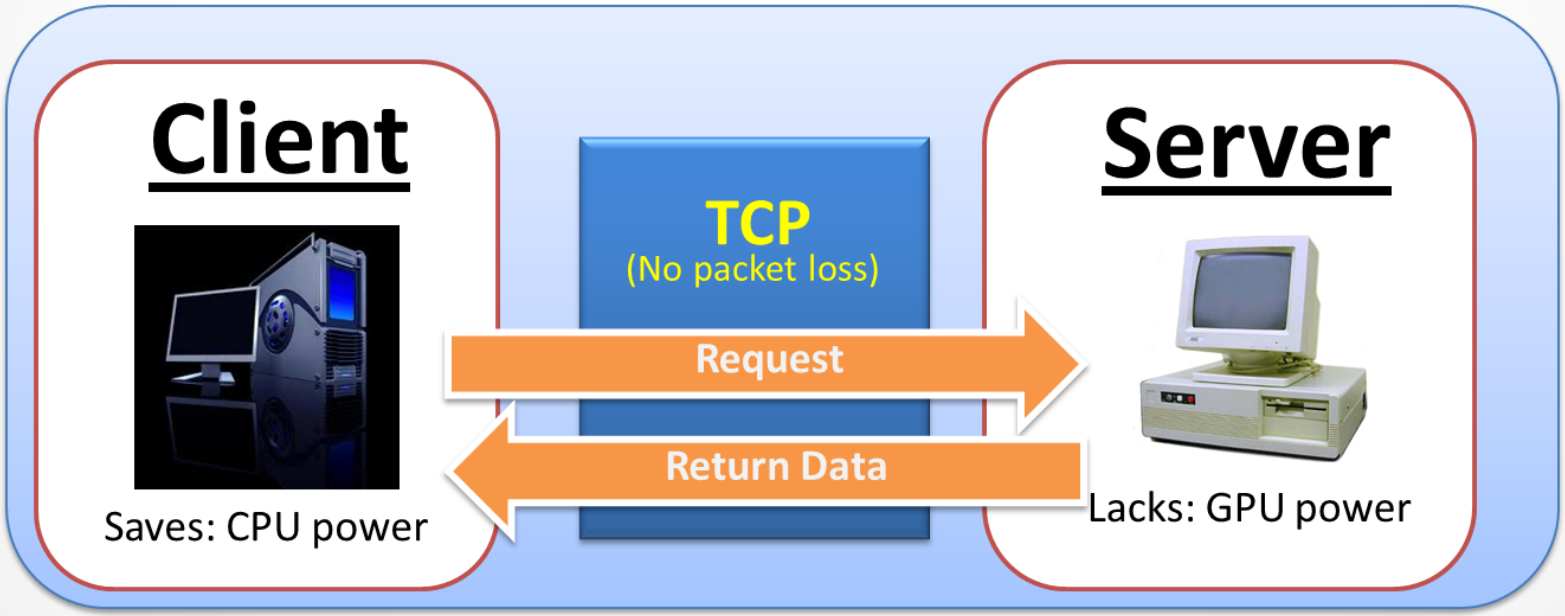


UDK-Mindset Integration

- Abstract view on UnrealScript classes (total >2300)



UDK-Mindset Integration



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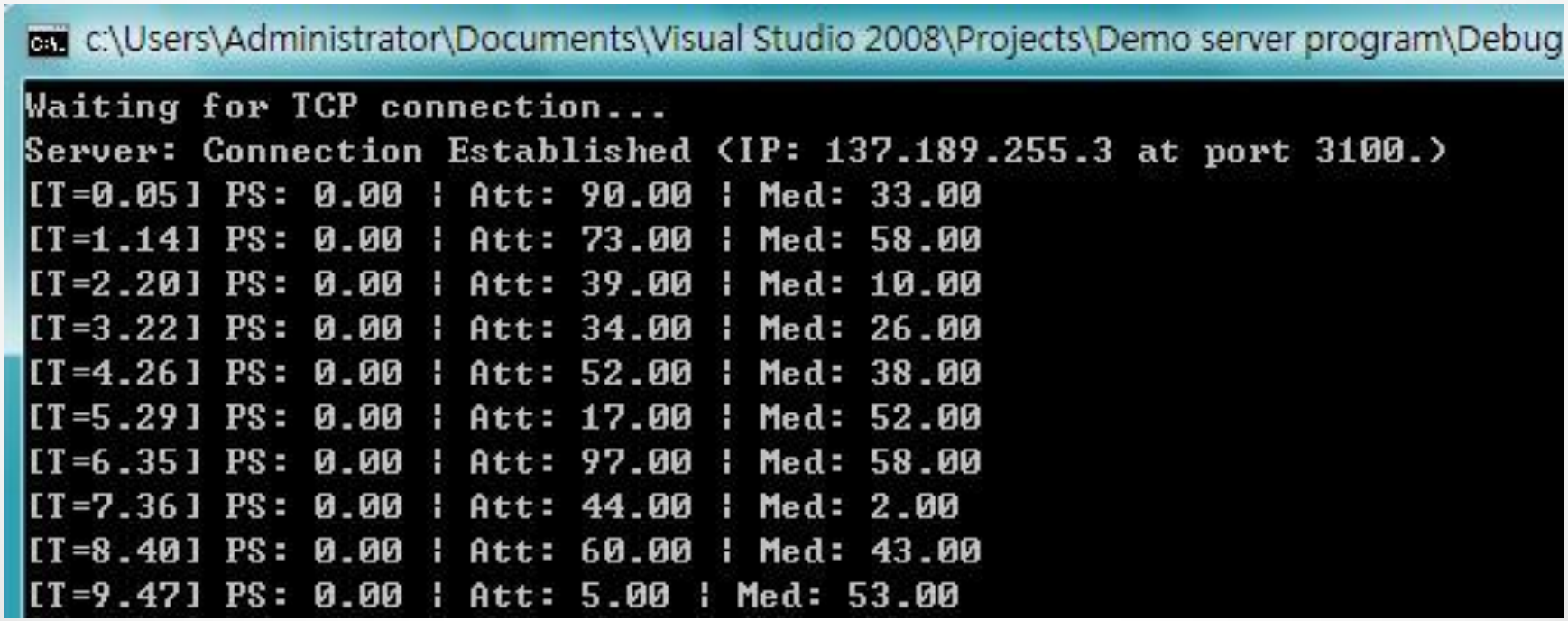

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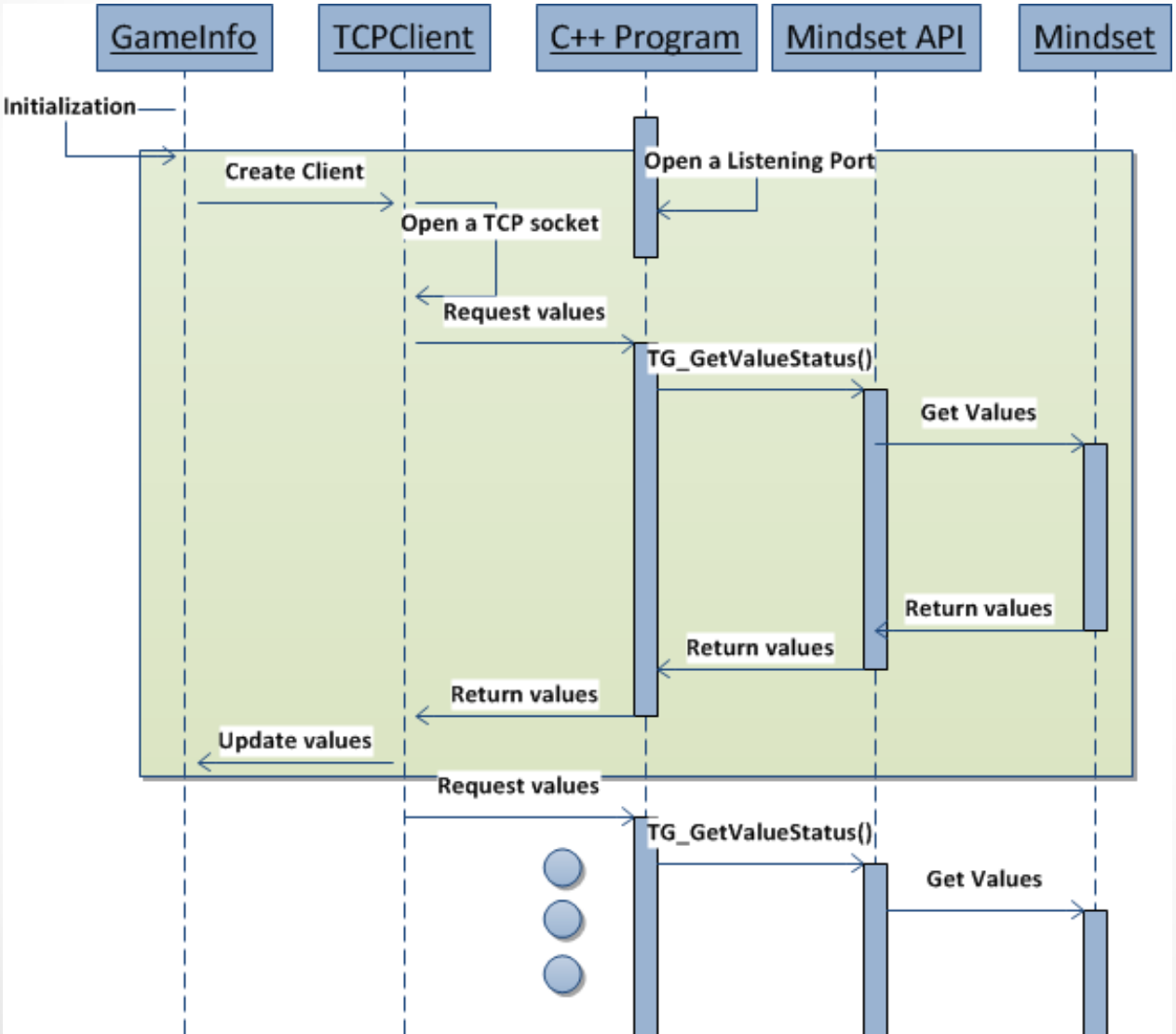
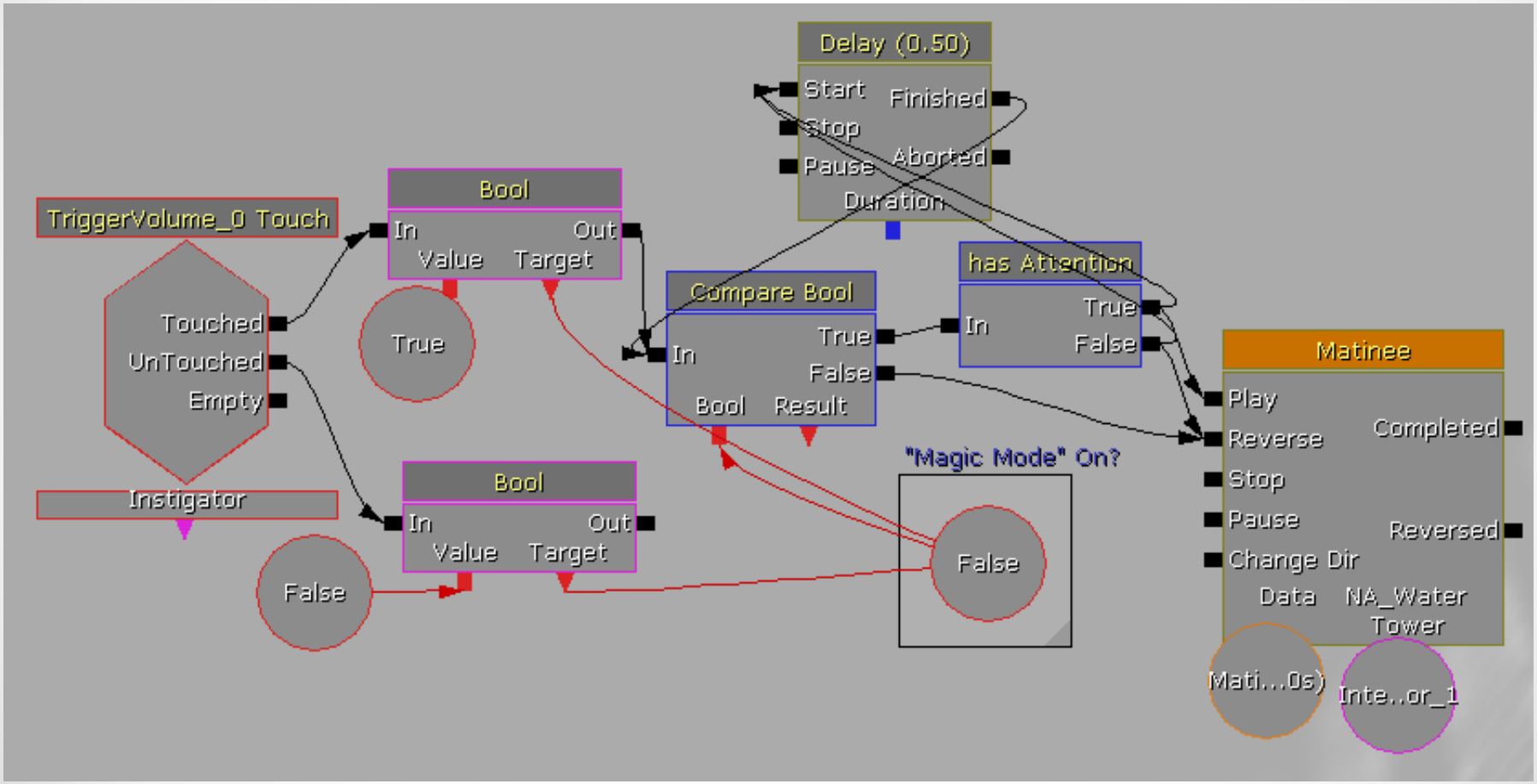
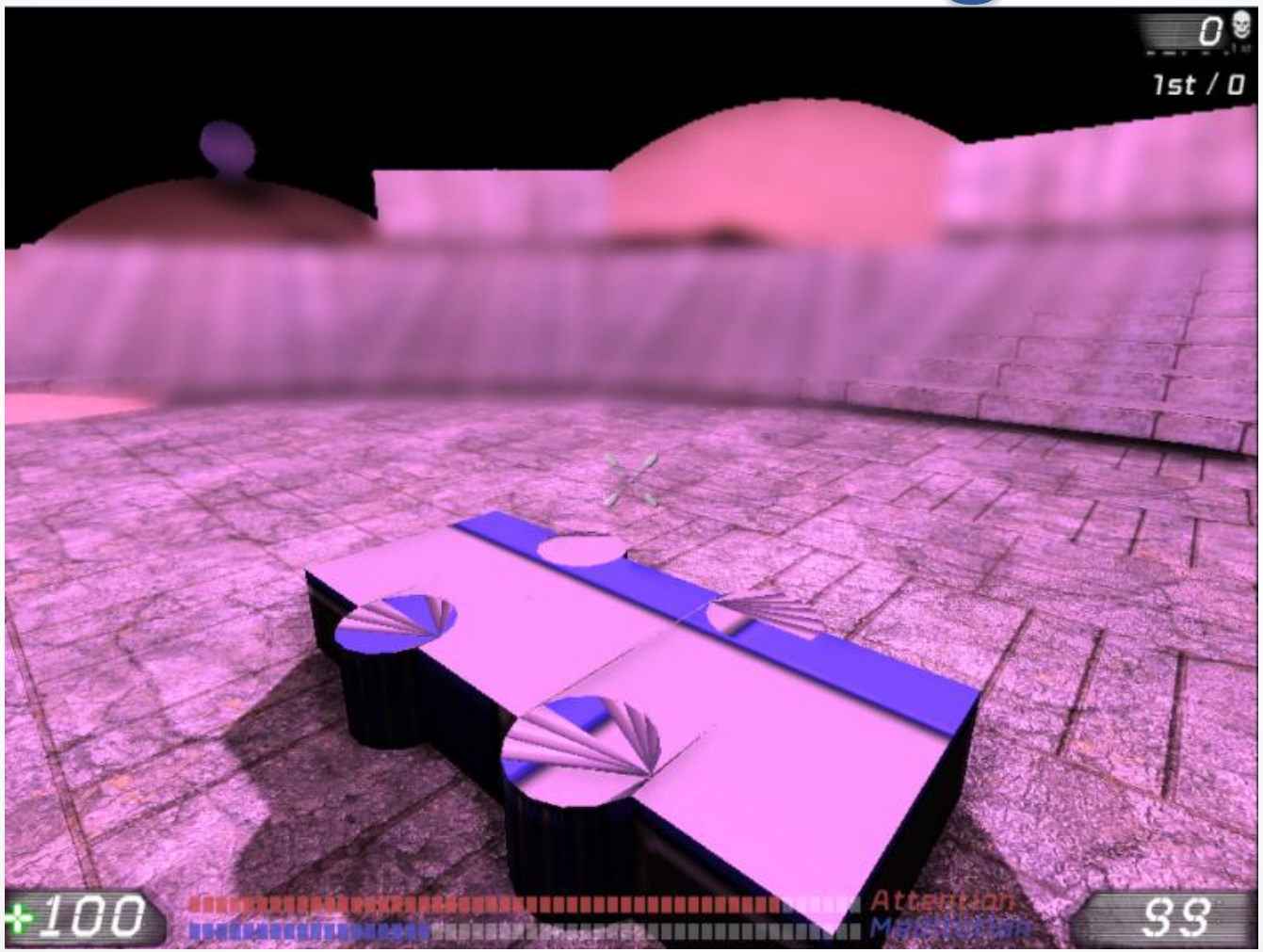


UDK-Mindset Integration

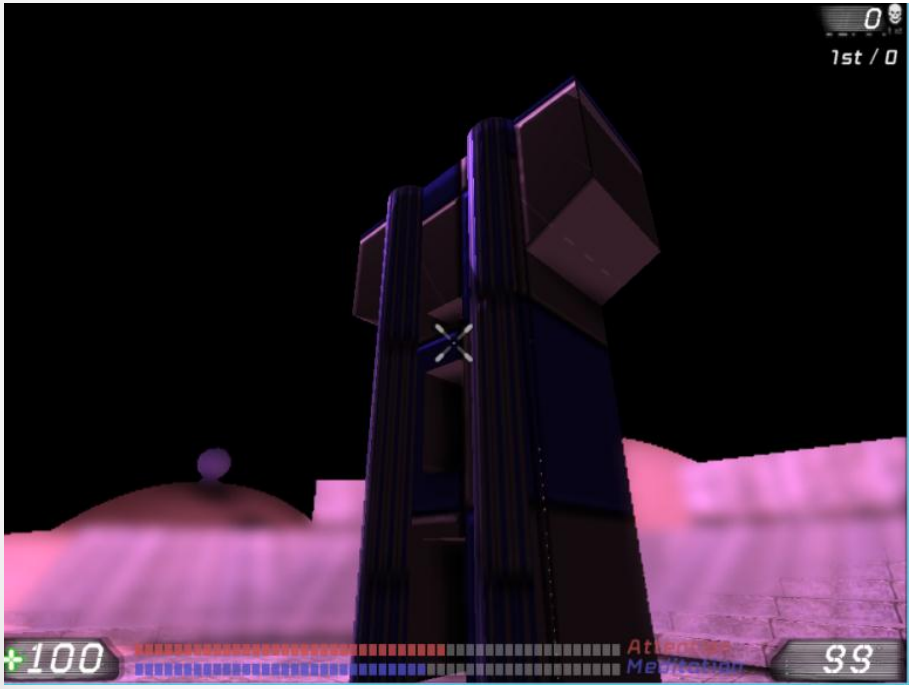


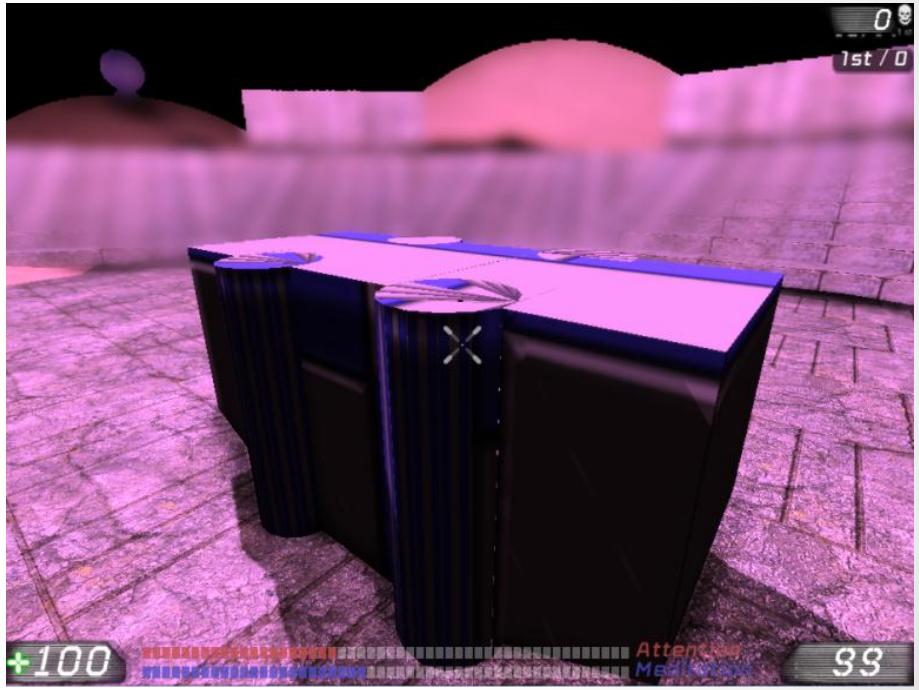
UDK-Mindset Integration

UDK-Mindset Integration



UDK-Mindset Integration



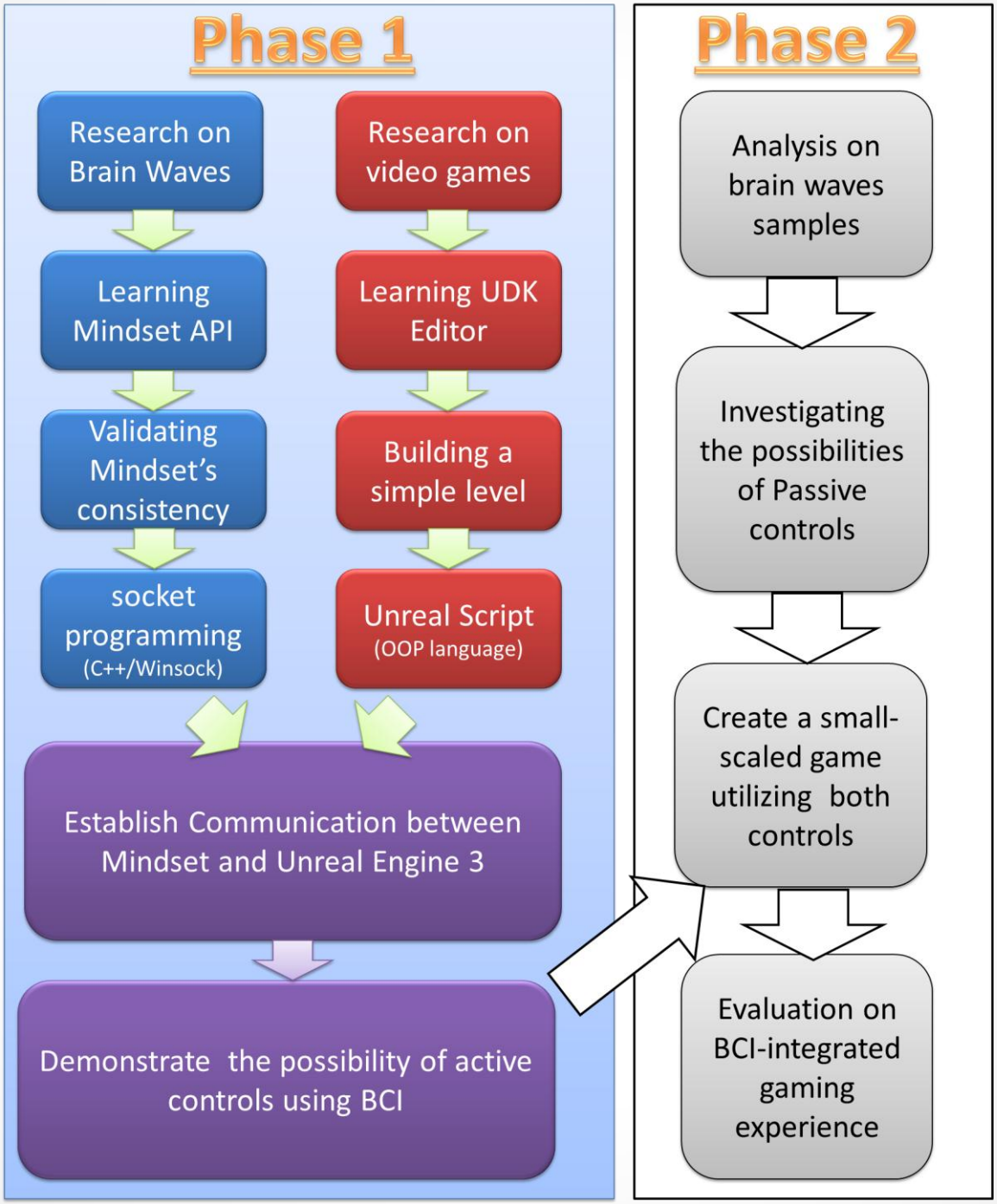


$$S_t = A_{t-1} + \frac{A_t - A_{t-1}}{T}$$

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

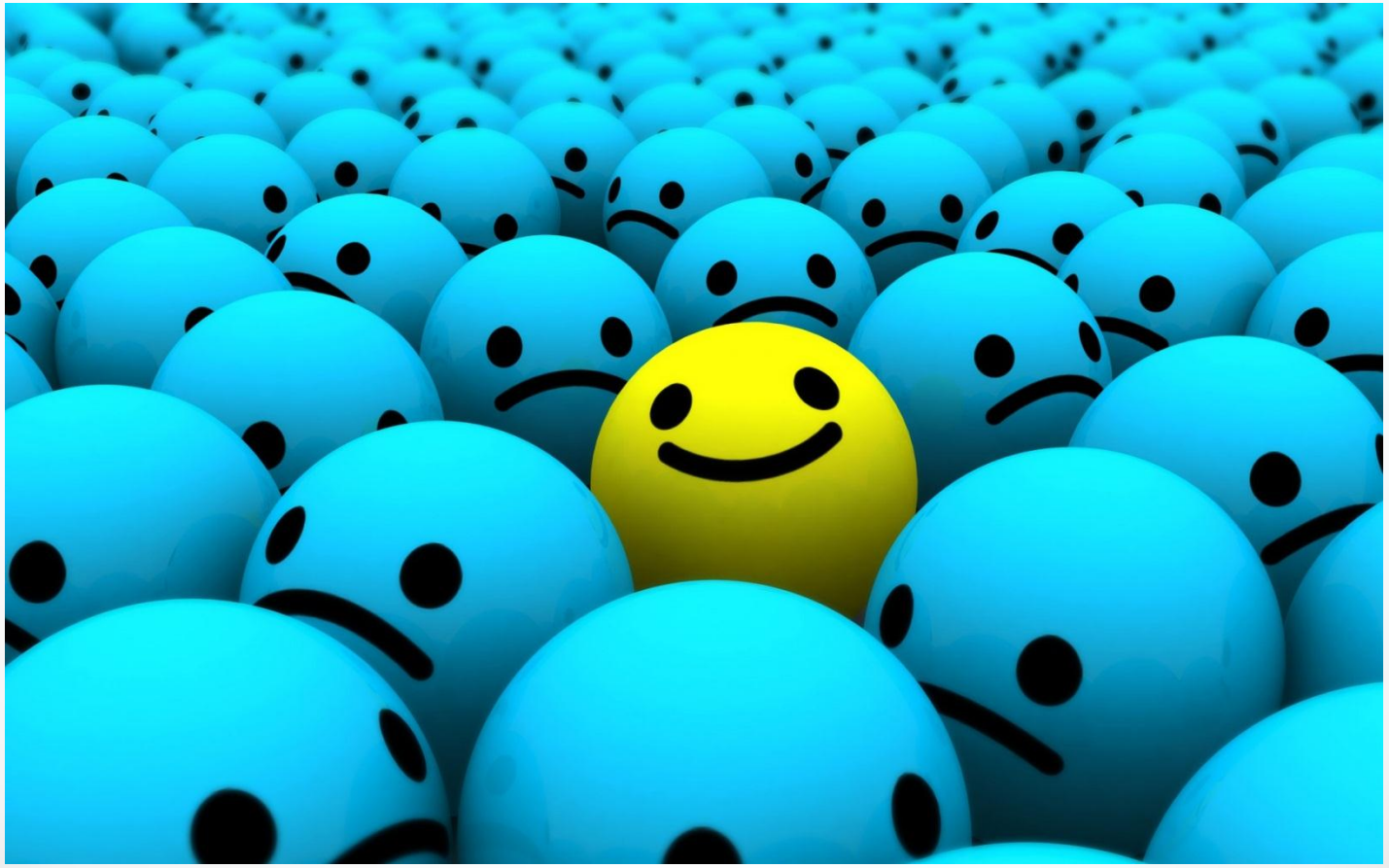
Demo Video

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

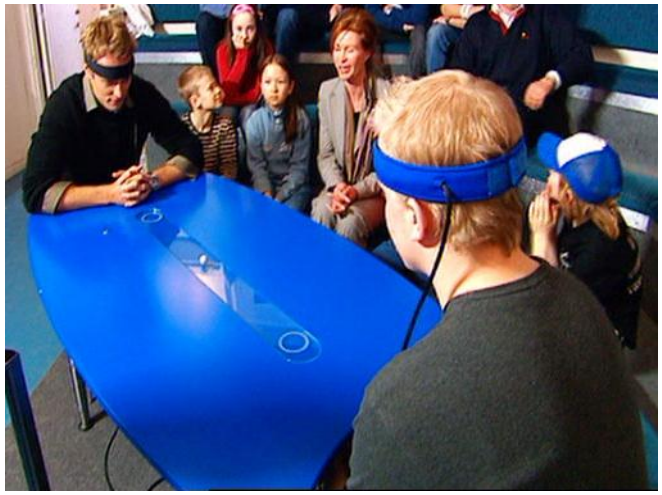
- Passive Control

Future Work

- Small-scaled BCI game with evaluation

Q&A Session

Existing BCI games



Mindball

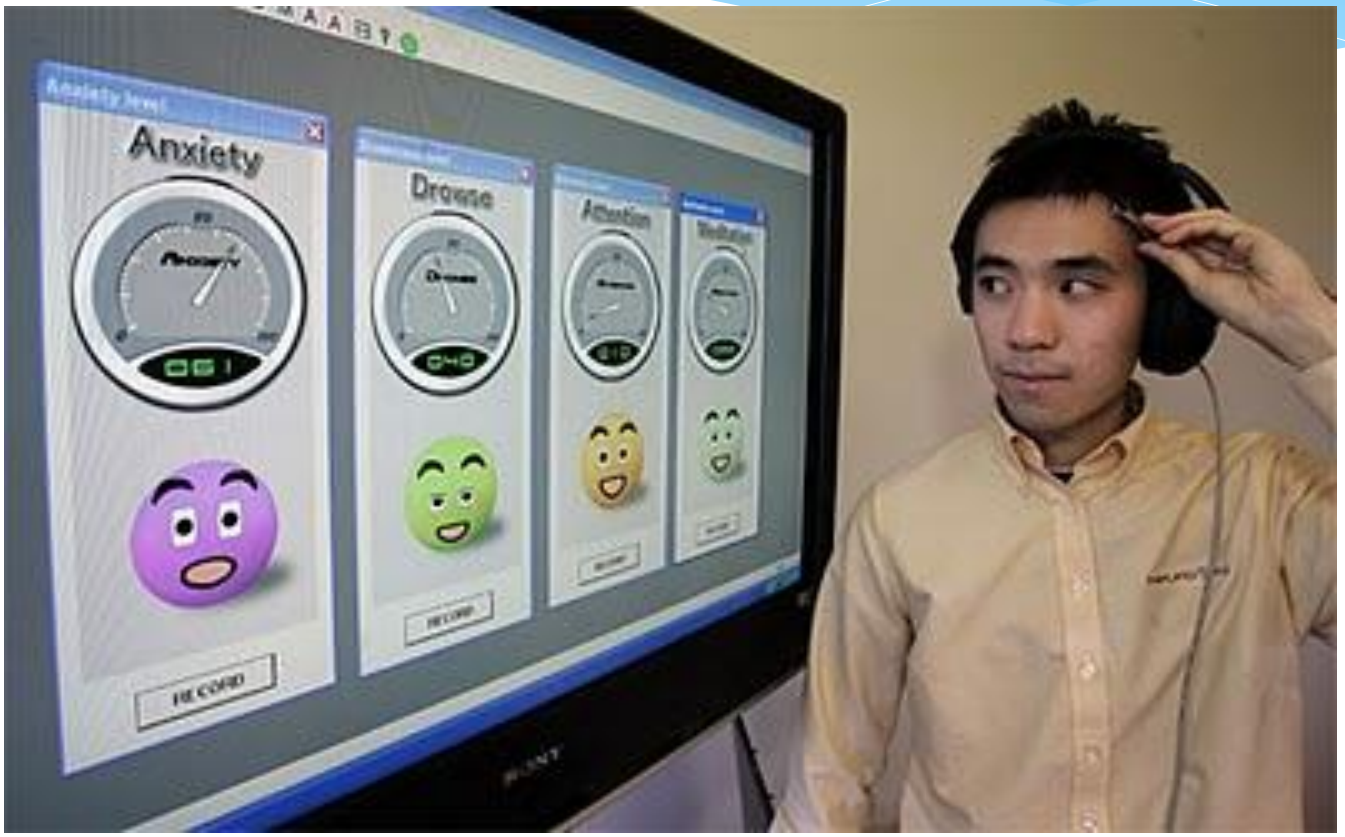
MindFlex

Existing BCI Games

Neuroboy

Judecca

Difficult-to-adjust Mindset



Difficult-to-adjust Mindset

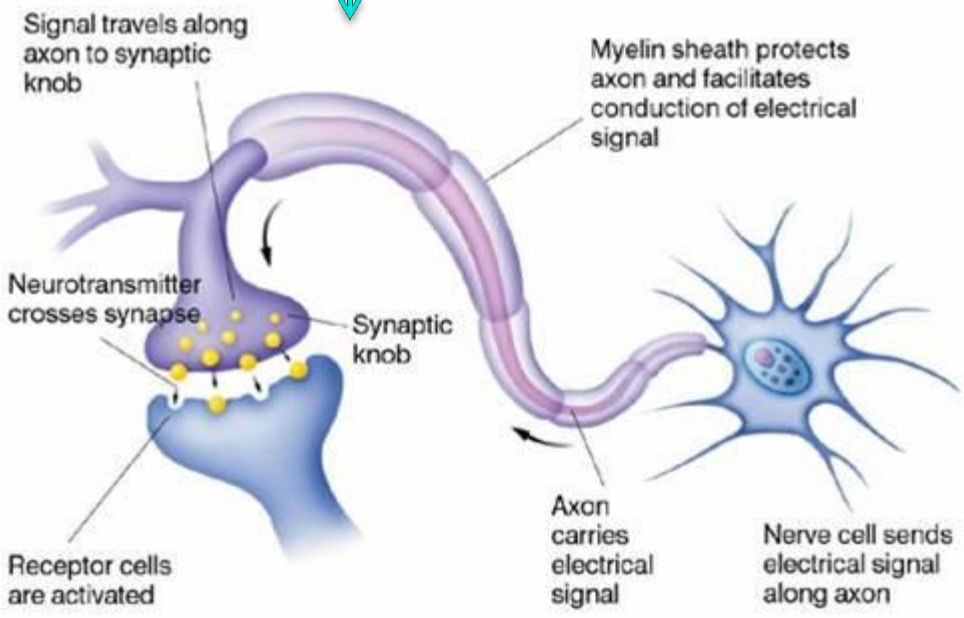
5. Conclusions and future work

The usability and reliability of MB readings to assess attention levels and to amalgamate with user-generated data was evaluated in an assessment exercise in Second Life, N=34. The results regarding usability suggest some users had problems wearing the device due to head sizes or hair interference and that the device's signals to indicate flat batteries are poor. Furthermore, 35% thought the device was neither comfortable not uncomfortable, 37.5% thought it was neither easy nor difficult to wear and 47.5% said they had a satisfactory experience with the device. More

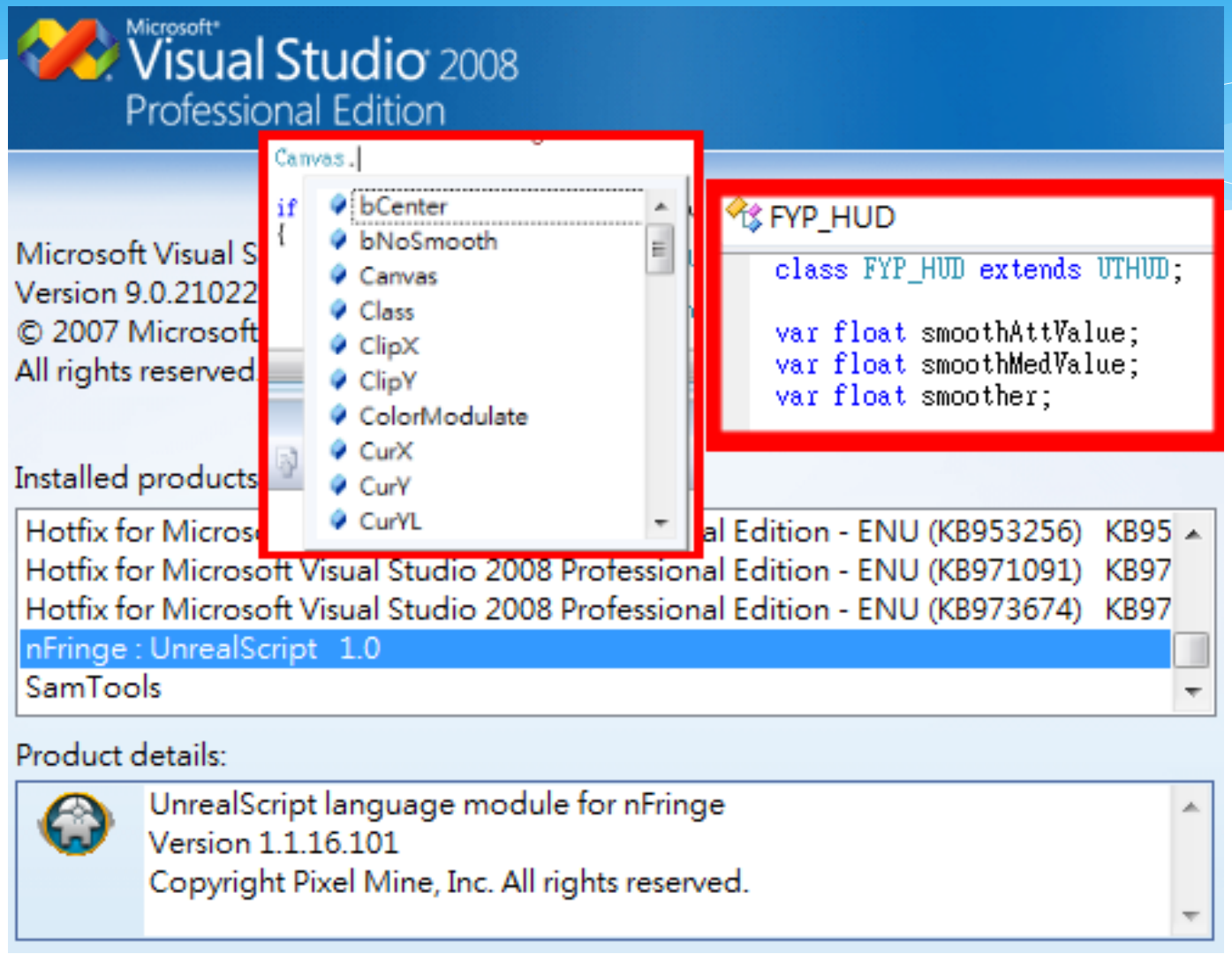
Assessing NeuroSky's Usability to Detect Attention Levels in an Assessment Exercise
http://www.springerlink.com/content/c471m5083xp905g6/fulltext.pdf

Brain… waves?

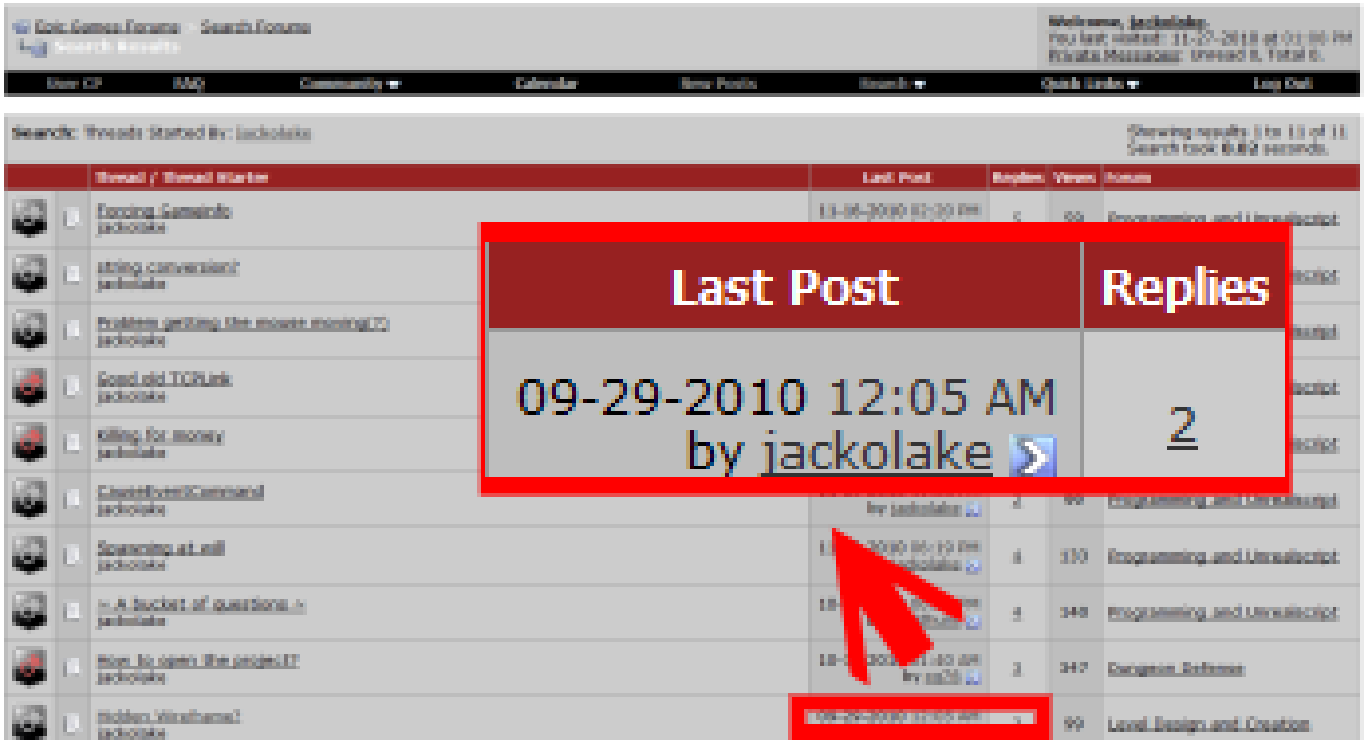
Brain wave sensor
(detects **induced** micro-current)



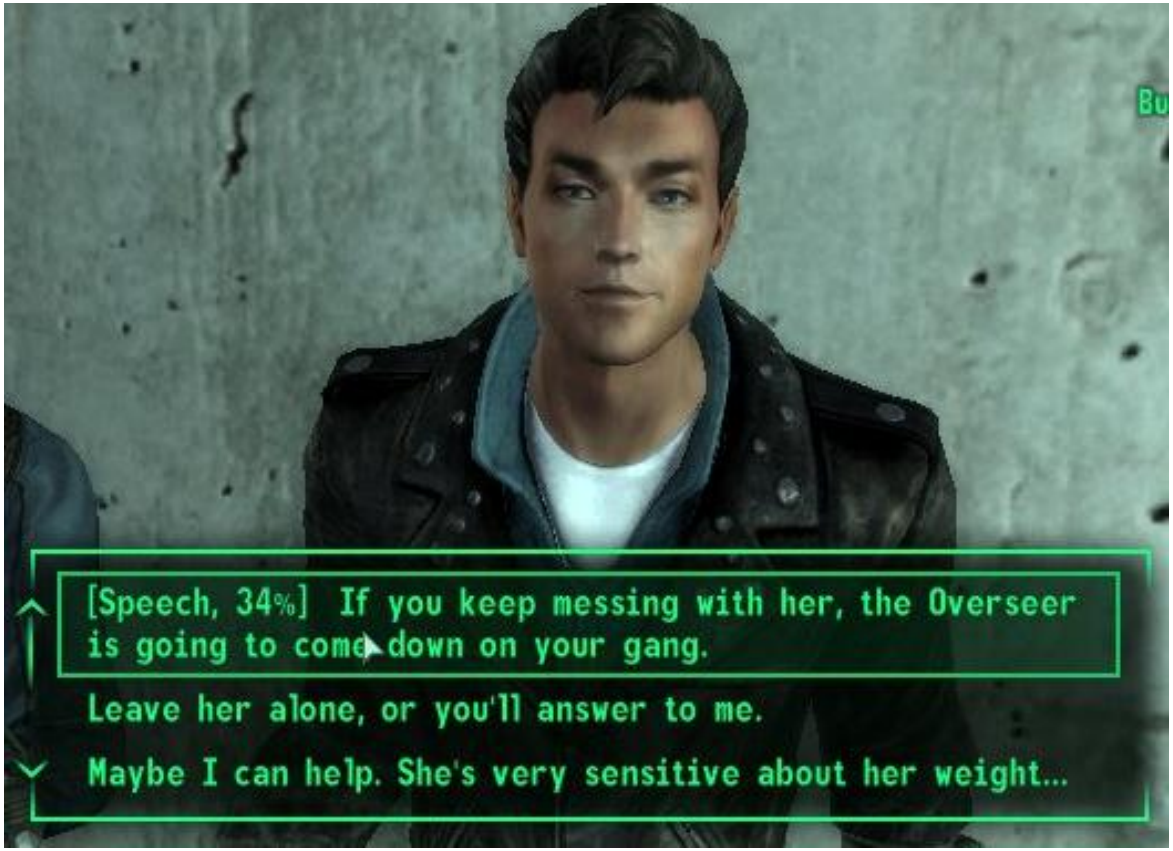
Writing UnrealScript



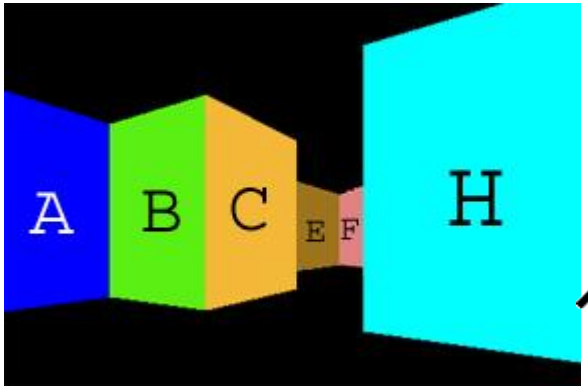
Getting Stuck in UDK

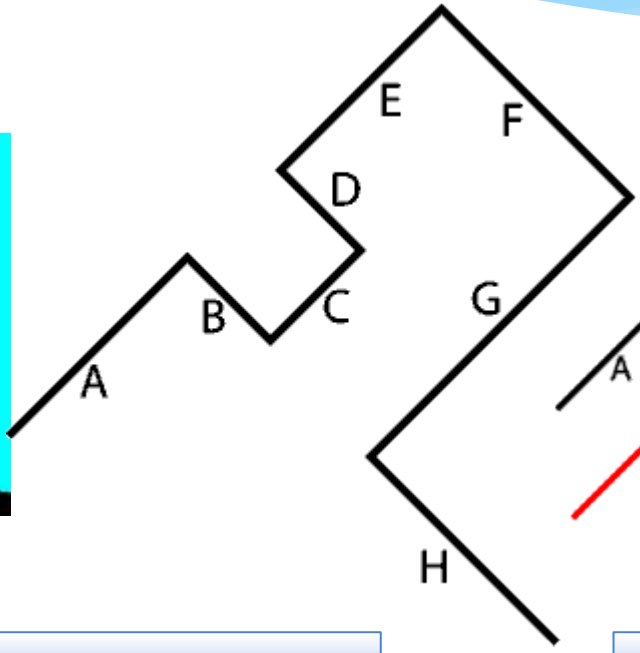


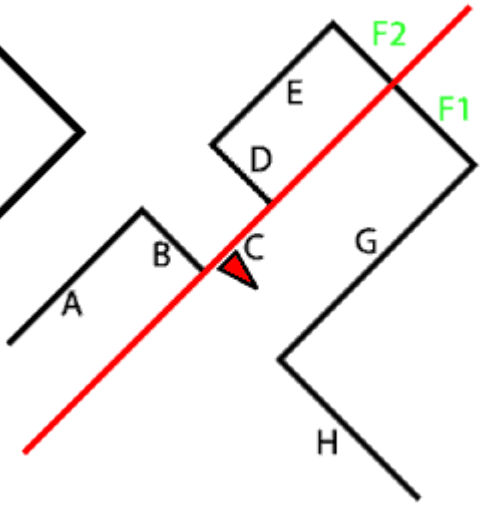
More Passive Control



Binary Space Partitioning (BSP)





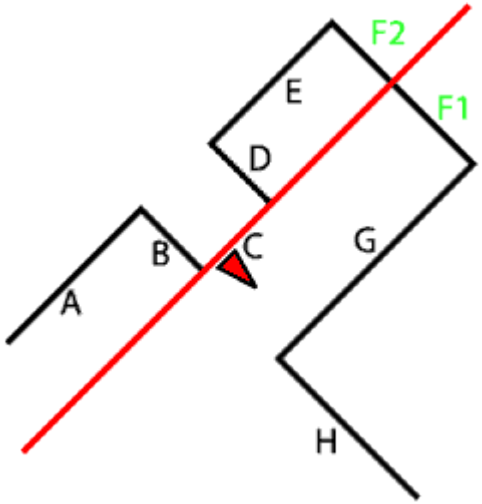


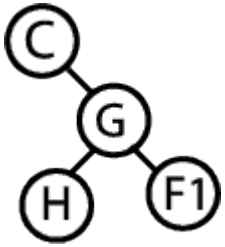
3D & Top Views

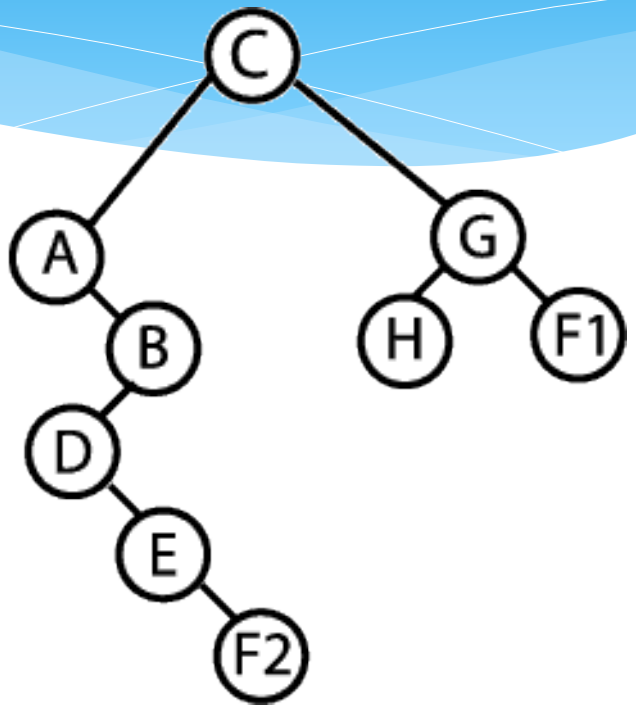
Hyperplane

http://maven.smith.edu/~mcharley/bsp/createbsptree.html

Binary Space Partitioning (BSP)







1 Pass

Completed

http://maven.smith.edu/~mcharley/bsp/createbsptree.html

Data Flow of Mindset

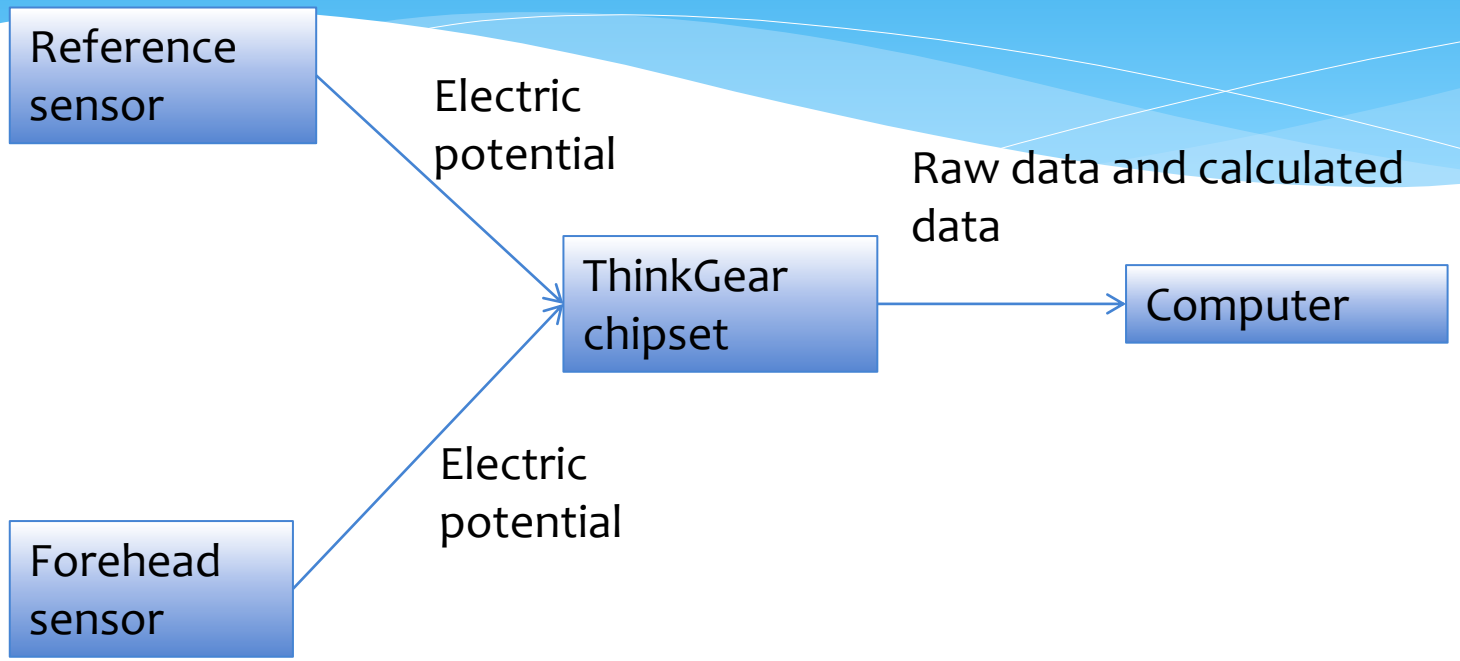


Figure 3.1.3-2 Data flow of Mindset

Relevant Brainwaves

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation

Relaxed Participants

Name	Overall Attention	Clip1	Overall Meditation	Clip1
antonio	61.6513	39.7857	55.7599	39.5179
Ben	46.6544	66.5	54.7819	44.9286
Boris	54.6327	51.7551	59.619	55.2857
EddyLau	27.5927	38.2931	36.5236	19.5862
KK	43.3062	39.7759	51.6547	59.2414
otacon	54.9112	59.8596	47.8726	39.5439
ray	61.8203	47.8214	43.098	29.1071
WaiMo	26.7741	45.4909	46.1628	47.7818
yiunganyuk	49.3415	17.587	66.0557	47.413
yuen	50.2704	38.3448	63.8665	63.6724
yuen520	49.7545	35.2593	60.1661	68.2407
Average	47.88266	43.67935	53.2328	46.75625
	Part 1 Average - Overall average			
	Attention	Meditation		
	-4.20332	-6.47655		

Questionnaire Result

For Clip#1 (the string orchestra), which of the followings best describes your general emotion?	For Clip#1 (the string orchestra), a strike of loud sound was played, which of the followings best describes your emotion at that moment?	Which of the followings best describes your emotion AFTER that?	For Clip#2 (the Pope's speech), which of the followings best describes your general emotion?	For Clip#2 (the Pope's speech), which of the followings best describes your general emotion for the first half of the clip?	Which of the followings best describes your general emotion for the remaining part of the clip?	For the first test of Clip#3 (the Bikini), which of the followings best describes your emotion BEFORE you got the answer?
Relaxed	Excited	Normal	Concentrated	Concentrated	Bored	anxious
Bored	Bored	Bored	Bored	Bored	Bored	Bored
Relaxed	Excited	Concentrated	Bored	Bored	Bored	Concentrated
Relaxed	Relaxed	Bored	Bored	Bored	Bored	Concentrated
Relaxed	Excited	Bored	Bored	Concentrated	Excited	Bored
Relaxed	Excited	Excited	Bored	Bored	Bored	Excited
Relaxed	Fear	Excited	Bored	Bored	Bored	Bored
Excited	Excited	Excited	Bored	Bored	Bored	Concentrated
Relaxed	shocked	Normal	Bored	Bored	Bored	Normal
Bored	Surprised	Relaxed	Bored	Bored	Bored	Bored
Fear	Excited	Fear	Bored	Fear	Fear	Bored
Relaxed	Excited	Relaxed	Bored	Bored	Concentrated	Concentrated
Relaxed	Fear	Concentrated	Bored	Bored	Bored	have not reading the question
Bored	Bored	Bored	Concentrated	Concentrated	Relaxed	Bored
Relaxed	Excited	Relaxed	Bored	Bored	Bored	Relaxed
Relaxed	Excited	Concentrated	Relaxed	Relaxed	Fear	Excited
Bored	Excited	Concentrated	Bored	Bored	Bored	Concentrated
Bored	Concentrated	Concentrated	Bored	Bored	Concentrated	Concentrated
Bored	Bored	Bored	Bored	Bored	Bored	Concentrated

Questionnaire Result

Which of the followings best describes your emotion AFTER you got the answer?	On which attempt did you got the answer?	For the second test of Clip#3 (the Bikini), which of the followings best describes your emotion BEFORE you got the answer?	Which of the followings best describes your emotion AFTER you got the answer?	On which attempt did you get the answer?	For Clip#4 (Spot the ghost), which of the followings best describes your general emotion BEFORE the ghost popped out?
Excited	Had to read the answer	anxious	Excited	Had to read the answer	Concentrated
Bored	First attempt	Bored	Bored	First attempt	Bored
Concentrated	Had to read the answer	Concentrated	Concentrated	Had to read the answer	Concentrated
Relaxed	Had to read the answer	Concentrated	Concentrated	Had to read the answer	Concentrated
Concentrated	Had to read the answer	Concentrated	Concentrated	Had to read the answer	Concentrated
Excited	Had to read the answer	Concentrated	Relaxed	Had to read the answer	Bored
Bored	Had to read the answer	Bored	Bored	Had to read the answer	Concentrated
Concentrated	Had to read the answer	Concentrated	Concentrated	Had to read the answer	Fear
Normal	Had to read the answer	Normal	Normal	Had to read the answer	Normal
Bored	Third attempt	Bored	Relaxed	Third attempt	Fear
Bored	Had to read the answer	Fear	Concentrated	Had to read the answer	Fear
Relaxed	Had to read the answer	Concentrated	Relaxed	Had to read the answer	Concentrated
have not reading the question	Had to read the answer	have not reading the question	have not reading the question	Had to read the answer	Concentrated
Concentrated	Had to read the answer	Concentrated	Concentrated	Had to read the answer	alerted
Concentrated	Had to read the answer	Relaxed	Suprised	Had to read the answer	Concentrated
Concentrated	Had to read the answer	Concentrated	Excited	Had to read the answer	Concentrated
Relaxed	Had to read the answer	Concentrated	Relaxed	Had to read the answer	Concentrated
Relaxed	Had to read the answer	Concentrated	Relaxed	Had to read the answer	Fear
Excited	Had to read the answer	Concentrated	Excited	Had to read the answer	Concentrated