Exercise Video Games?

Exercise video games combine entertainment and exercise in an effort to encourage physical activity.

Examples
- Wii Fit, Wii Sports
- Dance Dance Revolution
- Fisher-Prices Smart Cycle

Motivation

- National levels of obesity increasing over the last two decades
- Potential health risks associated with inactive lifestyles
  - 67% of heads of households play video games
  - Average players spend 7 hours/week gaming
- Exercise video games combine the fun of gaming with physical activity
Goals

- Provide information for developers interested in exercise games
- Discuss physiology and psychology of exercise and how it applies to exercise gaming
- Summarize and assess a wide body of collected knowledge

Workshop Outline

- Exercise motivation
- Quality of exercise
- Game design principles
- Future of exercise gaming
EXERCISE MOTIVATION

What Motivates You?

What Motivates You?
• We all have many motivators / demotivators

• Important to understand what guides us to a particular behaviour

• And it is important to understand that we are all different
Profusion of Factors [Dominick & Morey 05]

- Demographic Factors
  - Age, gender, ethnicity, marital status, number of children, ...

- Cognitive and Psychological Factors
  - Barriers, enjoyment, ...

- Behavioural Factors
  - Activity history, smoking, diet, alcohol, ...

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The Theory

Theory of Planned Behavior [Ajzen 91]

- Attitude toward the behavior
- Subjective norm
- Perceived behavioral control
- Intention
- Behavior
- Perceived behavioral control
- Subjective norm
- Intention
- Behavior

What do you think of going for a jog? Washing the car? Voting in the election?
Theory of Planned Behavior [Azjen 91]

Attitude toward the behavior

Subjective norm

Perceived behavioral control

Intention

Behavior

Societal attitudes to drunk driving, smoking, obesity

Theor

y

of Planned Behavior

Azjen 91

Attitude toward the behavior

Subjective norm

Perceived behavioral control

Intention

Behavior

"No matter what I do, I can’t lose weight. There’s no way I could run a marathon."

Theor

y

of Planned Behavior

Azjen 91

Attitude toward the behavior

Subjective norm

Perceived behavioral control

Intention

Behavior

When designing exercise games, need to consider target market

Are you aiming for people who are already physically active, or helping sedentary people become active?

Applied to exercise [Rhodes 06]:

• Attitude predicts exercise intention

• Intention predicts adherence

Theor

y

of Planned Behavior

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Behavior
Transtheoretical Model of Behavioral Change

**Stages of Change**
- Focuses on decision making of the individual rather than social influences on behaviour
- Temporal description of intentional change

**Processes of Change**
- Independent Variables
- Covert and overt activities that people use to progress through stages of change
- Consciousness raising e.g.

**Temptation Scale**
- An outcome measure
- Related to theory of self efficacy
- Temptation decreases through stages of change while self efficacy increases

**Decisional Balance**
- An outcome measure
- Reflects the individual's relative weighing of the importance of the pros and cons of changing

TTM: Stages of Change

**Precontemplation**
- People are not intending to take action in the foreseeable future (6 months)
- May be uninformed or demoralized from prior attempts to change
- Tend to avoid reading, thinking or talking about their high-risk behaviors
- May be resistant or unmotivated, but traditional programs may not be matched to their needs

**Contemplation**
- People are intending to change in the next 6 months
- More aware of the pros of changing and also aware of the cons
- This balance can produce ambivalence and keep people stuck here for quite some time
- “Chronic contemplation” or “Behavioural procrastination”

**Preparation**
- People intend to take action in the immediate future, usually in the next month
- Typically have taken action in recent past
- Generally have a plan (e.g., join gym, buy self-help book)
- Should be recruited for action-oriented interventions

**Action**
- Should focus on skills development and implementation

**Maintenance**
TTM: Stages of Change

Precontemplation
Contemplation
Preparation
Action
• People have made specific overt modifications in life styles within past 6 months
• Can measure behavior changes here
• People stay in action stage until change is sufficient for standard criteria established by scientists
Maintenance

Precontemplation
Contemplation
Preparation
Action
• People are working to prevent relapse
• Less tempted to relapse than those in action and are increasingly more confident that they can continue their change.
Maintenance

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Self Efficacy (Bandura 94)
Self Efficacy [Bandura 94]
**Self Efficacy** [Bandura 94]

- "I can't do that. That isn't me. I don't belong there."

- Belief in ability to overcome obstacles
- Domain-specific
  - Your Halo 3 self-efficacy may be different from your exercise self-efficacy
  - Your swimming self-efficacy may be different from your soccer self-efficacy or your Wii Tennis self-efficacy

**Self Efficacy** [Bandura 94]

- Self-efficacy predicts
  - Enjoyment of sports [Rhodes]
  - Drop-out rate from weight loss program [Mitchell and Stuart 84]

**Exercise Role Identity** [Curry & Weaner 87]

- We all have many roles
  - Father, teacher, guild-member, husband, …
- Do you view yourself as a
  - Swimmer, golfer, marathon runner, soccer player?
Exercise Role Identity [Curry & Weaner 87]

- Strong correlation between salience of exercise role identity and enjoyment of sports
- Poor exercise role identity a barrier to initiating physical activity

Concrete Factors

What motivates us to do exercise?

Music

- Upbeat music decreases feeling of anger, fatigue, depression [Wales 85, Lee 87]
- Exercising to music reduces perceived exertion [Steptoe & Cox 88]
- Acts as distracter from physical discomfort [Boutcher & Tenske 90]

Music

- Importance in choice of music
  - Positive associations with past experiences
  - Billy Joel vs Slayer
Instructor [Westcott 91, Wininger & Pargman 03]

- Importance of
  - Knowledge
  - Teaching skills
  - Enthusiasm
  - Personal attention

Grouping [Hohepa et al. 06]

- Familial and peer support important
  - Barrier of inactive friends
  - Self-perception of incompetence compared to peers
  - Fear of mockery

Grouping [Beauchamp et al. 07]

- Grouping increases exercise adherence
- But groups must be compatible
  - E.g., similar age

Play Style

- Competition can be motivational [Moran 04]
  - But losing over and over again can be demotivating
  - Particularly for people with low exercise self-efficacy
Play Style

- Cooperation
  - Can overcome some problems with competition [Dominick & Morey 05]

And Back to Self Efficacy

- Not immutable
- Ongoing receive positive feedback can lead to improved self-efficacy
- Importance of achievable, short-term goals [Bandura 04]

Games and Motivation [Warburton et al. 07]

- Combining exercise and games can be motivational
  - Increased adherence
  - Worked harder
  - Higher fitness benefit

Lessons Learned

- Importance of understanding what motivates (and de-motivates) people
  - Theory of Planned Behaviour
  - Trans-theoretical Model of Behavioral Change
  - Exercise Self-Efficacy
  - Exercise Role Identity
- And concrete factors
  - Music
  - Instructor
  - Grouping
  - Play Style
QUALITY OF EXERCISE IN EXERCISE VIDEO GAMES

Tad Stach
Queen's University

Outline

- what is good exercise?
  - ACSM recommendations

- investigating quality of exercise in gaming
  - how effective is exercise gaming?
  - how does it compare to non-active gaming?
  - how does it compare to real-world physical activity?
  - exercise games for therapy

- conclusions and recommendations

What is good exercise?

- American College of Sports Medicine (ACSM) recommendations
  - quantity of exercise
  - quality of training
  - recommendations for developing and maintaining
    - cardio respiratory fitness
    - body composition
    - muscular strength and endurance
    - flexibility

ACSM recommendations

- cardiorespiratory fitness and body composition
  - frequency: 3-5 days a week
  - intensity: 55/66%-90% of HR_{max}
    40/50%-85% of VO_{2R} (or HRR)
  - duration: 20-60 min of continuous or intermittent aerobic activity
  - mode: any activity using large muscle groups, maintained continuously, rhythmical and aerobic in nature
ACSM recommendations

- Muscular strength and endurance, body composition, and flexibility
  - **Resistance training**: one set of 8-10 exercises that target all muscle groups 2-3 days a week (8-12 reps)
  - **Flexibility training**: stretch the major muscle groups a minimum of 2-3 days a week

Physical demands of exercise gaming

- How effective are active video games in terms of exercise?
- Several studies have looked at the quality of exercise in video games
  - Dance Dance Revolution
  - EyeToy

Dance Dance Revolution

- Released by Konami in 1998
- Player hits arrows with feet to musical and visual patterns
- Goal is to tap arrows in time with the music
Dance Dance Revolution

Exercise benefits of DDR

- players of DDR:
  - average 65%-70% of HR$_{max}$
  - average 44%-75% of VO$_2$R
- meets the minimum ACSM recommendations
- playing DDR can increase fitness
- extended play required [Tan, 2002]
- greater player experience results in greater energy expenditure [Sell, 2008]

Exercise benefits of DDR

- children playing DDR:
  - average 64% of HR$_{max}$
  - average 23% of VO$_2$R

- disassociation between HR and VO$_2$
- a minimum of 1hr 5min play time required for reduction in body weight [Unnithan, 2006]

EyeToy

- released in 2003 by Sony
- peripheral camera for Playstation 2

- vision and gesture recognition used to capture input
- succeeded by PlayStation Eye (PS3)
EyeToy

Exercise benefits of EyeToy

- players of EyeToy games:
  - average approximately 78% of $HR_{max}$
  - achieve moderate levels of $VO_2$
  - expend 2.9-6.5 kcal/min

- intensity is consistent with physical activity recommendations [Luke, 2008]
- similar intensity to light exercise (e.g., walk, skip, jog) [Maddison, 2007]

Summary

- existing active games
  - have the potential to maintain and improve physical health (ACSM guidelines)
  - can be effective at increasing activity levels in both children and adults

- more than 30 minutes of play time may be required
- greater difficulty level = greater physical exertion

- more investigation required

Comparing active and non-active gaming
Comparing active and non-active gaming

- Do exercise video games provide significantly more physical activity than traditional games?

- Comparing exercise gaming to non-active gaming
  - Wii
  - XaviX

Wii

- Released in 2006 by Nintendo

- Wii Remote uses accelerometers and IR to track motion in 3D space

- Includes Wii Sports – a sports simulation game

Wii and non-active games

- Energy expenditure during gameplay:
  - Sedentary*: 125.5 kJ/kg/min
  - Wii bowling: 190.6 kJ/kg/min
  - Wii tennis: 202.5 kJ/kg/min
  - Wii boxing: 198.1 kJ/kg/min

- Wii games have the potential to increase movement and energy expenditure in children and adults
  - [Lanningham-Foster, 2009]

- Insufficient intensity to contribute towards recommended exercise
  - [Graves, 2007]

*Project Gotham Racing, Extreme Skate Adventure
XaviX

- released in 2004 by SSD
- series of peripherals connect to XaviX Port
- captures movement with accelerometers and/or pressure sensors

XaviX Bowling

- XaviX Bowling: 1.89 kcal/min
- XaviX J-Mat: 5.23 kcal/min

XaviX J-Mat

- energy expenditure during gameplay:
  - seated bowling: 1.31 kcal/min
  - XaviX bowling: 1.89 kcal/min
  - XaviX J-Mat: 5.23 kcal/min
- heart rate during gameplay:
  - seated bowling: 89 BPM
  - XaviX bowling: 102 BPM (~48% of HR max)
  - XaviX J-Mat: 160 BPM (~76% of HR max)

Active gaming can result in a meaningful increase in HR compared to seated gaming [Mellecker, 2008]
Summary

- energy expenditure during active gaming is higher compared to traditional gaming
- active gaming can result in a meaningful increase in HR compared to non-active gaming
- however, the intensity provided by current active games may not be sufficient enough (ACSM guidelines)

Comparing active gaming to real-world exercise

- do exercise video games provide significantly more physical activity than traditional games?
- comparing exercise gaming to non-active gaming
  - GameBike
  - Dance Dance Revolution

GameBike

- released by Cat Eye
- compatible with GameCube, PlayStation 2, and Xbox
- available in several versions
GameBike and traditional training

- after a 6 week program:
  - significant difference in attendance of GameBike vs. traditional training (78% vs. 29%)
  - VO$_{2\text{max}}$ significantly increased in GameBike vs. traditional training
  - no significant changes in body composition

- GameBike users had greater attendance leading to higher amounts of physical activity
- combining exercise with video games results in greater fitness benefits [Warburon, 2007]

DDR and traditional training

- energy expenditure after 15 min:
  - treadmill walk: 76.09 kcal
  - walk video: 70.84 kcal
  - DDR: 60.65 kcal

- no significant differences among modes of activity
- DDR elicited a higher level of enjoyment [Mealy, 2008]

Summary

- exercise gaming can provide similar health benefits of traditional training
- the greater enjoyment seen in exercise gaming can lead to better adherence
- people may be willing to exercise more often with active games
Exercise gaming for therapy

- Exercise gaming has been proposed as a tool to aid in physical therapy
- Several studies have investigated the benefits of exercise gaming in therapy
  - GameCycle
  - GameWheels

GameCycle

- Released by iTech Fitness
- Merges upper body exercise with video games
- Compatible with GameCube
GameCycle for therapy

- adolescents with spina bifida using a GameCycle:
  - reached at least 50% of HHR
  - reached at least 50% of VO₂R

- most subjects increased their maximum work capability (3 times/week, 16 weeks)
- GameCycle is adequate for improving work capacity in adolescents with spinal dysfunction [Widman, 2006]

GameWheels for therapy

- 20 minutes of play results:
  - no game: 122 BPM
  - GameWheels: 127 BPM
  - significant difference between GameWheels and without for average oxygen consumption

- GameWheels allowed players to reach their training zones faster and maintain it
- the majority of participants reported that GameWheels be helpful [O'Connor, 2001]

Summary

- exercise devices combined with video games can help encourage physical activity for people with physical disabilities
- these systems provide similar or greater physical benefits when compared to traditional therapy

Conclusions and Recommendations
Conclusions

- many games developed for novelty, NOT exercise (e.g., Wii, EyeToy, DDR)

- exercise/active gaming is better overall than sedentary gaming and similar to traditional training

- all exercise games have the potential to improve fitness and health

Recommendations

1. exercise component of games should be vigorous enough to meet ACSM guidelines for developing and maintaining fitness

2. physical movements should target large muscle groups

3. may require customization for each player (e.g., dynamic adjustments based on personal effort)

4. games should be engaging enough to support regular and long-term play (20-60 mins, 3-5 days a week)

5. remember that games should be fun!
DESIGNING EFFECTIVE EXERCISE VIDEO GAMES

Formal Elements of Games*
- Players
- Objectives
- Procedures
- Rules
- Resources
- Conflicts
- Boundaries
- Outcomes

Dramatic Elements of Games*
- Challenge
- Play
- Premise
- Character
- Story
- World Building
- Dramatic Arc

Know Your Market
- Game to help amateur triathletes do bicycle training in winter

* From Tracy Fullerton's Game Design Workshop
FuturePlay 2009  6/7/2009
Know Your Market

- Example: Game to help amateur triathletes do bicycle training in winter
  - Target market has very high exercise self-efficacy, salience of exercise role identity

- Example: Game to help amateur triathletes do bicycle training in winter
  - Amateur triathletes train collaboratively
  - Except for elite, races are only loosely competitive
  - Race against your own time
  - Not obvious that competitive racing game would work well!

- Example: Game to encourage sedentary middle-aged men to do more exercise
  - Exercise self-efficacy probably low
  - Target market in pre-contemplation / contemplation phases
Achievable Short and Long-Term Goals

- Games do this pretty well
  - Achievements
  - MMORPG levels
    - First levels easy, quick
    - Player-settable difficulty levels

Hide player’s fitness level

- People with low self efficacy are easily intimidated
  - E.g., Newcomers in gym may fear being mocked, judged, or view the goal of becoming fit as unachievable
  - May quit before beginning
Pitfall

- As player becomes more powerful, avatars look superior
  - WoW: Level 80 versus Level 1
- Therefore, base levels on player’s fitness
  - Avatar starts overweight, puny
  - Appearance improves as reward for better fitness

Provide Leadership for Novice Players

- Importance of instructor in real-world exercise
  - Top notch tutorials to guide players through early stages of gameplay
  - Systems allowing players to mentor others
    - Earth and Beyond exploration experience
  - Live mentorship from qualified instructors
  - NPC mentorship

Principle

Remove Barriers to Grouping
Pitfall

- Only allow similarly fit people to play together
- Gate content based on fitness level
- ...stopping people playing with their friends

Solutions

- City of Heroes' sidekicks
- Unreal Tournament Fatboy Mode
- Frozen Treasure Hunter’s asymmetric roles
- Heart Burn’s biometric feedback

Asymmetric Roles [Yim 2007]
Principles Conflict

- Hiding fitness level makes it difficult to reward progress
- Removing barriers to grouping makes it hard to have long-term goals
Beyond the Wii Remote

Accelerometers, bikes, and cameras are just the beginning...

Future of Exercise Games

Commercial input
- Other existing input devices such as bongo drums, DDR pads, next-gen WiiMotes

Traditional exercise
- Integrating traditional exercise, such as running, walking, and biking outdoors

Novel input
- Creating innovative input devices with sensors and actuators

Commercial Input Devices: Industry Faceoff

Nintendo Wii MotionPlus
- Launches on June 12
- “Giving you that one-to-one control movement of your arm motion and then mapping it directly to that one-to-one movement of your character on-screen”

Sony PS3 Motion
- Premiering at E3 next month
- Dedicated wand-shaped controller than is designed to enable more natural interaction with a game
- infrared LEDs tracked with a webcam-like device and track depth

Microsoft X Box 360
- Full-body Motion
- Premiering at E3 next month
- Technology from 3DV Zcam
- Uses a camera that senses x, y, colour, and depth (through infrared)
Commercial Input Devices: Newcomers

**Gametrak Freedom**
- In2Games created device for Xbox 360 and PS3
- Uses ultrasound to do 3D positioning
- Similar to previous controller attempts, but the market is ripe

**InvenSense**
- Pitch and Yaw MEMS gyroscope
- Senses acceleration and angular momentum
- Used in upcoming Wii MotionPlus accessory, the first 6-axis motion processing device for consumer applications

**Powergrid**
- Around for a while
- Variable isometric resistance to work your upper body
- Used in Push&Pull

Future of Exercise Games

- Integrating traditional exercise, such as running, walking, and biking outdoors

Traditional Exercise

- Gemini
- UbiFit Garden
- Fish 'n Steps
- Neat-o-games
- Jogging over a Distance
- Kukini

Gemini

- Target Demographic
  - 18-24 year-old gamers
- Exercise
  - Integrated offline in a cumulative fashion
- Input
  - Sensor mote that detects activity and context
- Innovation
  - Ubiquity, social context, addiction to games

UbiFit Garden

- **Target Demographic**
  - Regular mobile phone users who want to increase their physical activity
- **Exercise**
  - Integrated in a cumulative weekly display
- **Input**
  - Proprietary fitness device (the MSP)
- **Innovation**
  - Interactive application, glanceable display


Fish ‘n Steps

- **Target Demographic**
  - Intermediate levels TTM (contemplation/action)
- **Exercise**
  - Step count
- **Input**
  - Pedometer
- **Innovation**
  - Social display, virtual pet whose health depends on activity

http://www.springerlink.com/content/vtw615807853xn0v/

Neat-o-games

- **Target Demographic**
  - Mobile phone users
- **Exercise**
  - Integrated offline and in real time
- **Input**
  - Mobile phone with accelerometers
- **Innovation**
  - Interwoven into life, activity points provide hints into traditional games (e.g., sudoku)


Jogging Over a Distance

- **Target Demographic**
  - Joggers who are separated geographically
- **Exercise**
  - Jogging
- **Input**
  - Heart rate
- **Innovation**
  - Uses spatial audio feedback for motivation

http://www.distancelab.org/projects/jogging/
Kukini

- Target Demographic
  - MMORPG gamers and runners
- Exercise
  - Jogging
- Input
  - Nike+iPod hardware
- Innovation
  - Builds on Salen and Zimmerman’s Rules of Play; moves from quests to social play


Future of Exercise Games

- Creating innovative input devices with sensors and actuators

Location-based Games

- Location-based Games
- Breakout for Two
- Table Tennis for Three
- Remote Impact
- Kick Ass Kung Fu
- Biosensors

Human Pacman
AR Quake
Feeding Yoshi
Can You See Me Now?
Treasure
Pirates!

http://www.regamondryk.com/pubs/Hagerworth_ACM_CIE.pdf
Breakout for Two

Table Tennis for Three

Remote Impact

Kick Ass Kung Fu
Biosensors

Physiological measures

- Galvanic Skin Response (GSR)
  - Palms and soles of feet
  - Psychological arousal
- Electromyography (EMG)
  - Isometric tension, or detection of motion
  - Cheek, forehead
- Cardiovascular
  - Electrocardiography (EKG)
  - Heart Rate (HR)
- Electroencephalography (EEG)
  - Detection of electrical activity in the brain

Problems with Biosignals

Biosignals

- RespRaw
- RespAmp
- RespRate
- GSR
- EMG (jaw)
- IBI
- HR
- EKG

Physics of galvanic skin response (GSR)
- Palms and soles of feet
- Psychological arousal

EEG
- Detection of electrical activity in the brain
Heart Rate Games

- **Triple Beat**
  - De Oliveira and Oliver, 2008

- **Pulse Masters Biathlon**
  - Nenonen et al., 2007

- **Tetris 64**
  - Released by Nintendo only in Japan in 1998

Galvanic Skin Response Games

- **MindGames**
  - Relax to Win
  - Collective Calm

Biathlon

- **Three Play Modes**
  - Traditional input
  - Biosensors
  - Biosensors that modulate traditional input

Heart Burn

- **multiplayer exercise game**
  - address the problem of different fitness levels among competitors by scaling performance using heart rate
Summary

- Exercise Motivation
  - Understand what motivates people to exercise and integrate these into game design
- Effectiveness of Exercise Games
  - Potential health benefits of exercise video games
- Designing Effective Exercise Games
  - Traditional games design principles could backfire in exercise games
- Future of Exercise Games
  - Don’t be constrained by today’s input devices; new research is generating innovative technologies
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