FACULTY OF POLITICAL AND SOCIAL SCIENCES

INTERACTIVE MEDIA AND ENTERTAINMENT

Prof. Dr. Laura Herrewijn 2019-2020

GHENT UNIVERSITY

VIRTUAL ENVIRONMENTS: PT. 1

GHENT UNIVERSITY

READER

- Fox, J., Arena, D., & Bailenson, J. N. (2009). Virtual Reality. A Survival Guide for the Social Scientist. *Journal of Media Psychology, 21*(3), 95-113.

GHENT UNIVERSITY

INTRODUCTION TO VIRTUAL ENVIRONMENTS

- Overview of:
  - Definitions and types of VEs
  - History of VEs
  - Profitability and popularity of VEs
  - User motivations for VEs
  - The characteristics and effects of VEs
  - Applications of VEs
  - The study and use of VEs in the social sciences

Pt. 1: this week!

GHENT UNIVERSITY

VIRTUAL ENVIRONMENTS: DEFINITION

- What is a virtual environment (VE)?
  - "A digital space in which a user's movements are tracked and his/her surroundings rendered, or digitally composed and displayed to the senses, in accordance with those movements"
  - For example: digital games, virtual worlds
    - Movement is tracked by means of keyboard and mouse, game controller,…

GHENT UNIVERSITY

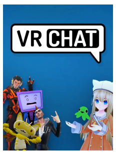
DIGITAL GAMES: DEFINITION

- Interactive programs for one or more players, meant to provide entertainment (+ possibly more)
- Adaptations of 'traditional game systems' (with rules, player representations (i.e. avatars), environments) managed through electronic means

GHENT UNIVERSITY

VIRTUAL WORLDS: DEFINITION

- Computer-based simulated environments that (generally) allow for multiple users who can create a personal character (i.e. avatar), and explore the virtual world, participate in its activities and communicate with others

HISTORY OF VIRTUAL ENVIRONMENTS

- This part of the lecture will be based on the following chapter that we discussed in lecture 2!
  - Miller, C. H. (2014). *Digital Storytelling: A Creator's Guide to Interactive Entertainment.* Burlingon, MA: Focal Press.
    - *Chapter 2: Backwater to Mainstream: The Growth of Digital Entertainment*

HISTORY OF DIGITAL GAMES

- First computer game, developed by MIT student Steve Russell in 1962: Spacewar
  - Two-player game: duel between two spaceships

HISTORY OF DIGITAL GAMES

- 1972: first home console, the Magnavox Odyssey (created by Ralph Baer), is released (+12 games)

HISTORY OF DIGITAL GAMES

- 1971: Nolan Bushnell and Ted Dabney (Atari) created an arcade game (coin-operated entertainment machine) version of Spacewar: Computer Space → failure, too difficult to play

HISTORY OF DIGITAL GAMES

- 1972: Atari created arcade game Pong (1975: home console): success!
- Pong helped generate an enormous wave of excitement about digital games
  - Flurry of arcade games
    - Played on arcade cabinets, quarter for # minutes of play
    - Hardware too expensive for home market though
  - Arcade game parlors became increasingly popular: 1.5 million coin-operated arcade games in operation in the US by 1981
    - Social hangouts


HISTORY OF DIGITAL GAMES

- Late 1970s – early 2000s: commercial optical disc storage medium is introduced
  - LaserDisc
  - CD-ROM (Compact Disc-Read Only Memory)
  - CDi (Compact Disc-interactive)
  - DVD (Digital Video Disc)
  - Blu-ray Disc

→ Media for audiovisual material: music, movies, games,...

GHENT UNIVERSITY

HISTORY OF DIGITAL GAMES

- Thanks to these platforms, the popularity of home console and PC games took off!

GHENT UNIVERSITY

HISTORY OF DIGITAL GAMES

→ The 50 best digital games of all time, according to critics: https://www.businessinsider.nl/best-video-games-metacritic-2017-11/?international=true&r=US

GHENT UNIVERSITY

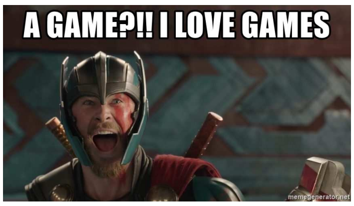
HISTORY OF VIRTUAL WORLDS

- The invention of digital games + the Internet (and its potential to create social communities) = virtual worlds
  - 1995: Worlds Chat (first 3D online world available on the internet; online chat system with avatars and interesting environments to explore)
  - 1995: ActiveWorlds (3D online world that also allowed users to build structures: homes, environments,…)
  - 2000: Habbo (one of the most popular and longest running virtual worlds, targeted towards teenagers)
  - 2003: Second Life (one of the most popular virtual worlds in the 2000s, targeted towards adults)
  - 2017: VRChat (virtual world that can be accessed in VR, focusing on both creating your own environments and exploring the world with others)

GHENT UNIVERSITY

INCREASING IMPORTANCE OF VES

- VEs are becoming increasingly important in people's lives
  - Especially digital games!



GHENT UNIVERSITY

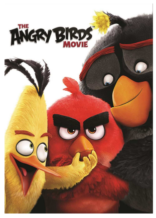
LARGEST ENTERTAINMENT SECTOR

- Gaming is bigger than it ever was; bigger than every other form of entertainment!

GHENT UNIVERSITY

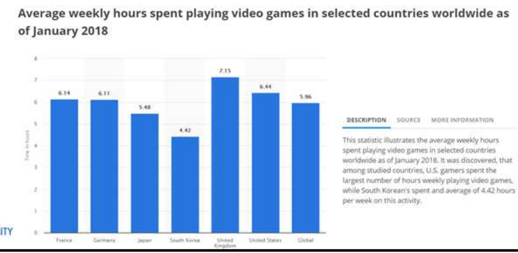
BEST-SELLING, MOST LUCRATIVE ENTERTAINMENT PRODUCTS

GAME ADAPTATIONS



LEISURE TIME

- People are spending more and more of their time playing digital games (~time that used to go to traditional media)



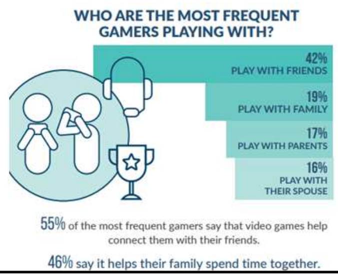
EVER-INCREASING, DIVERSE AUDIENCE

- 64% of US households own a gaming device (average of 2 gamers per household)
- The average gamer is 34 years old
- Gamers age 18 or older represent more than 70% of the game-playing population
- 60% of Americans play digital games daily
- Adult women represent a greater portion of the game-playing population (33%) than boys under 18 (17%)
- 45% of US gamers are women

(Entertainment Software Association, 2018)

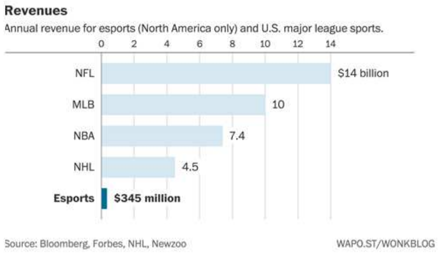
SOCIAL PLAY

- 56% of the most frequent gamers play multiplayer games at least once a week

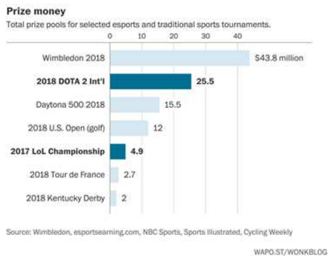


E-SPORTS

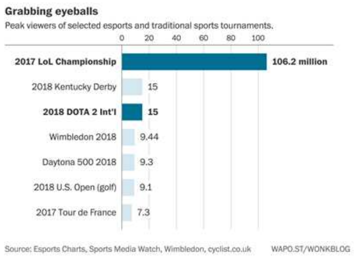
E-SPORTS



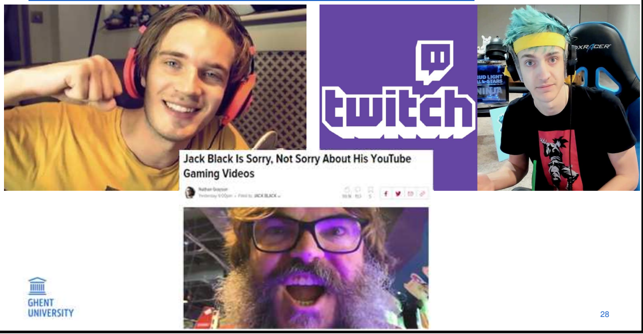
E-SPORTS



E-SPORTS



GAMING STREAMERS & VLOGGERS



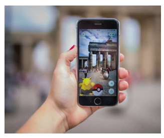
LOW VS. HIGH-IMMERSIVE VES

- VEs can also be distinguished based on the capabilities of the platform/hardware on which they are experienced
  - Low-immersive VEs vs. high-immersive VEs

LOW IMMERSIVE VES

- Low-immersive VEs
  - By means of mobile devices, computers, game consoles,... (omnipresent in daily life)
    - Keypresses, mouse or game controller movements, touch controls,… provide a simple form of tracking
    - The (computer/mobile device/TV) screen reflects these changes via appropriate rendering





HIGH IMMERSIVE VES

- High-immersive VEs
  - Virtual Reality!
  - By means of wearable equipment (e.g. head-mounted display (HMD) = VR headset)

GHENT UNIVERSITY

HIGH IMMERSIVE VES

- High-immersive VEs
  - Standard setup
    - Interacting with the VE by means of:
      - Keyboard + mouse, traditional game controllers (i.e. “older” setup)
      - Motion-tracked controllers (→ most popular with recent VR setups)
    - Body movement possible (depending on VE/hardware), but restricted to a certain area = room-scale tracking

GHENT UNIVERSITY

HIGH IMMERSIVE VES

- High-immersive VEs
  - Motion setup
    - Interacting with the VE by means of motion-tracked controllers
    - Less restricted body movement: move freely and at full speed in 360° without getting hurt

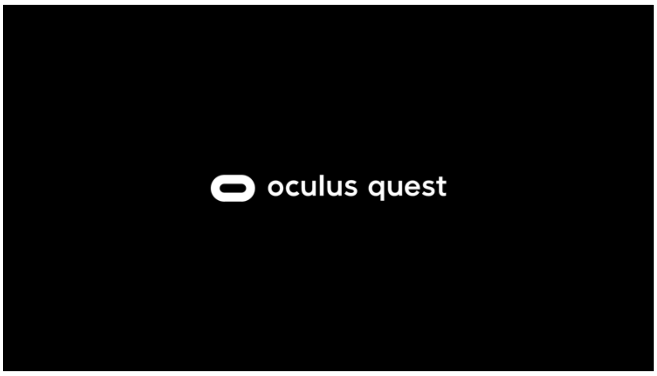
GHENT UNIVERSITY

HIGH IMMERSIVE VES: VR HEADSETS

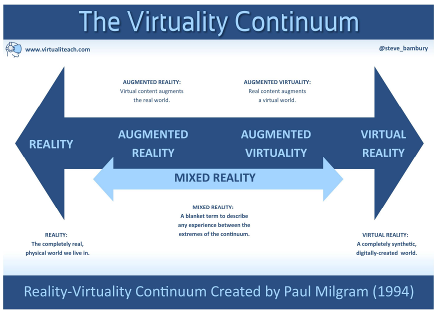
- Overview of the most successful consumer VR headsets:
  - Tethered to a computer:
    - Oculus Rift: original Rift (2016), Rift S (2019)
    - HTC Vive: original Vive (2016), Vive Pro (2018), Vive Pro Eye (2019), Vive Cosmos (2019)
    - PlayStation VR (2016)

    → Earlier versions: tracking by means of external sensors; recent versions (Rift S, Cosmos): tracking included in headset + controllers
  - Stand-alone:
    - Oculus Go (2017)
    - HTC Vive Focus (2018)
    - Oculus Quest (2019)

GHENT UNIVERSITY

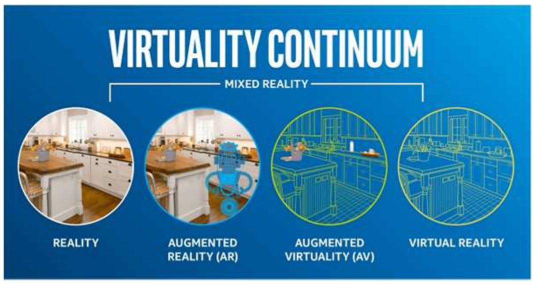


REALITY-VIRTUALITY: DIFFERENT 'REALITIES'



GHENT UNIVERSITY

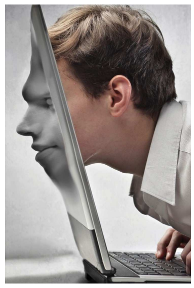
REALITY-VIRTUALITY: DIFFERENT 'REALITIES'



GHENT UNIVERSITY

VIRTUAL REALITY: DEFINITION

- A digitally created space (= VE) that humans can access by donning sophisticated computer equipment
- Once inside that space, people can be transported to a different world, a substitute reality in which one can interact with objects, people, and environments, the appearance of which are bound only by the limits of the human imagination



GHENT UNIVERSITY

VIRTUAL REALITY: HISTORY

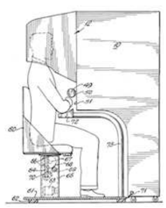
- VR has existed for decades
  - Founded in science fiction
  - Pygmalion's Spectacles (1935): short story by Stanley Weinbaum
    - *In the story, the main character meets a professor who invented a pair of goggles which enabled "a movie that gives one sight and sound, taste, smell, and touch. You are in the story, you speak to the shadows (characters) and they reply. The story is all about you, and you are in it."*


PYGMALION'S SPECTACLES
By STANLEY G. WEINBAUM
Author of "The Black Flame," "A Martian Odyssey," etc.

GHENT UNIVERSITY

VIRTUAL REALITY: HISTORY

- Mid 1950s, cinematographer Morton Heilig developed the Sensorama (patented 1962)
  - Arcade-style theater cabinet that would stimulate all the senses while watching a film (six short films were produced for this purpose)
    - Stereo speakers
    - Stereoscopic 3D display
    - Fans
    - Smell generators
    - Vibrating chair



GHENT UNIVERSITY

VIRTUAL REALITY: HISTORY

- From the 1960s on, computer artists and scientists, military engineers, research labs,… started working on developing Head-Mounted Displays (HMDs)

1960: the first HMD called the "Telesphere Mask"
Also by Morton Heilig!

VIRTUAL REALITY: HISTORY

- 1968: Ivan Sutherland and Bob Sproull created the first VR/AR HMD called the Sword of Damocles
  - Connected to a computer
  - Too heavy for any user to comfortably wear, so suspended from the ceiling (hence its name)
  - User needed to be strapped into the device
  - The computer-generated graphics were very primitive wireframe rooms and objects

VIRTUAL REALITY: HISTORY

- The HMDs got smaller, more comfortable, cheaper and easier to use over the years
- Most of the VR headsets that were created for the consumer market were a bit of a commercial failure though, until…

VIRTUAL REALITY: HISTORY

- 2012: the modern VR revolution was kickstarted ☺
  - Palmer Luckey launches a Kickstarter to fund the development of his prototype headset: the Oculus Rift
    - Initially pitched as being the next big thing for gaming
  - Campaign raises almost 2.5 million dollars

VIRTUAL REALITY: HISTORY

- 2014:
  - Facebook buys Oculus
    - The social media giant sees potential in the Oculus technology, and not only for gaming
  - Other tech giants start working on their own VR projects
    - PlayStation VR, HTC Vive,…
    - Also mobile VR: smartphone-based budget headsets such as Google Cardboard, Samsung Gear VR,... are developed

VIRTUAL REALITY: HISTORY

- 2016-2017: VR products are truly ready for primetime!
  - The Oculus Rift and the HTC Vive lead the way

VIRTUAL REALITY: HISTORY

- 2018-2019: Standalone VR rises, mobile VR dies
  - The Oculus Go, Oculus Quest, HTC Vive Focus,… are developed
    - Need no computer or phone to work
    - Very affordable
    - The public loses its interest in mobile VR as a result

VIRTUAL REALITY: HISTORY

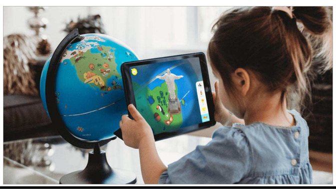
- 2019: VR is shifting rapidly
  - VR standalone headsets such as the Oculus Quest can now also create mixed reality content (in combination with a recording device)
  - Many advanced headsets are on the horizon:
    - Extremely wide fields of view
    - Hand scanning and eye tracking
    - …

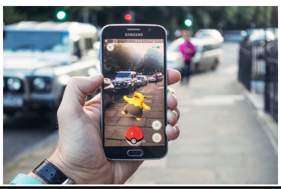
VIRTUAL REALITY: HISTORY

- For a complete overview of the history of VR, check out: https://www.vrs.org.uk/virtual-reality/history.html

AUGMENTED REALITY: DEFINITION

- AR supplements reality, rather than completely replacing it (Azuma, 1997, p. 356)
- AR can be defined as the superposition of virtual objects (i.e. computer-generated images, texts, sounds,...) on the real environment of the user (Faust et al., 2012, p. 1164)



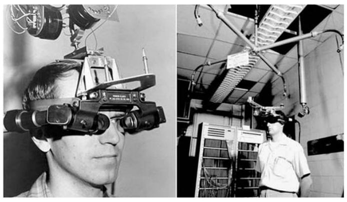


AUGMENTED REALITY: HISTORY

- The idea for AR has been around for a long time as well
  - Just like VR: rooted in science fiction
    - The Master Key (1901): novel by Frank L. Baum
      - Describes the adventures of a 15 year old boy who accidentally touches "the Master Key of Electricity," encountering a Demon who gives him various gifts
      - One of these gifts is a Character Marker:
        - *It consists of this pair of spectacles. While you wear them every one you meet will be marked upon the forehead with a letter indicating his or her character. The good will bear the letter 'G,' the evil the letter 'E.' The wise will be marked with a 'W' and the foolish with an 'F.' The kind will show a 'K' upon their foreheads and the cruel a letter 'C. Thus you may determine by a single look the true natures of all those you encounter.*

AUGMENTED REALITY: HISTORY

- The invention of AR technology dates back to 1968 as well: Sutherland & Sproull's Sword of Damocles (first VR/AR HMD)



AUGMENTED REALITY: HISTORY

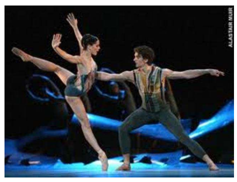
- 1974: Myron Kruger built a laboratory called "Videoplace"
  - Projection and camera technology was used to emit onscreen silhouettes which surrounded users for an interactive experience

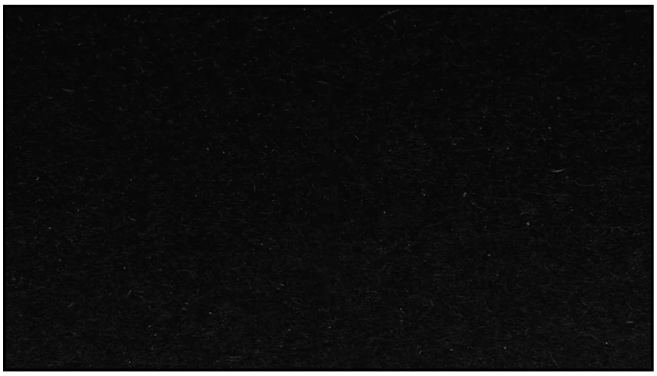
AUGMENTED REALITY: HISTORY

- In the 1980s and 90s, AR transitioned out of the lab: industrial and entertainment applications
  - 1992: Virtual Fixtures
    - Allowed military personnel to virtually control and guide machinery for training purposes

AUGMENTED REALITY: HISTORY

- 1994: theater production called Dancing in Cyberspace
  - Acrobats dancing alongside virtual objects on the physical stage
- 1998: Sportsvision broadcasts the first live NFL game with the virtual yellow yard marker
  - Still used today, but more advanced!





AUGMENTED REALITY: HISTORY

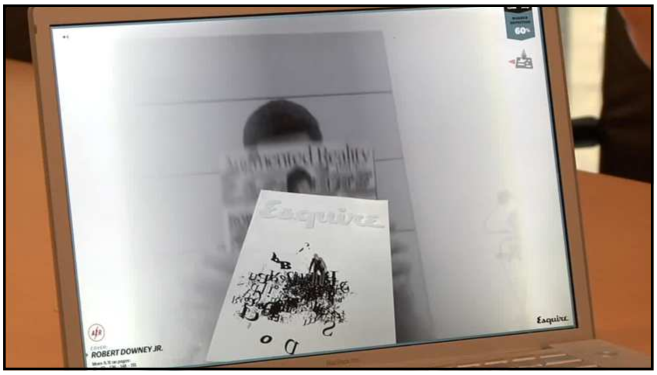
- In the 2000s and 10s, AR started to roll out to consumers and businesses (on top of its industrial & entertainment applications)
  - Rise of mobile AR
  - Rise of wearable AR devices

GHENT UNIVERSITY

AUGMENTED REALITY: HISTORY

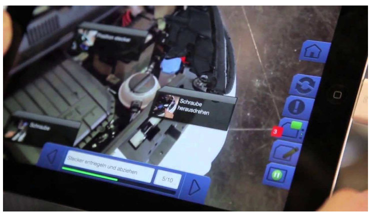
- 2009: Esquire Magazine used AR in print media for the first time
  - AR made the pages come alive when readers scanned the cover

GHENT UNIVERSITY



AUGMENTED REALITY: HISTORY

- 2013: Volkswagen debuted the MARTA app (Mobile Augmented Reality Technical Assistance)
  - Give technicians step-by-step repair instructions



GHENT UNIVERSITY

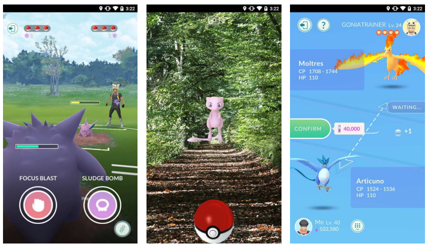
AUGMENTED REALITY: HISTORY

- Tech giants start to work on wearable AR devices
  - 2014: Google unveiled its Google Glass device
    - AR glasses that users could wear for immersive experiences
  - 2016: Microsoft launches its HoloLens
    - More advanced than Google Glass but with a hefty price tag

GHENT UNIVERSITY

AUGMENTED REALITY: HISTORY

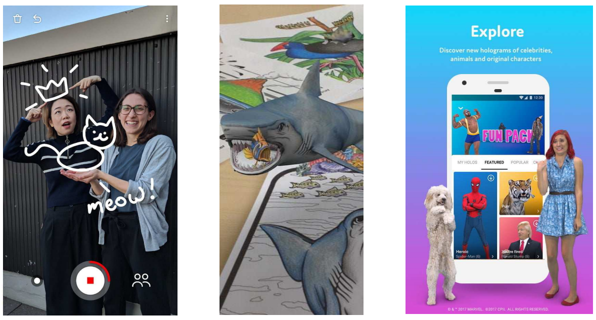
- In 2016, Pokémon Go brought (mobile) AR to the masses ☺



AUGMENTED REALITY: HISTORY

- Pokémon Go's success kickstarted a whole new wave of consumer AR products, especially for entertainment

AUGMENTED REALITY: HISTORY

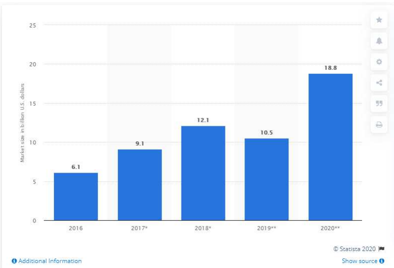


AR/VR INDUSTRY

- Due to all of these evolutions, the AR and VR industries are growing at a fast pace
  - Global AR/VR market is expected to reach 18.8 billion dollars in 2020!

AR/VR INDUSTRY

- Forecast of the AR and VR market size worldwide from 2016 to 2023 (in billion US dollars)



AR/VR: MOTIVATIONS

- Technologies such as AR and VR are also expected to give rise to new user motivations!
  - Let's take a look at one specific case: Pokémon Go!

READER

- Zsila, A., Orosz, G., Bothe, B., Toth-Kiraly, I., Kiraly, O., Griffiths, M., & Demetrovics, Z. (2018). An empirical study on the motivations underlying augmented reality games: The case of Pokémon Go during and after Pokémon fever. *Personality and Individual Differences*, 133, 56-66.

MOTIVATIONS FOR PLAYING POKÉMON GO

- 2016: Pokémon Go became the most popular game in the history of mobile games
- Due to AR technology: completely new playing phenomenon!
- Goal of the study: identify the motivational factors that explain the new playing style associated with Pokémon Go

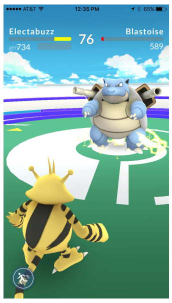
POKÉMON GO: BACKGROUND INFO

- Pokémon Go:
  - Based on the long-running, popular Pokémon franchise
  - Features location-based AR elements
    - Promoting physical activity, going outside
    - Helping local businesses grow due to increased foot traffic
    - Also controversy: contributing to accidents, creating public nuisances, security concerns,…

What if I told you Pokemon Go was created by dogs to get extra walks

POKÉMON GO: GAMEPLAY

- Gameplay premise:
  - Player creates an avatar
  - Chooses a team to fight with
  - By moving around in real world surroundings, the player can find and capture wild Pokémon
  - Players can also find eggs that hatch Pokémon over time (after walking 2km, 5km, 10km)
  - Players can participate in Gym battles in which they can improve their skills by challenging other players who have control over the Pokémon gym
  - …



MOTIVATIONS FOR PLAYING POKÉMON GO

- Zsila et al. started from the motivational factors that were identified by Demetrovics et al. (2011) regarding online gaming:
  - Motives for Online Gaming Questionnaire (MOCQ):
    - Social
    - Escapism
    - Competition
    - Coping
    - Skill Development
    - Fantasy
    - Recreation

MOTIVATIONS FOR PLAYING POKÉMON GO

- Zsila et al. also performed exploratory qualitative research (among 37 players of Pokémon Go) to explore possible additional motives for playing Pokémon Go
  - Three additional motivations were identified:
    - Outdoor activity
    - Nostalgia
    - Boredom

MOTIVATIONS FOR PLAYING POKÉMON GO

- Online survey study among regular Pokémon Go players (during PoGo's peak in summer 2016, and a couple of months later, in November 2016)
  - Assessing the 7 motivations identified by the MOCQ
  - And the 3 new motivations, identified by the exploratory qualitative research

GHENT UNIVERSITY

MOTIVATIONS FOR PLAYING POKÉMON GO

- The results of the study show that both the "older" MOCQ motivations and the "new" motivations occurred among the Pokémon Go player base
- The strongest motives were:
  - Recreation (MOCQ)
  - Outdoor activity (new)
  - Nostalgia (new)
  - Boredom ("new")
- The weakest motives were:
  - Skill development
  - Escapism

GHENT UNIVERSITY

SEE YOU NEXT WEEK! ☺

- Don't forget to play your game...
- ...and fill out the gameplay diary/survey at least once per week!

GHENT UNIVERSITY

FACULTY OF POLITICAL AND SOCIAL SCIENCES

INTERACTIVE MEDIA AND ENTERTAINMENT

Prof. Dr. Laura Herrewijn 2019-2020

GHENT UNIVERSITY

VIRTUAL ENVIRONMENTS: PT. 2

GHENT UNIVERSITY

READER

– Fox, J., Arena, D., & Bailenson, J. N. (2009). Virtual Reality. A Survival Guide for the Social Scientist. *Journal of Media Psychology, 21*(3), 95-113.

GHENT UNIVERSITY

INTRODUCTION TO VIRTUAL ENVIRONMENTS

– Overview of:
  – Definitions and types of VEs
  – History of VEs
  – Profitability and popularity of VEs
  – User motivations for VEs
  – The characteristics and effects of VEs
  – Applications of VEs
  – The study and use of VEs in the social sciences

Pt. 2: this week!

GHENT UNIVERSITY

CHARACTERISTICS: MULTI-MODAL SENSORY STIMULATION

– VEs employ hardware that can address a variety of sensory modalities
  – Visual stimuli (graphics)
  – Auditory stimuli (sounds, music)
  – Haptic stimuli (touch)

GHENT UNIVERSITY

CHARACTERISTICS: VIVIDNESS

– Multi-modal sensory stimulation will determine the vividness/richness of the VE!
  – Vividness or richness considers the stimulus and sensory information available from the medium
    – Breadth of vividness: whether sight, sound and haptic (i.e. touch) functionality were incorporated
    – Depth of vividness: image/sound/haptic quality and speed

→ *!!VR: completely immerses senses in VE (vividness ↑)*

GHENT UNIVERSITY

CHARACTERISTICS: INTERACTIVITY

- The tracking and rendering process of VEs allows for high levels of interactivity (vs. traditional media)
  - Users have an active role in the VE
  - They have an immediate and observable impact on the VE's content

→ !!VR: VE reacts to natural behaviors (interactivity↑)

GHENT UNIVERSITY

CHARACTERISTICS: INTERACTIVITY

- The degree of interactivity is determined by the extent to which users can participate in modifying the form and content of a VE in real-time
  - Speed of interaction: speed of response time
  - Range of interaction: number of variations in the experience
  - Mapping of interaction: how a body part, such as a hand or eye, could control or change the environment

GHENT UNIVERSITY

PSYCHOLOGICAL EFFECTS: USER EXPERIENCE

- Blocking of sensory cues from physical reality (i.e. high vividness)

  \+

  High interactivity of VEs

  =

  Increasingly intense user experience

- A large impact on the psychological experience of immersion/presence/incorporation, especially!

GHENT UNIVERSITY

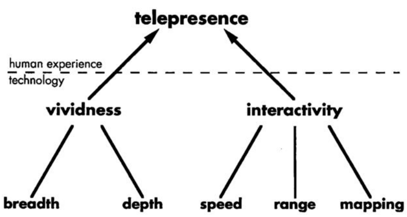
PSYCHOLOGICAL EFFECTS: PRESENCE

- Presence refers to a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience
  - The sense of "being there", via a communication medium (Steuer, 1992)
  - The experience of losing oneself in a mediated environment (Witmer & Singer, 1998)
  - The illusion of non-mediation (Lombard & Ditton, 1997)

GHENT UNIVERSITY

PSYCHOLOGICAL EFFECTS: PRESENCE

- The experience of presence is especially profound in VEs, even more so in high-immersive ones (i.e. VR!!)



Source: Steuer (1992, p. 81)

GHENT UNIVERSITY

PHYSIOLOGICAL EFFECTS: USER EXPERIENCE

- Users may also experience physiological effects in VEs
  - Physiological responses to (increasingly intense) user experience in VEs
    - E.g.: experiencing anger in VEs will lead to increases in heart rate, blood pressure, galvanic skin response, respiration, skin temperature (Macedonio et al., 2007)

GHENT UNIVERSITY

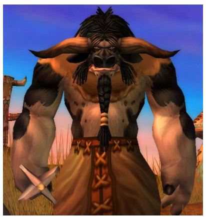
PHYSIOLOGICAL EFFECTS: CYBERSICKNESS

– Cybersickness: the experience of dizziness, light-headedness and nausea after spending time in VEs (especially those that are highly-immersive)
  – Can decrease over time, as users become more familiar with the experience of presence (Bailenson & Yee, 2006)
  – Type of technology and its sophistication have a big impact on it
    → Recent VR headsets and experiences tend to induce a lot less cybersickness!

GHENT UNIVERSITY

REPRESENTATIONS OF PEOPLE

– Realistic vs. cartoon
– Social interactions with:
  – Avatars: controlled by another human
  – Agents: computer-controlled by means of artificial intelligence



GHENT UNIVERSITY

REPRESENTATIONS OF PEOPLE

– Avatars vs. agents → different effects
  – More involvement and stronger physiological effects when people believe they are interacting with an avatar
    → People will behave and feel similar to how they would interact with a real person (Hoyt et al., 2003; Okita et al., 2008)

GHENT UNIVERSITY

REPRESENTATIONS OF PEOPLE

– Realistic presentations of avatars/agents (advances in photorealistic modeling, AI,…)
  → avatars/agents are becoming increasingly lifelike
  → and can greatly affect users' experiences within a VE

GHENT UNIVERSITY

READER

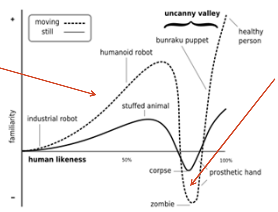
– Mori, M. (1970). The Uncanny Valley. *Energy, 7*(4), 33-35. [In Japanese]
  – Translated in English by MacDorman, K. F., & Kegeki, N. in 2012, and published in the *IEEE Robotics & Automation Magazine, 19*(2), 98-100.

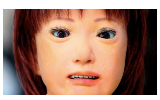
GHENT UNIVERSITY

UNCANNY VALLEY

– The phenomenon whereby an animated figure or robot that looks, moves and behaves almost – but not quite – human, arouses a sense of unease or revulsion in the person viewing it (Masahiro Mori, 1970)

Cute!





Creepy!

GHENT UNIVERSITY

UNCANNY VALLEY

UNCANNY VALLEY

UNCANNY VALLEY

NEW THEORETICAL CONSTRUCTS: TSI

- Unique nature of VEs also led to the discovery of new theoretical constructs
  - Transformed social interaction (TSI): VEs enable us to modify interpersonal communication in ways that are not possible in the real world
    - Enhance perceptual abilities
      - More personal information available
      - Multilateral perspective taking
    - Alterations in time and space (e.g. rewinding)
    - Changing self-presentation

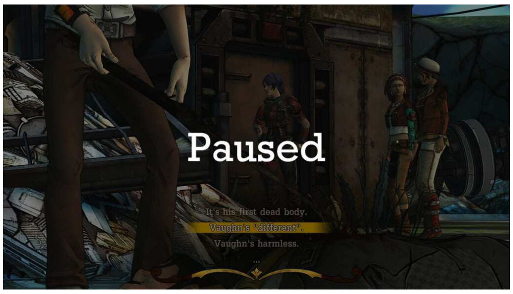
TSI: MORE PERSONAL INFORMATION AVAILABLE

TSI: MULTILATERAL PERSPECTIVE TAKING (FIRST-PERSON VIEW)

TSI: MULTILATERAL PERSPECTIVE TAKING (THIRD-PERSON VIEW)

TSI: MULTILATERAL PERSPECTIVE TAKING (GOD-LIKE VIEW)

TSI: ALTERATIONS IN TIME AND SPACE



GHENT UNIVERSITY

TSI: CHANGING SELF-PRESENTATION

- Proteus effect (Yee & Bailenson, 2007)
  - The user's behavior in the VE conforms to the modified self-representation, regardless of the true physical self

READER

- Yee, N., & Bailenson, J. (2007). The Proteus Effect: The Effect of Transformed Self-Representation on Behavior. *Human Communication Research, 33*(2007), 271-290.

GHENT UNIVERSITY

THE PROTEUS EFFECT

- What is the impact of users' self-representation in a VE on their behavior there?
  - If users' self-representation changes, will it change how they interact with others in the VE?

GHENT UNIVERSITY

THE PROTEUS EFFECT

- Yee and Bailenson proposed the existence of the Proteus effect based on several psychological theories:
  - Behavioral confirmation
  - Self-perception theory
  - Deindividuation theory

GHENT UNIVERSITY

BEHAVIORAL CONFIRMATION

- Behavioral confirmation: process whereby the expectations of one person (i.e. the perceiver) cause another person (i.e. the target) to behave in ways that confirm the perceiver's expectations (Snyder et al., 1977)
  - A type of self-fulfilling prophecy
  - Snyder et al. (1977): let male and female students interact over the phone
    - When male perceivers thought the female target was attractive, this caused her to behave in a more friendly and charming manner (regardless of how attractive she really was)

→ *Yee & Bailenson: also true for VEs and attractive avatars?*

GHENT UNIVERSITY

SELF-PERCEPTION AND DEINDIVIDUATION

- Behavioral confirmation: one potential pathway for avatars to change how a person behaves online
- But:
  - Might an avatar also change how a person behaves independent of how others perceive him/her?
    - When given an attractive avatar, does a person become more friendly and sociable regardless of how others interact with them?

→ Self-perception theory and deindividuation theory

GHENT UNIVERSITY

SELF-PERCEPTION THEORY

- Self-perception theory: people observe their own behaviors to understand what attitudes may have caused them (Bem, 1972)
  - People are going to interpret their own behaviors rationally in the same way that they try to explain other people's behaviors

GHENT UNIVERSITY

SELF-PERCEPTION THEORY

- Numerous experimental studies support the self-perception theory
  - Make participants take on several facial expressions and afterwards ask them how they feel (Laird, 1974):
    - Frowning → anger and aggression ↑
    - Smiling → happiness and social affection ↑
      - These emotions also spilled over to stimuli that were observed: cartoons were found to be more humorous in the smiling vs. frowning condition
  - Make participants believe that their heartbeat has increased while viewing a photograph of a person and ask them to rate the person's attractiveness (Valins, 1966): attractiveness ↑

GHENT UNIVERSITY

SELF-PERCEPTION THEORY

- Numerous experimental studies support the self-perception theory (cont.):
  - Make participants wear black (vs. white) uniforms: aggression ↑ (Frank & Gilovich, 1988)
    - Wearing a black uniform is a behavior that subjects used to infer their own dispositions
    - "Just as observers see those in black uniforms as tough, mean, and aggressive, so too does the person wearing that uniform"

    → subjects adhere to this new identity by behaving more aggressively
  - Also replicated in a VE! (Merola et al., 2006)
    - Using avatars with black vs. white robes: desire to commit antisocial behavior ↑

GHENT UNIVERSITY

DEINDIVIDUATION THEORY

- Deindividuation: the loss of self-awareness in groups
- Factors that lead to deindividuation (e.g. anonymity) might reinforce group salience and conformity to group norms
  - Often used to provide an explanation for a variety of negative, antinormative collective behavior, e.g. violent crowds, lynch mobs, genocide
  - But effects can be both anti- and prosocial!
    - In a teacher-learner experiment with electric shocks as punishment, subjects in costumes that resembled KKK robes delivered significantly longer shocks than subjects in nurse uniforms (Johnson & Downing, 1979)
    - Effects were stronger when subjects were made anonymous

GHENT UNIVERSITY

SELF-PERCEPTION AND DEINDIVIDUATION

- Deindividuation can also occur in online and virtual environments due to their anonymity and reduced social cues
  - In VEs, the avatar is the primary identity cue
  - Users may conform to the new identity (with its own expectations and stereotypes) that is inferred from their avatars
- Deindividuation + self-perception theory: users may conform to the behavior that they believe others would expect them to have

→ *Yee & Bailenson propose this as the Proteus effect!*

GHENT UNIVERSITY

EXPLORING THE PROTEUS EFFECT

- Yee & Bailenson: two experimental studies to explore the Proteus effect in VEs
  - Let participants interact with a confederate's avatar in VR
  - Study 1: manipulate the attractiveness of the participants' avatar
    - Hypothesis: attractive individuals are perceived to have more positive traits (e.g. be more extraverted, social) so this will reflect in participants' behavior: they will approach other avatars more closely and disclose more personal info
  - Study 2: manipulate the height of the participants' avatar
    - Hypothesis: taller individuals are perceived to be more competent and confident, so this will reflect in participants' behavior: they will behave in a more confident manner while negotiating

GHENT UNIVERSITY

EXPLORING THE PROTEUS EFFECT

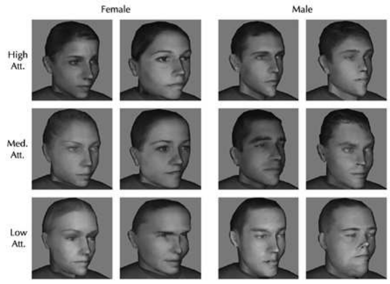


Figure 1 Faces with high, medium, and low attractiveness ratings by gender.

GHENT UNIVERSITY

CONFIRMING THE PROTEUS EFFECT

- The results of the two studies confirm Yee & Bailenson's expectations (and therefore, the Proteus effect)!
  - The appearances of participants' avatars had an impact on their behavior!
    - Participants with more attractive avatars approached the other avatar more closely and disclosed more personal information
    - Participants with taller avatars were more confident and aggressive while negotiating with the other avatar

GHENT UNIVERSITY

IMPLICATIONS

- Proteus effect: important theoretical framework for understanding behavior in VEs where users are able to choose/customize their avatar's appearance
  - In Yee & Bailenson's studies: only one interaction with another avatar
  - But: in virtual communities, thousands of users interact with altered self-representations!
    → The Proteus effect may impact behavior on the community level
      - If thousands of users interact, and they all have attractive avatars, will the community become more friendly and intimate?
      - If users spend a lot of time in these VEs, will the behavioral changes carry over to the real world?
      - Etc.

GHENT UNIVERSITY

APPLICATIONS

- Main application of VEs/VR/AR: entertainment!
  - Gaming
  - Non-gaming
    - Media: 360°/3D/VR video
      - Documentary & cinematic experiences
      - Events (e.g. sports, music)
      - Travel
      - …
    - Social (e.g. virtual worlds)

GHENT UNIVERSITY

FACEBOOK HORIZON

- *Welcome to Facebook Horizon, an ever-expanding, thriving VR world where you can explore, play, and create. There's no end in sight to the extraordinary adventures and amazing experiences you can have. Discover interesting communities, paint a masterpiece, or form a team and compete in action-packed games. You can build a Horizon World of your own using a variety of intuitive tools. Or get to know other Horizon citizens and be inspired by their creations. In Horizon, you are not just discovering a new world, you are part of what makes it great.*

APPLICATIONS BEYOND ENTERTAINMENT

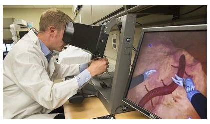
- VEs (and the psychological and physiological effects they can engender: especially presence!) are also being applied in other settings!
  - VEs are often used to create a more effective treatment or training environment

APPLICATIONS: SPACE

- NASA has run VR application programs since 1989
  - Uses VR in hardware development, operations development, support and missions operation training, e.g.:
    - It's cheaper and safer to train astronauts on the ground before they embark on a mission into deep space
    - NASA is also mapping Mars in VR, based on all the images that have been gathered of the planet's terrain over time → enables better planning of missions

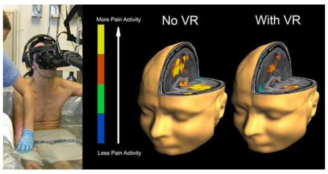
APPLICATIONS: MEDICAL

- Medical applications for VR include patient simulators, which enable trainee doctors to trial their techniques on virtual people
- Smart glasses using AR technology (e.g. Google Glass) have been used successfully to help during surgeries by:
  - Improving accuracy of needle placement
  - Delivering necessary information:
    - Remotely seeing X-rays (instead of having to walk away from operating table to go see the X-rays)



APPLICATIONS: MEDICAL

- But VEs (and especially VR) in medical contexts can also offer value to patients!
  - Physical rehabilitation
  - Pain management (VR as a distraction method)



APPLICATIONS: THERAPY

- VEs/VR in therapy:
  - Treat patients suffering from specific phobias
  - Stimulate specific problems (e.g. cravings, eating disorders)

  → cope with anxiety-inducing situations in a healthy manner (in a controlled, safe environment)

APPLICATION OF VR & AR: MILITARY

- VEs are also being used in a variety of military contexts (especially VR):
  - Flight simulators
  - Simulations of conflict scenarios
  - Development of cross-cultural communication skills (prepare for deployment to a different country)

VES AS A METHOD IN SOCIAL SCIENCE

- VEs are also very interesting tools for social scientists!
  - Advantages of using VEs as a method:
    - More realistic manipulations in experimental studies (e.g. “imagine standing at the edge of a precipice” vs. actually seeing the precipice in front of you)
    - Exact replication of experimental setting (e.g. same environment, objects and people in each session)
    - More control (no interference from cues that might disrupt studies in real world environments, e.g. ringing cell phones, presence of other people)

VES AS A METHOD IN SOCIAL SCIENCE

- Advantages (continued):
  - Creation of stimuli that are unavailable or difficult to manage in the real world (e.g. snakes, large crowds, children)
  - Real-time, rich and ‘objective’ data collection is possible (e.g. by recording people’s actions, gaze, etc.)

VES AS A METHOD IN SOCIAL SCIENCE

- These advantages of VEs regarding stimulus creation and data collection also enable the study of social psychological processes in VEs vs. real-life
  - Non-verbal behavior and behavioral mimicry
  - Social influence and interpersonal persuasion
  - Social facilitation and social inhibition
  - Prosocial behavior
  - Stereotyping and prejudices

STUDYING SOCIAL PSYCHOLOGICAL PROCESSES IN VES

- Non-verbal behavior and behavioral mimicry
  - For example: chameleon effect
    - If a virtual human undetectably mimics a participant’s head movements, the participant rates the agent more positively and is more likely to agree with the persuasive message than if no mimicry occurs (Bailenson & Yee, 2005)

STUDYING SOCIAL PSYCHOLOGICAL PROCESSES IN VES

- Social influence and interpersonal persuasion
  - For example: same-sex in-group favoritism
    - Participants demonstrate greater attitude change when they hear a persuasive message from a virtual human of the same sex as themselves (Guadagno et al., 2007)

STUDYING SOCIAL PSYCHOLOGICAL PROCESSES IN VES

- Social facilitation and social inhibition
  - For example: the presence of an audience of other avatars affects performance
    - Completion of an easy vs. a difficult task in the presence of avatars, agents, or alone
      - When people are told the virtual humans are human-controlled avatars rather than computer-controlled agents, their performance on easy tasks is boosted but their performance on difficult tasks is hindered (Hoyt et al., 2003)

GHENT UNIVERSITY

STUDYING SOCIAL PSYCHOLOGICAL PROCESSES IN VES

- Prosocial behavior
  - For example: helping an avatar
    - The same proportion of people help out or express concern for a virtual needy person as has been observed in real world studies (Gilliath et al., 2008)

GHENT UNIVERSITY

STUDYING SOCIAL PSYCHOLOGICAL PROCESSES IN VES

- Stereotyping and prejudices
  - For example: gender (sexism)
    - Participants exposed to a stereotype-confirming virtual female express more sexism and anti-woman attitudes than participants who encounter a non-stereotypical virtual female

GHENT UNIVERSITY

SEE YOU NEXT WEEK! ☺

- Don't forget to play your game...
- ...and fill out the gameplay diary/survey at least once per week!

GHENT UNIVERSITY

Opbouw ‘interactive media and entertainment’

Introduction
History and characteristics of IME
Fields of study related to IME
User experiences within IME (pt. 1 & 2)
Motivations for engaging with IME
Virtual environments (pt. 1 & 2)
Social media
Interactive media and persuasive communication
Interactive journalism
Interactive and social TV

Virtual Reality

A Survival Guide for the Social Scientist

Jesse Fox, Dylan Arena, and Jeremy N. Bailenson

Stanford University, Stanford, CA, USA

Abstract. In this article, we provide the nontechnical reader with a fundamental understanding of the components of virtual reality (VR) and a thorough discussion of the role VR has played in social science. First, we provide a brief overview of the hardware and equipment used to create VR and review common elements found within the virtual environment that may be of interest to social scientists, such as virtual humans and interactive, multisensory feedback. Then, we discuss the role of VR in existing social scientific research. Specifically, we review the literature on the study of VR as an *object*, wherein we discuss the effects of the technology on human users; VR as an *application*, wherein we consider real-world applications in areas such as medicine and education; and VR as a *method*, wherein we provide a comprehensive outline of studies in which VR technologies are used to study phenomena that have traditionally been studied in physical settings, such as nonverbal behavior and social interaction. We then present a content analysis of the literature, tracking the trends for this research over the last two decades. Finally, we present some possibilities for future research for interested social scientists.

Keywords: virtual reality, media effects, immersive virtual environments, computer-mediated communication, virtual worlds

Virtual reality (VR) was originally conceived as a digitally created space that humans could access by donning sophisticated computer equipment (Lanier, 1992; Rheingold, 1991; Sutherland, 1968). Once inside that space, people could be transported to a different world, a substitute reality in which one could interact with objects, people, and environments, the appearance of which were bound only by the limits of the human imagination. Images of people in bulky headgear, heavily wired gloves, and space age clothing became symbolic of the emergent technological revolution of computing and the possibilities of transforming the capabilities of the human mind and body. Futurists heralded VR as an imminent transition in the ways humans would experience media, communicate with one another, and even perform mundane tasks. In the early nineties, pioneering scientists began considering new ways this groundbreaking technology could be used to study social interaction and other psychological phenomena (Bente, 1989; Biocca 1992a,b; Loomis, 1992). In subsequent years, VR has continued to capture the imagination of scientists, philosophers, and artists for its ability to substitute our physical environment and our sensory experiences – what we understand as reality – with digital creations.

In the current paper, we seek to provide the reader not familiar with virtual reality technology with a fundamental understanding of its components and provide all readers with a comprehensive analysis of the role VR has played in social science. First, we define the nature of virtual reality and virtual environments. Next, we present an overview, designed for the nontechnical reader, of the hardware and equipment used to create virtual reality. Then, we discuss the history of VR research in the social sciences. From this literature, we delineate three ways in which social scientists have studied virtual reality: As a technology or medium in and of itself, wherein scientists pose questions about nature of the virtual experience and its effects; as an application, in which VR is used to create a more effective or efficient treatment or training environment to be implemented in a real world setting; and finally, as a method for studying social scientific phenomena in a novel, more effective, or more controlled manner. Next, we present our findings from a content analysis of this literature. Finally, we discuss future directions for VR research within the social sciences.

What Is a Virtual Environment?

A *virtual environment* (VE) is a digital space in which a user's movements are *tracked* and his or her surroundings *rendered*, or digitally composed and displayed to the senses, in accordance with those movements. For example, in a computer game, a user's joystick motions can be tracked and his or her character moves forward, rendering a new environment. Or, a Nintendo Wii player can physically swing the Wii remote, and the screen shows a bowling ball rolling down the lane. The goal of a virtual environment is to replace the cues of the real world environment with digital ones. According to Biocca and Levy (1995), "The blocking of sensory impressions from physical reality is a crucial part of the most compelling VR experiences. The senses are immersed in the virtual world; the body is entrusted to a reality engine" (p. 135). The psychological ex-

DOI 10.1027/1864-1105.21.3.95

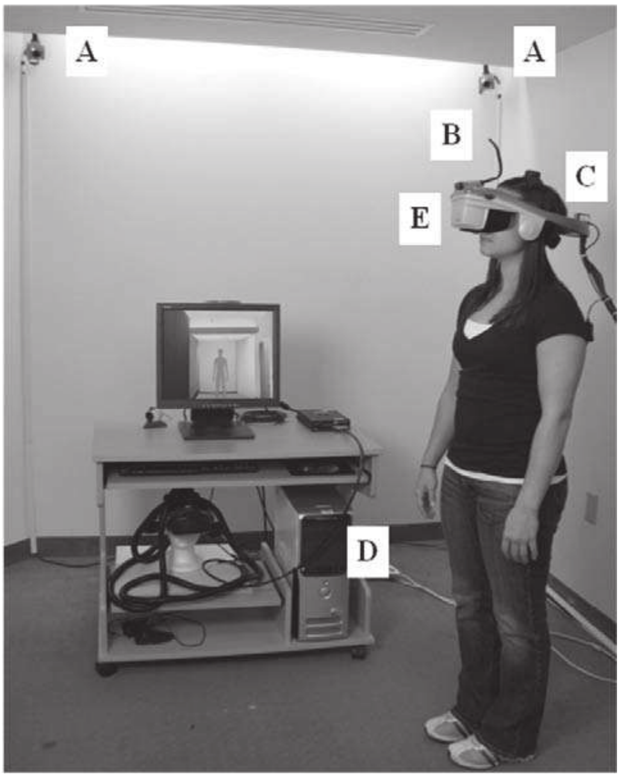


Figure 1. An example of a virtual environmental setup. Cameras (A) track an optical sensor (B) indicating the participant's position in the room. An accelerometer (C) gathers information about the participant's head movements. This information is relayed to the computer (D), which determines how the room is rendered and what the participant sees in the head-mounted display (E).

perience of losing oneself in the digital environment and shutting out cues from the physical world is known as *immersion* (Witmer & Singer, 1998). A VE can be implemented on any number of computer-based platforms, from a cellular telephone screen to a desktop monitor to a fully immersive virtual environment (IVE) in which a user can move around a physical space while wearing computer equipment. See Figure 1 for an example of a virtual environment.

The tracking and rendering process allows a much greater level of interactivity than traditional media. Unlike other media, a user in a virtual environment has a role within the medium, and his or her actions have an immediate and observable impact on the content of the medium. This interactivity may augment the effects of virtual environments because the user is typically active and cognitively engaged throughout the experience, in contrast to more passive media activities such as television viewing. Indeed, interactivity is one feature which contributes to making virtual reality so perceptually realistic because it reacts to our natural behaviors.

Because of the claims of many futurists in the early 1990s, when people hear the words "virtual reality," it is often with a dose of skepticism and technological trepidation: What happened to that bizarre world where everyone sits at home and experiences life in a funky helmet? The fact is that much of the high-end virtual reality technology featured in these futuristic fantasies has not diffused as quickly as other emergent technologies (e.g., cellular phones) because it remains too costly and cumbersome for everyday use. In the meantime, more simple virtual environments have become increasingly prevalent. People are generally unaware that low-end virtual reality using the cycle of tracking and rendering is a daily experience for many via computers, videogame consoles, and cellular phones. Considering that almost one of every four people worldwide (nearly 1.6 billion) uses the Internet (Internet World Stats, 2009), three of every five people use cellular phones (Jordans, 2009), and over 400 million videogames were sold last year (NPD Group, 2009), it is clear that low-immersive virtual environments are becoming a significant part of human existence around the world. The prevalence of exposure to VEs, and particularly their increasingly common use for social interaction, suggests that they are a necessary topic of social scientific study.

Why is VR of Interest to Social Scientists?

Many scholars have been involved in the introduction of VR to the social sciences, but three are notable for their contributions. Communication scholar Frank Biocca popularized the approach of studying VR as a medium through a series of influential journal articles (Biocca, 1992a,b; Lanier & Biocca, 1992) and the subsequent publication of *Communication in the Age of Virtual Reality*, coedited with Mark Levy, in 1995. Jack Loomis brought one of the first VR labs to a psychology department in the late eighties and published a landmark paper on the construct of presence in 1992 (Loomis, 1992). In the late nineties, Jim Blascovich joined Loomis and established a major research center at the University of California at Santa Barbara based on using immersive VR to study the social sciences. Blascovich and colleagues developed the theoretical and structural foundation to foster numerous research programs. It is worth noting that these scholars not only performed pioneering research in their own labs, but also focused their efforts on reaching out to other scholars in their respective disciplines and encouraging them to explore the possibilities of these new technologies.

As all three of these scholars argue, the utility of virtual reality for social science is inherent in the nature of the technology. One of the major goals driving the design and development of VR was to provide a space for people to interact without the constraints of the physical world (Lanier, 1992). As Biocca and Delaney (1995) noted, "VR is a medium for the extension of body and mind" (p. 58). Given the ability to recreate both real and fantasy environments and the multitude of sensory experiences within each, VR presents the opportunity to explore many social and psychological phenomena – both those that occur in the physical world as well as novel experiences unique to VR.

In addition, social scientists are taking interest in VR as an emergent medium that is playing a growing role in our everyday lives, facilitating both traditional mass media functions and interpersonal interactions. Although we have yet to enter an age where our communication occurs mostly in fully immersive virtual environments, the widespread adoption of the Internet and reliance on mobile media devices indicates that this transition may be imminent.

Hardware Setups

Virtual environments come in many forms, and often these are determined by the capabilities of the platform or hardware with which one is experiencing the VE. Virtual environment hardware may be something as simple as a cellular phone or as complex as a fully immersive virtual reality setup, which incorporates wearable equipment that allows the user to move in the physical environment.

The most rudimentary VEs are those available on desktop computers, mobile devices such as cellular telephones and handheld gaming devices, and traditional videogame consoles. These environments may be two- or three-dimensional. Typically, keypresses and mouse or joystick movements are employed by the user to move a viewpoint or a representation, thus providing a simple form of tracking. The monitor then reflects these changes via appropriate rendering. For example, a user may press the right arrow key or tilt a joystick to the right to move a videogame character from left to right on the screen and progress through a depicted virtual environment. New technologies have increased the tracking ability and movement veridicality in desktop setups via webcams and remotes (e.g., the Nintendo Wii). More immersive VEs often use a *head-mounted display* (HMD) to render virtual environments. An HMD is comprised of a helmet or headpiece with LCD screens affixed in front of the eyes to provide a wide, stereoscopic view of the computer-generated environment (Chung et al., 1989; Furness, 1987; Sutherland, 1968).

An HMD may be used in a simple, nonmobile setup, wherein the user's body remains stationary and only head movements are tracked. Head orientation is typically tracked through a device, such as an *accelerometer,* which provides feedback regarding the pitch, yaw, and roll of the user's head. If the user is in a fully immersive virtual environment and permitted to move around in the physical space, *optical* (light-based) or *magnetic trackers* may be attached to the user to send information about the user's x, y, and z position (Meyer, Applewhite, & Biocca, 1992; also see Welch, 2009, for a history of tracking technologies). Some recent developments, such as the HIVE (huge immersive virtual environment; Waller, Bachmann, Hodgson, & Beall, 2007), feature portable, untethered equipment that enables users to move around in much larger spaces. Another type of fully immersive environment, such as the CAVE® (computer-assisted virtual environment; Cruz-Neira, Sandin, DeFanti, Kenyon, & Hart, 1992; Sutcliffe, Gault, Fernando, & Tan, 2006), involves the use of multiple cameras and projection screens in an enclosed room to give users the impression that they are surrounded by the VE.

More complex VEs employ hardware that addresses different sensory modalities beyond visual stimuli (Turk & Robertson, 2000). For example, auditory aspects of a virtual environment can be transmitted through headphones or speakers. Sound is interpreted by the brain three-dimensionally, so the ability for a virtual environment to create spatialized sound (e.g., a virtual human's voice coming from the direction of the speaker and growing louder as the speaker approaches) enhances the realism of the VE experience (Kalawsky, 1993; Loomis, Hebert, & Cicinelli, 1990; Zahorik, 2002). Matching appropriate auditory cues with visual cues also enhances realism; for example, the sound of a door slamming should coincide with the visual depiction of the slamming door.

The sense of touch has also been incorporated in VEs through the use of sensory gloves and other haptic devices (Lanier, 1992, 1997; Salisbury & Srinivasan, 1997; Tan & Pentland, 1997). Some haptic devices may be employed to allow a user to exert touch and grasp or move a virtual object. Other haptic devices enable the user to feel the texture of a surface or receive *force feedback*, a felt reaction that can occur, for example, when trying to depress an object and having it bounce back (Basdogan, Ho, Srinivasan, & Slater, 2000; Tan & Pentland, 1997).

Inside the Virtual Environment

VEs are usually characterized by the same basic elements we observe in our physical environment: ground, sky, and other components of external landscapes; the floors, ceilings, and walls of internal spaces; and both realistic and fantastic objects.

From the perspective of social science, the most interesting virtual objects are representations of people. Representations of people in VEs can vary from a high-fidelity virtual human to an anthropomorphized animal in an online role-playing game (see Nowak & Rauh, 2006, for a review), and this representation can have effects on both the user and observers (Castronova, 2004, 2005; Schroeder, 2002; Schroeder & Axelsson, 2006; Yee & Bailenson, 2007; Yee, Bailenson, & Ducheneaut, 2009). Beyond their appearance, these representations are distinguished by who or what controls their actions. *Avatars* are controlled by a human user, whereas *agents* are controlled by an algorithm (Bailenson & Blascovich, 2004).

When a virtual human is controlled by an algorithm, it is referred to as an *embodied agent* (Cassell, 2000). This distinction is worth noting because research has shown that people react differently when they believe a virtual representation is controlled by a human as opposed to a computer. Notably, when people believe they are interacting with an avatar, their physiological responses and behaviors are more similar to how they would interact with a real person (Hoyt, Blascovich, & Swinth, 2003; Okita, Bailenson, & Schwartz, 2008)

According to Reeves and Nass's (1996) media equation, humans have a limited ability to distinguish between real and mediated representations, as the brain has not evolved in response to the latter. Additionally, advancements in photorealistic facial modeling (Bailenson, Beall, Blascovich, & Rex, 2004), computational emotional models (Badler, Phillips, & Webber, 1992; Gratch & Marsella, 2005), and artificial intelligence to direct conversation (Bickmore & Cassell, 2005; Cassell, 2000) have enabled the creation of increasingly lifelike and interactive virtual humans, which has been shown to have an impact on users' experiences within the virtual environment (Bailenson et al., 2005; Bailenson, Yee, Merget, & Schroeder, 2006). Thus, virtual humans are a particularly compelling subject to study because research indicates that participants often react to virtual humans similarly to how they react to real people (Donath, 2007; Garau, Slater, Pertaub, & Razzaque, 2005).

VEs may also provide sensory information beyond the visual; for example, sound effects and ambient noise are often implemented to bolster the user's feelings of immersion in the VE (Västfjäll, 2003). Social scientists may wish to use these cues to enhance the user's immersion, or they may wish to examine the role of such cues within the unique space of a VE. For example, Williams, Caplan, and Xiong (2007) found that in *collaborative virtual environments* (CVEs), VEs in which multiple people are networked and share tasks, participants' voices can have an effect on task outcomes as well as perceptions of others. Touch may also be incorporated in virtual interactions with haptic devices (Haans & Ijsselsteijn, 2005; Lanier, 1997). Like human touch, virtual touch may be used to apply force and move virtual objects (Tan & Pentland, 1997), to perform a collaborative task (Basdogan et al., 2000) or to communicate and express emotions (Bailenson, Yee, Brave, Merget, & Koslow, 2007). These technologies enable social scientists to create rich virtual environments in which they can study a range of multisensory phenomena.

VEs in Social Science

There are three primary ways virtual environments have been incorporated in the social sciences. First, VEs have been studied by social scientists as *objects* in and of themselves. What is the human experience like within a VE that is similar to or different from the experiences in the physical world? For example, researchers are interested in how VEs can be used to evoke emotional reactions. Secondly, VEs have been created with the intention of *application* outside of the laboratory in order to achieve real world goals. For example, surgical VEs have been developed to familiarize doctors with new medical procedures. Finally, VEs have been used as a *method* to study social scientific phenomena, enabling the replication and extension of real world experiments in a more controlled environment and also helping researchers create stimuli that may be too costly or impractical to achieve in the real world. For example, several researchers have used VEs to study how people react to certain forms of nonverbal communication or whether stereotyping of interactants occurs. These different categories of research present several angles from which a social scientist may be interested in studying or implementing VEs.

In our discussion here we focus predominantly on immersive virtual environments as opposed to online VEs or videogames (for these topics, see Anderson, Gentile, & Buckley, 2007; Barab, Hay, Barnett, & Squire, 2001; Cassell & Jenkins, 1998; Castronova, 2005; Dede, 2009; Vorderer & Bryant, 2006; Williams, 2006; Yee, 2006a,b), because there is no current literature that reviews the extent of social scientific work on and in IVEs.

Virtual Environments as Objects of Social Scientific Study

When virtual reality first emerged in social science, it was because researchers were interested in studying the different aspects of VR as a potential new medium. As with other media, research became focused on evaluating the form and content of VR and how variations in each affected the user (Petersen & Bente, 1991).

One variable of interest is *presence* (also referred to as *telepresence*), the user's feelings that the mediated environment is real and that the user's sensations and actions are responsive to the mediated world as opposed to the real, physical one (Biocca, Harms, & Burgoon, 2003; Lee, 2004; Lombard & Ditton, 1997; Loomis, 1992; Riva, Davide, & Ijsselsteijn, 2003; Slater & Steed, 2000; Steuer, 1992; Wirth et al., 2007; Witmer & Singer, 1998). The user experiences presence as "being there" or "losing oneself" in the mediated environment (Lombard & Ditton, 1997). Although presence has been examined in the context of other media such as television and books, because of the immersive nature of the virtual experience, it is of particular importance to VE researchers. Presence may be a result of characteristics of the technology used (Ijsselsteijn, de Ridder, Freeman, Avons, & Bouwhuis, 2001), aspects of the environment such as graphic realism (de Kort & Ijsselsteijn, 2006; Ivory & Kalyanaraman, 2007), or individual differences among users (Sacau, Laarni, & Hartmann, 2008). The examination of presence is important as previous studies have shown that the subjective experience of presence can impact the effectiveness of virtual treatments (Villani, Riva, & Riva, 2007) and the degree to which these stimuli translate into real world behavior (Fox, Bailenson, & Binney, in press; Persky & Blascovich, 2008; Price & Anderson, 2007). In a review of the research, Lee (2004) identified three different aspects of presence, including *physical, spatial,* or *environmental presence* (the feeling that you are in a particular virtual space; Lee, 2004), *social presence* (the feeling that another person is sharing the virtual space with you; Biocca et al., 2003), and *personal* or *self-presence* (the experience of a virtual self-representation as an extension of the self; Ratan, Santa Cruz, & Vorderer, 2008).

VEs can also be designed to evoke emotional responses. The EMMA project, for example, was created to explore the utility of VEs as "mood devices" to manipulate users' feelings while in a virtual space (Riva et al., 2007). A VE can be designed to evoke a particular emotion by depicting scenes such as a sad-looking park with an empty playground and a gloomy sky (Alcañiz, Baños, Botella, & Rey, 2003), a relaxing park with sunshine and soothing cues (Riva et al., 2007), or an anxiety-inducing room full of snakes (Bouchard, St-Jacques, Robillard, & Renaud, 2008). Virtual humans can also be used to influence users' emotions through their actions, dialog, and portrayed expressions (Gratch & Marsella, 2005; Kamada, Ambe, Hata, Yamada, & Fujimura, 2005; Nijholt, 2004; Rizzo, Neumann, Enciso, Fidaleo, & Noh, 2001).

In addition to the psychological effects of VEs, users may also experience physiological effects. One well-documented effect is *cybersickness* or simulator sickness. Some users, particularly those susceptible to light-based stimuli, may experience dizziness, light-headedness, and nausea after spending time in VEs, particularly if the VEs are fully immersive (Stanney & Salvendy, 1998). Several studies have demonstrated that beyond individual sensitivities (e.g., susceptibility to motion sickness or a history of migraines), the type of technology, its level of sophistication, and the time spent immersed may also play a role (Sharples, Cobb, Moody, & Wilson, 2008; Stanney, Hale, Nahmens, & Kennedy, 2003). For example, an increase in *lag*, or the time delay between the user's actual motions and the updating of the visual scene, is an issue of the technology that may cause illness. A recent longitudinal study, however, has demonstrated that cybersickness tends to decrease over time as participants become more familiar with the experience of immersion (Bailenson & Yee, 2006).

Beyond simulator sickness, researchers have also investigated other physiological responses to VEs, as they may be indicators of psychological states (Blascovich, 2000). Macedonio, Parsons, Diguiseppe, Weiderhold, and Rizzo (2007) successfully used virtual environments to induce anger, leading to increases in heart rate, blood pressure, galvanic skin response, respiration, and skin temperature. Bullinger et al. (2005) found that combining a provocative VE with a stressful cognitive task caused an increase in the generation of the stress hormone cortisol, whereas neither stimulus alone affected cortisol. Meehan, Razzaque, Insko, Whitton, and Brooks (2005) were able to increase participants' heart rate and skin conductance (i.e., perspiration) with a virtual height simulation, and also found that these increases served as good measures for participants' experience of presence. Slater, Guger et al. (2006) found that participants responded physiologically to interaction with a virtual human as if it were a real person. Additionally, Slater, Antley et al. (2006) found that heart rate and galvanic skin response can also be used to identify breaks in presence, or when participants are reminded of the fact that they are physically in the real world while they are immersed in the virtual world. Baumgartner, Valko, Esslen, and Jänke (2006) tracked brain activation as participants were exposed to a virtual roller coaster that made a continuous loop as well as a more realistic ride that made twists, turns, and dives. In addition to experiencing increased electrodermal activity, participants reported greater spatial presence in the realistic condition. An EEG also revealed greater activation of the brain areas related to spatial navigation during the realistic coaster. As the measurement of brain activity and physiological responses becomes increasingly accurate and mobile, it is likely that researchers will continue to explore these effects within the context of virtual environments using technologies such as fMRI (Baumann et al., 2003; Mraz et al., 2003).

The unique nature of virtual environments also led to the discovery of new theoretical constructs. Virtual technologies enable us to modify interpersonal communication in novel ways that we could not achieve in the real world, resulting in *transformed social interaction* (TSI; Bailenson, Beall, Loomis, Blascovich, & Turk, 2004; Bailenson, Beall et al., 2005). According to Bailenson, Beall, Loomis et al. (2004), TSI presents advantages over traditional forms of communication in three realms. First, TSI presents users with the opportunity to enhance their normal perceptual abilities (Bailenson & Beall, 2006). For example, participants might be able to see other participants' names, affiliations, or other relevant personal information hovering over their avatars. Participants can also view an environment from different points in the room through *multilateral perspective taking*. Second, VEs also enable manipulations of the context of the interaction including time and space (Bailenson & Beall, 2006); participants may choose to "rewind" a conversation to hear part of it again, or "pause" while they collect their thoughts. Third, and perhaps the most fruitful realm for TSI research, is controlling self-representation, namely "decoupling the rendered appearance of behaviors of avatars from the human driving the avatar" (Bailenson & Beall, 2006, p. 3). For example, *identity capture* entails obtaining the participant's image and using software to morph it with other individuals' images. Blending the two representations gives the other individual some of the more familiar features of the self; the resulting similarity and familiarity breeds more liking of this individual (Bailenson, Garland, Iyengar, & Yee, 2006).

The *Proteus effect* is a particular application of TSI in which a user's self-representation is modified in a meaningful way that is often dissimilar to the physical self. When the user then interacts with another person, the user's behavior conforms to the modified self-representation regardless of the true physical self or the other's impressions (Yee & Bailenson, 2007; Yee et al., 2009). For example, when participants embody attractive avatars, they disclose more personal information and approach another avatar more closely. When participants embody taller avatars, they are more confident in a negotiation task (Yee & Bailenson, 2007).

Another method of transforming the self-representation involves the use of a virtual human that is photorealistically similar to the physical self but behaves independently of the self. This representation can be modified to have an experience or perform a behavior that the user has not or currently cannot. After this exposure, users are more likely to imitate the behavior that the virtual self modeled. For example, Fox and Bailenson (2009) found that users who had seen their virtual selves exercise in a VE reported performing more exercise in the following 24 h than those who had not. Simply transforming the self-representation in the virtual world led to a desirable behavior in the real world.

As these studies have shown, the manipulation of different characteristics of a virtual environment can have a profound impact on the user, both psychologically and physiologically. Not only do these features of VEs have immediate effects within the environment, but these effects can carry over into the real world, indicating that VEs have the potential to become powerful tools in the applied realm.

Applications of Virtual Environments

As virtual reality has gained traction in the social sciences, innovative scholars have begun exploring its viability in the creation of novel stimuli, treatments, and learning environments for use outside of the laboratory. One of the most common applications of VEs is via virtual reality exposure therapy (VRET; Gregg & Tarrier, 2007; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008; Riva, 2005; Rothbaum, Hodges, & Kooper, 1997). Psychiatric researchers realized that VEs could be used to treat patients suffering from a specific anxiety or phobias. In the virtual environment, patients are gradually introduced to the negative stimulus in a virtual setting until they become desensitized or are able to cope with their fear or anxiety. VRET has been used to treat acrophobia (the fear of heights; Coelho, Santos, Silvério, & Silva, 2006), agoraphobia (fear of open spaces; Botella et al., 2007), arachnophobia (fear of spiders; Cote & Bouchard, 2005); aviophobia (fear of flying; Rothbaum, Hodges, Smith, Lee, & Price, 2000); public speaking anxiety (Harris, Kemmerling, & North, 2002), panic disorder (Botella et al., 2007) and social phobia (Roy et al., 2003). VRET has also been employed in the successful treatment of combat-related posttraumatic stress disorder (PTSD; Reger & Gahm, 2008; Rothbaum, Ruef, Litz, Han, & Hodges, 2003).

VEs have also been explored as a tool for cognitive behavioral therapy. Researchers have found that virtual cues can be used to stimulate alcohol cravings (Cho et al., 2008) and nicotine cravings in cigarette smokers (Baumann & Sayette, 2006). Thus, it is expected that these stimuli may be used therapeutically to teach addicts to cope with craving-inducing cues in a variety of situations. VEs have also been used in studying patients with eating disorders by exposing them to high-anxiety environments such as a kitchen filled with fattening foods and examining patients' emotional reactions (Gutiérrez-Maldonado, Ferrer-García, Caqueo-Urizar, & Letosa-Porta, 2006). Researchers expect that these environments will be incorporated in therapy in which patients learn to cope with anxiety-inducing situations in a healthy manner.

Another increasingly common application is the use of virtual reality therapy in physical rehabilitation (Schultheis & Rizzo, 2001; Sveistrup et al., 2003). Virtual environments have two features that uniquely facilitate physical rehabilitation: The ability to capture and review one's physical behavior three-dimensionally, thus enabling a close and interactive examination of one's progress and failures, and the ability to see one's own avatar rendered in real time from a third-person point of view (Bailenson et al., 2008). Additionally, virtual environments can be used to safely recreate real environments that might be challenges for those who have suffered an injury (e.g., crossing a busy intersection). VEs have been used to help stroke victims regain a sense of balance while walking (Deutsch & Mirelman, 2007) and help children with cerebral palsy develop muscular coordination (Bryanton et al., 2006). The visual nature of VEs has also facilitated novel treatments for children with amblyopia ("lazy eye"; Eastgate et al., 2006).

Aside from these applications, VEs have been employed in a variety of other medical contexts. VEs have been shown to be an effective distraction method for helping patients manage pain (Gold, Belmont, & Thomas, 2007; Hoffman et al., 2008). Children exposed to an interactive distraction in an HMD as opposed to other forms of distraction significantly increased their pain tolerance and pain thresholds (Dahlquist et al., 2007). Virtual models of the human body have become popular interactive tools for teaching medical students, nurses, and doctors the basics of human anatomy as well as complicated surgical procedures (O'Toole et al., 1998; Spitzer & Ackerman, 2008). VEs have also been used to teach medical personnel communication and decision-making skills because they can portray a variety of situations, from a regular checkup to the chaos of an emergency room, that practitioners may face (de Leo et al., 2003; Johnsen et al., 2006; Kenny, Rizzo, Parsons, Gratch, & Swartout, 2007; Mantovani, Castelnuovo, Gaggioli, & Riva, 2003).

The military has also taken an active interest in the development of training environments. One of the earliest applications of VR was the development of flight simulators, which provided pilots with a safer and less expensive way to learn flying skills (Furness, 1987; Pausch, Crea, & Conway, 1992). Virtual simulations of conflict scenarios have been used to teach soldiers how to make quick and effective decisions under stressful circumstances (Hill et al., 2003). VEs have also been used to help soldiers develop cross-cultural communication skills to prepare for their deployment to a different country (Deaton et al., 2005).

Aside from medical and military interests, several industries have taken interest in the ability to create VEs for training purposes and networked collaboration spaces. Although the initial development is rather involved, creating a VE for training employees is an overall less expensive, less risky, less variable, and possibly more effective method than hands-on training (which may interfere with productivity or present a safety issue) or traditional media (which do not permit interactivity or "hands on" practice; Brough et al., 2007). Another opportunity to incorporate VEs is through the development of virtual workplaces (Wilson & D'Cruz, 2006) or collaborative virtual environments that allow interaction via avatars (Benford, Greenhalgh, Rodden, & Pycock, 2001; Joslin, Di Giacomo, & Magnenat-Thalmann, 2004; Normand et al., 1999; Reeves, Malone, & O'Driscoll, 2008).

Because both training and collaboration can be facilitated by a virtual environment, it is unsurprising that a great deal of research energy is going toward the development of virtual classrooms (Moreno & Mayer, 2007). Digital enhancements offer unlimited opportunities for infusing the subject matter directly into the classroom, whether that entails making a Tyrannosaurus Rex appear next to the teacher during a science lesson or having Mark Twain lead a literature class about Huck Finn's adventures. Additionally, classroom variables can be manipulated to create the optimal learning environment. For example, sitting at the front of the classroom and receiving the majority of the teacher's eye gaze both enhance student learning, but these factors are not achievable for every student in a physical classroom as there are only so many seats and so much time a teacher can spend attending to a single student. In the virtual classroom, however, these factors can be manipulated so that every student receives these benefits; indeed, research has demonstrated that these virtual manipulations result in greater learning (Bailenson, Swinth et al., 2008).

VEs as a Method to Study Social Scientific Phenomena

The pioneering work of Jim Blascovich and colleagues led to the use of virtual environments to study social and psychological phenomena. Blascovich et al. (2002) cited several advantages to using VR in studies. First, VR allows the researcher to create experimental situations with more mundane realism, thus making participants' reactions to the stimuli more genuine than the typical combination of written vignettes and questionnaires (Blascovich et al., 2002). For example, rather than invoking fear by asking participants to imagine standing at the edge of a precipice or giving them a written passage describing the scenario, VR allows participants to be immersed in that situation and to see the precipice in front of them. VR and other networked technologies may also help alleviate the problem of nonrepresentative sampling (Blascovich et al., 2002). Rather than relying on immediately available participants, networked environments allow the inclusion of samples from distal locations, thus providing variation in the participant pool. Another issue VR helps resolve is the lack of exact replication of the experimental setting and stimulus (Blascovich et al., 2002). Consider, for example, the use of confederates. When the confederate stimulus is computer-programmed, the variability of that presentation is limited and precisely replicated down to the second and millimeter (Bailenson, Blascovich, Beall, & Loomis, 2001). In the real world, however, multiple confederates may vary on their demographic characteristics, appearance, or nonverbal behaviors in a way that causes unintentional variation in the stimulus. Even the same confederate may vary from day to day on eye contact, manner of dress, or degree of precision in adherence to the experimental script. VR can provide more control for such fluctuations to ensure that unintentional cues are avoided. Additionally, VR can be used to create a variety of environments (e.g., a shopping mall, a doctor's office, a movie theater, or an airplane cabin) in a controlled manner, thus providing the advantage of being able to study occurrences in these places without interference from other cues that might disrupt studies in corresponding real world environments (e.g., the smell of food or ringing cell phones). In the same vein, VR can be used to create stimuli that are unavailable or difficult to manage in the real world, such as large crowds, snakes, or children.

This ability to selectively craft stimuli is part of the reverse engineering approach (Bailenson et al., 2001; Bente, Krämer, Petersen, & de Ruiter, 2001; Bente, Petersen, Krämer, & de Ruiter, 2001). In the physical world it is very difficult to filter out the multitude of cues that contribute to any given experience. For example, if communication researchers want to study the effect of body posture on perceptions of a speaker's credibility, they must deal with several confounding cues, such as the speaker's natural facial expressions, head movements, and gestures. Using a virtual stimulus, however, these cues can all be removed or neutralized; also, the exact same stimulus can be created initially, with only a slight change in the programming to create the body posture manipulation. The main advantage of this approach is that the variable of interest is effectively isolated and can be examined without confounds.

Another benefit of the reverse engineering approach is the ability to replicate traditional theoretical studies in a more "pure" fashion given this control. Social scientists may take their pick of theories and put the relevant constructs to the test using VEs. For example, Fox and Bailenson (2009) implemented social cognitive theory (Bandura, 1977, 2001) in a study of exercise behavior modeling and were able to uniquely examine the concept of identification by using a virtual stimulus that varied only in the presentation of the model's face, which was either the self or an unknown other. Human models would have varied on other dimensions, such as height, weight, and body shape, which might have confounded the manipulation of interest.

Several methods for studying social scientific phenomena within virtual environments have been proposed (Blascovich et al., 2002; Loomis, Blascovich, & Beall, 1999; Schroeder, 2002; Schroeder, Heldal, & Tromp, 2006). Typical methods of assessment and data gathering such as survey responding, observation, and audiovisual recording work in VEs as easily as in other contexts, but VEs offer several advantages for data collection. Scripts for created virtual environments can be written to automatically record data regarding the user's movements, gaze, and gestures, alleviating the subjective and often painful process of having coders review videotape. These functions also gather data almost continuously, reporting at fractions of a second that are too minute for human coders to distinguish. VEs also enable this data to be integrated in real time with multiple networked participants (e.g., Bente, Rüggenberg, Krämer, & Eschenberg, 2008). Automatic data collection from online virtual worlds can provide information on task performance and social and economic exchange (Bainbridge, 2007). Additionally, many online environments permit the launch of specific modules that can be custom-built by computer programmers to record the exact data a researcher wants and filter out unwanted metrics (e.g., Friedman, Steed, & Slater, 2007; Yee & Bailenson, 2008; Yee, Bailenson, Urbanek, Chang, & Merget, 2007).

These advantages in stimulus creation and data collection have enabled researchers to examine a wide variety of sociopsychological phenomena. In the following section, we review in detail the findings of studies in virtual environments on nonverbal behavior, including eye gaze and proxemics; behavioral mimicry; interpersonal persuasion; social anxiety; social facilitation and inhibition; leadership; prosocial behavior; and prejudice and stereotyping.

Nonverbal behavior was one of the first subjects of social scientific study in virtual environments. Bente and colleagues (Bente, 1989; Bente, Feist, & Elder, 1996; Bente, Krämer et al., 2001; Bente, Petersen et al., 2001) were among the first to use computer animated humans to study nonverbals. The researchers videotaped dyadic interactions and then rendered the nonverbal behaviors of the participants using virtual humans. Participants were asked to judge their impressions of the interactions for the video and animation, and only marginal differences were identified between the two stimuli. Bailenson et al. (2001; Bailenson, Blascovich, Beall, & Loomis, 2003) replicated some work on proxemics using a VE. Similar to real world findings, the researchers observed that participants who approached a virtual human treated it like a real person and maintained its "personal space" by not getting too close. Also reflective of real world proxemic behavior, participants maintained more space in front of the avatar when facing it than when asked to walk around to its back side. The researchers also found support for equilibrium theory with virtual humans: That is, participants came closer to an avatar that was not looking at them, but when the avatar made eye contact and they shared gaze, participants maintained a greater distance. Friedman et al. (2007) reported that users of Second Life abided by proxemics that paralleled those in the real world when interacting with other avatars. Yee et al. (2007) found a replication of real world proxemics and eye gaze in a study conducted in Second Life: Male pairs exhibited larger interpersonal distances and less eye gaze, whereas female pairs maintained smaller distances and used more direct eye gaze. In another study on eye gaze, Bente, Eschenberg, and Krämer (2007) found that, similar to face-to-face interactions, participants evaluated those that gave longer gazes more favorably than those who gave shorter gazes.

Bailenson and Yee (2005, 2007) incorporated nonverbal communication in their VE-based studies examining Chartrand and Bargh's (1999) *chameleon effect*, the notion that an individual is more persuasive if he or she mimics the nonverbal behaviors of the target. They found that if a virtual human undetectably mimicked a participant's head movements, the participant rated the agent more positively and was more likely to agree with the persuasive message than if no mimicry occurred (Bailenson & Yee, 2005). This result was also replicated using another form of nonverbal communication, a virtual handshake (Bailenson & Yee, 2007).

These findings indicate that users can implement aspects of virtual technology to facilitate persuasive outcomes. Because of the prevalence of online persuasive environments such as shopping websites and political chatrooms, as well as the transition of many of our daily communications to digital venues such as email and instant messaging, it is natural that virtual social influence has been a growing area of study. Now that 3-D environments and more lifelike agents and avatars are being implemented in these interactions, we can expect that increasing numbers of these persuasive messages will be delivered using a virtual human (Nijholt, 2004). The model of social influence in immersive VEs proposed by Blascovich (2001; Blascovich et al., 2002) has provided the groundwork for a large number of such studies.

Several researchers have explored the use of virtual humans as mechanisms for social influence. Guadagno, Blascovich, Bailenson, and McCall (2007) found that same-sex in-group favoritism, a common effect in the real world, also occurred in a virtual persuasive environment. Participants demonstrated greater attitude change when they heard the persuasive message from a virtual human of the same sex as themselves. Skalski and Tamborini (2007) used interactive and noninteractive agents to deliver a persuasive health message. Participants who encountered an interactive agent demonstrated a greater change in attitudes and intentions: They placed greater importance on the value of getting one's blood pressure checked and were more likely to schedule an appointment for a blood pressure reading. Read et al. (2006) found that men who role-played in an interactive virtual environment in addition to receiving safe sex counseling reduced their risky sexual behaviors more than those who only received counseling. Eastwick and Gardner (2009) explored sequential request techniques in virtual worlds. As in the real world, using a foot-in-the-door or a door-in-the-face technique to gain compliance was more effective than merely making a direct request.

In addition to their use as agents of influence, virtual humans can be used to elicit the same psychological responses people experience in the presence of real humans, such as social anxiety. Garau et al. (2005) found that socially anxious people were more likely than nonanxious people to avoid contact with agents in an IVE, indicating that the virtual humans also evoked apprehension in socially anxious participants. Slater, Pertaub, Baker, and Clark (2006) put confident and phobic people in a public speaking IVE and had them deliver a speech to either an empty room or a group of people. Confident speakers showed no difference in self-reported anxiety or heart rate, whereas phobic speakers demonstrated significantly more psychological and physiological anxiety in the populated room than in the empty room.

Because virtual humans evoke such responses, several studies have used them to examine *social facilitation* and *social inhibition*, the effects that an audience may have on task performance. Hoyt et al. (2003) asked participants to complete easy or hard tasks in the presence of two avatars, in the presence of two agents, or alone. When people were told the virtual humans were human-controlled avatars rather than computer-controlled agents, the hypothesized social facilitation effects occurred: Avatars boosted participants' performance on easy tasks but hindered their performance on difficult tasks. Park and Catrambone (2007) presented participants with similar tasks and tested them alone, in the presence of another person, or in the presence of a virtual human. The easy tasks were completed significantly faster when in the company of another person or a virtual human compared to the alone condition, but the difficult tasks took longer when another person or virtual human was present as opposed to being alone. Zanbaka, Ulinski, Goolkasian, and Hodges (2007) performed the same manipulation and found that these effects occurred whether the virtual human was projected or presented in an immersive environment. Blascovich et al. (2002) reported a similar finding in a virtual card-playing scenario: Participants playing with virtual humans tended to conform more to the virtual humans' betting behavior when told the other players were human-controlled avatars as opposed to computer-controlled agents.

Other interpersonal and group processes have been explored using VR. Gilliath, McCall, Shaver, and Blascovich (2008) studied prosocial behavior. They found that approximately the same proportion of people help out or express concern for a virtual needy person as has been observed in real world studies. Slater, Sadagic, Usoh, and Schroeder (2000) compared face-to-face and virtual groups and found that, despite the rudimentary nature of the VE, natural group processes such as leadership emergence and embarrassment occurred in both environments. Hoyt and Blascovich (2003, 2007) examined leadership using virtual environments. They manipulated transactional and transformational leadership styles in an IVE and found that participants' group performance and cohesiveness were equivalent to those who engaged in the same activity in the physical world (Hoyt & Blascovich, 2003). In another study, the authors used an IVE to activate sex stereotypes regarding leadership abilities and found that women with high levels of efficacy experienced reactance and outperformed low efficacy women (Hoyt & Blascovich, 2007).

Stereotyping and prejudice have been explored in other studies as well. Fox and Bailenson (2009) found that participants exposed to a stereotype-confirming virtual female in an IVE later expressed more sexism and antiwoman attitudes than participants who encountered a nonstereotypical virtual female. Groom, Bailenson, and Nass (2009) found that participants embodied in Black avatars in an IVE expressed more negative implicit attitudes toward Blacks than participants embodied in White avatars. Dotsch and Wigboldus (2008) placed Dutch participants in a CAVE® in which they encountered a White or a Moroccan agent. Participants maintained more personal distance with a Moroccan agent. Also, participants showed an increase in skin conductance levels when approaching a Moroccan in contrast to a White virtual human. Eastwick and Gardner (2009) noted that the effects of race carried over to online virtual environments as well; in their experiment, Black avatars were less successful using the door-in-the-face compliance technique than White avatars.

In sum, VEs have been successfully implemented to investigate a wide range of phenomena. In addition to this detailed literature review, we conducted a study to determine how many articles had been published about VR and what trends could be observed.

A Content Analysis of Social Scientific Research on VEs

To get a better sense of the ways in which virtual environments have been used in the social sciences, we undertook a content analysis of a sample of empirical articles about VEs in social science research. For each article in our sample, we determined which of the three previously described categories the article fit into, i.e., whether the VE studied in the article was the *object* of basic research, an *application* intended for real world use, or a *method* for facilitating the observation of some psychological phenomena that were the main focus of study. We also captured the institutional affiliation of the first author of each article so that we could investigate trends regarding dispersion of VE research among various academic disciplines over time.

Criteria for Article Selection

We created a coding scheme by specifying that we wanted to limit our analysis to empirical articles about virtual environments (VEs) in social science research. This specification has three key elements, which we codified as follows. If the article did not meet these three criteria, they were coded as *false positives*. First, the study must be empirical and report the collection of data that have not been published elsewhere. An article that summarized or reviewed relevant literature would not be included, nor would an article that describes various properties of a new VE without reporting results about its use. Second, the environment reported in an article must render some sort of virtual space that is presented to the user (this is usually a visual representation, but some such representations might be auditory or haptic) and must include some tracking mechanism for updating its rendering based on user input. An environment that would not qualify for inclusion is one in which users watch movement through a virtual space as "passengers" without any ability to change the rendered space or perspective, such as in an online 3-D movie. Third, we focused solely on social scientific research; that is, the data must include the behavior of at least one person other than the researcher(s). Thus, qualitative accounts of an individual's experience in a VE were excluded. Also, an article about a new peer-to-peer multicast system that only reported network latency measurements would not count as social science, because no results of human participation are reported.

Coding Criteria

Articles that met our criteria were then placed into one of the following three categories:

1) *Object:* The research is centrally concerned with the nature of the user's experience regarding the VE itself and the possible effects of that experience.
2) *Application:* The research is centrally concerned with creating and using a VE outside of the laboratory, for example in a psychiatrist's office or a corporate training center, to change how people behave in the real world.
3) *Method:* The research is centrally concerned with using a VE to examine real world phenomena. Research in this category may use the VE to manipulate variables that are not easy to replicate in the laboratory (e.g., simulating a crowd of people), potentially harmful in the real world (e.g., a busy intersection), or hard to control (e.g., the number of cues in a shopping mall that might encourage smokers to crave a cigarette).

Sample

Having established criteria for inclusion and categorization of articles, we next needed a master data set of scholarly articles from which we would sample. To create the data set, we searched the Web of Science from the online academic database ISI Web of Knowledge (http://www.webofknowledge.com/) for all journal articles or proceedings papers published before 2009 that included any of the terms "virtual environment(s)," "virtual world(s)," or "virtual realit(y/ies)" in their title, abstract, or keywords. On Monday, 23 Feb 2009, this search returned 6,617 articles, which constituted our population of articles.

Method

Using a coding scheme and a data set, we recruited a team of nine undergraduate research assistants to serve as coders for our analysis. We then performed two rounds of reliability training with these coders, using random samples of articles from our master data set (50 articles in the first round and 100 in the second). In each round, we had all coders categorize all articles in the sample as *object*, *application*, or *method* (or as a *false positive* if the article was not empirical, did not involve a VE, or was not social science); we then debriefed and came to consensus about how to code articles for which there had been disagreement.

After our second round of training, we divided our team so that five coders could concentrate on categorizing articles while another four coders could concentrate on finding first-author institutional affiliations. We then conducted a third and final training round with another random sample of 133 articles from our master data set. By the end of this third round of training, we calculated intercoder reliability using Fleiss's extension to Cohen's κ[1] (Fleiss, 1971) for our five-person categorization team and found an estimate of reliability of 0.61, which although somewhat low has been described as a "substantial" level of agreement (Landis & Koch, 1977) and was determined to be high enough for our purposes.

Because we had debriefed and come to consensus for every article about which there was disagreement in the three rounds of training, we already had 283 articles categorized with 100% agreement. We then assigned to each member of our 5-person categorization team another random sample of 100 articles, bringing the tally of categorized articles to 783; of these, 553 were coded as *false pos-*

[1] We also calculated Krippendorff's α (Krippendorff, 1980) to assess intercoder reliability; because our estimates using Krippendorff's α were extremely close to those using Fleiss's extension to Cohen's κ, we report only the latter throughout.

itives, leaving 230 articles that were coded as either *object*, *application*, or *method*. We divided these up among the members of our four-person affiliation team to find first-author affiliations. We did not further examine false positives or include them in the subsequent analysis.

Results

Examining our data, we were able to identify some trends in publications about VR. To determine these values, the number of relevant articles was divided by the total number of articles (230) to yield the percentages. First, as can be seen in Figure 2, social scientific studies examining VR as an object were most popular (41.3%), followed closely by VR applications (38.7%); only 20% of articles concerned the use of VR as a method for studying existing social scientific phenomena. Figure 3 demonstrates that VR studies began to emerge in the social scientific literature in the early nineties. All three categories have increased steadily over time, although in the last decade object and application studies have grown more rapidly than method studies.

The first author affiliation coding, seen in Figure 4, demonstrates that medical affiliations, including medicine, surgery, and psychiatry, were the most common (33.5%). This finding may be due to the fact that medical studies involve applications that are actively implemented in the training of medical students and doctors (Burdea & Coiffet, 2003), and such implementations present additional opportunities to collect and report data on the effectiveness of a system. Social scientific affiliations (e.g., psychology, communication, or education) were the second most common (31.7%). Because we were searching for social scientific studies, this finding is not surprising. Engineering studies (including computer science) were the third most common (29.1%); however, if we had not required human subject participa-

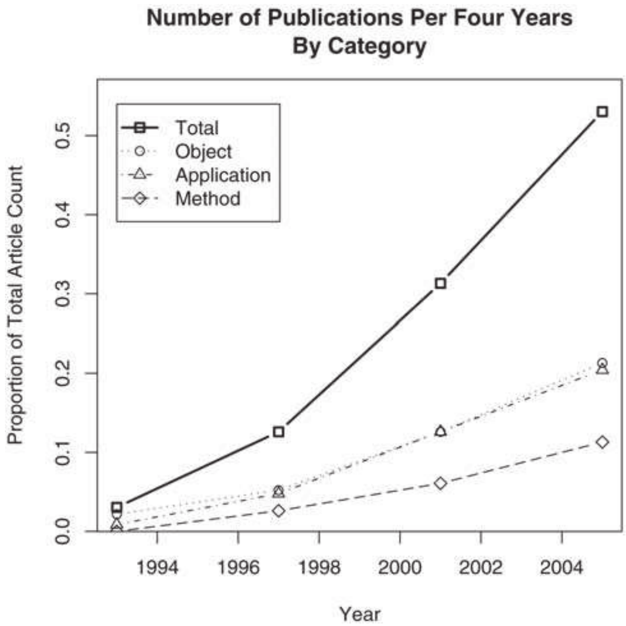


Figure 3. An examination of the three categories of VR studies over time.

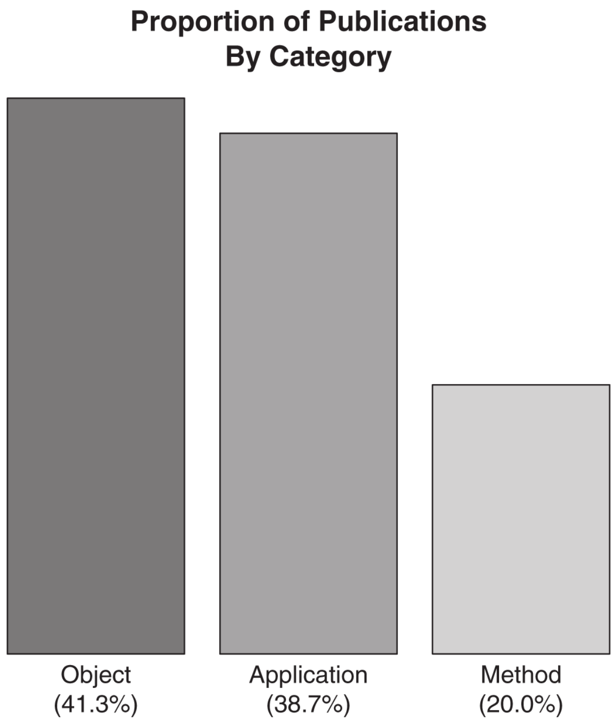


Figure 2. The distribution of articles categorized as object, application, and method.

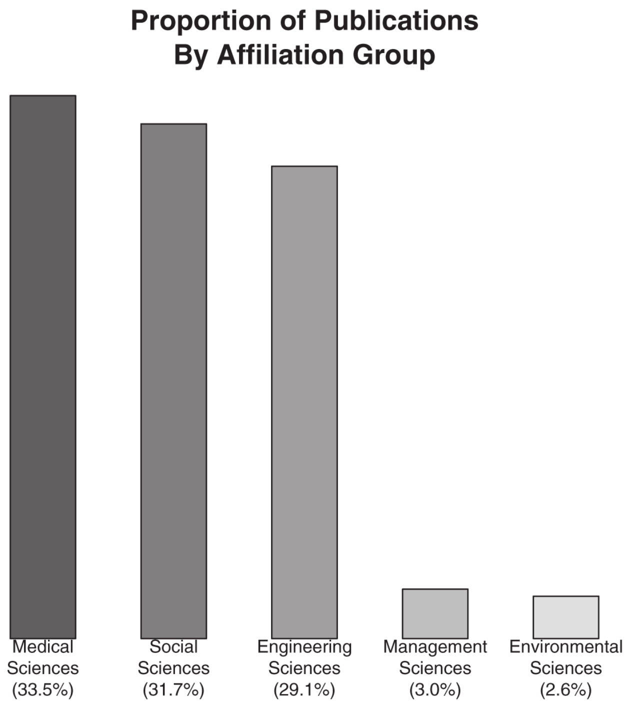


Figure 4. The first-author affiliations of our article sample.

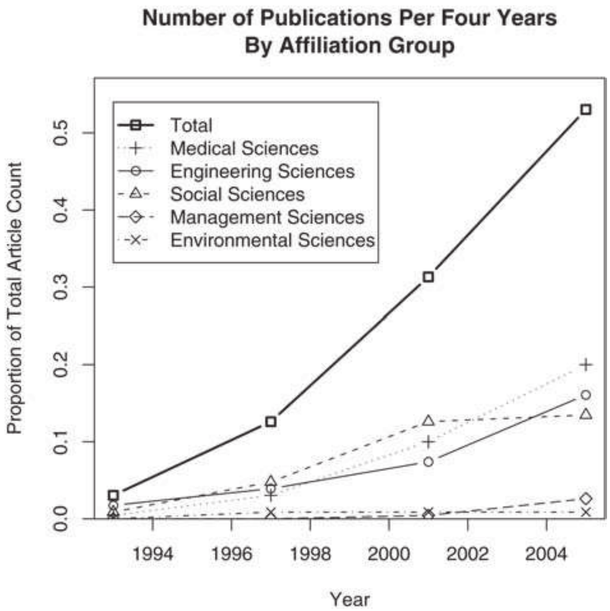


Figure 5. First-author affiliations over time.

tion, these studies would have likely predominated as engineering and computer science journals are rife with articles on emergent display, sensing, and tracking technologies. Since the early 1990s, all three of these categories have grown, although social sciences have remained steady since 2001 while engineering and medicine have continued to increase (see Figure 5). Finally, management sciences (e.g., business; 3%) and environmental sciences (2.6%) were represented in a couple of articles in our sample; however, they have not demonstrated much growth over time.

Future Directions: Where Can Social Scientists Go from Here?

We have seen that the social scientific study and implementation of virtual environments is becoming increasingly common. Because virtual technologies are still under development and testing, it is unsurprising that a large proportion of articles are devoted to the study of VEs as objects. We still have much to learn about the characteristics of the technology and their individual and cumulative sociopsychological impacts. The large number of application articles is also to be expected because the entities that wish to create VE applications, such as corporations and medical institutions, typically have more funding and personnel available to support such projects.

The results of the content analysis indicate that VEs are being underused as a method in the social sciences. The lack of usage is likely due to several factors. For example, many social scientists do not have a background in computers and technology. VEs are becoming increasingly user- and creator-friendly (Bartle, 2004), however, so a computer science degree is no longer necessary to understand and implement them. Computer literacy has become a fundamental aspect of education and essential to contemporary academia; thus, increasing numbers of scholars are emerging with the basic skill set needed for VE research. Another hindrance is that researchers are under the impression that VE research is cost-prohibitive. Although high-end equipment and fully immersive environments remain expensive, their costs are decreasing. Of greater interest is the availability of several online virtual environments, such as Second Life, that are free to use, accessible to any participant with an Internet connection, and relatively easy for researchers to modify.

With the technological and cost barriers removed, the individual scholar's question remains: "How can VEs benefit my line of research?" We can speculate about a number of future directions for the study of VEs as objects, the implementation of VEs as a method, and the application of VEs.

Communication researchers are presented with several different virtual media to explore as objects, perhaps implementing a traditional media effects paradigm and examining the characteristics of the medium, its content, and the cognitive, attitudinal, emotional, and behavioral effects on users (Bryant & Oliver, 2008). Although some basic questions have been addressed, little is known on the effects of different types of hardware setups on psychological and social outcomes. In the future, new explanatory models and theories for virtual experiences will emerge. Can we expect different effects on emotions, persuasive outcomes, aggression, and behavior from desktop VEs, physically tracked videogames like the Wii, and fully immersive virtual environments? What roles do interactivity and presence play in moderating or mediating these effects? It is possible that new theories and models addressing these specific aspects of new media will emerge, and VEs will be an effective platform with which to test them. Another issue is VE-specific content. What sort of trends in content are we seeing in existing VEs? Does this content reflect traditional media content, and will those trends continue with the emergence of new forms of VR technology? What novel forms of sensory content can we expect to emerge, and how will they be studied?

Media effects researchers should also consider transformed social interaction and the Proteus effect as fertile ground for examining how manipulations within the VE impact behaviors both inside and outside the virtual world. These concepts may be implemented to understand how traditional communication concepts may be altered in VEs. For example, CMC (computer-mediated communication) researchers have investigated the effects of different forms of self-presentation in online dating and social networking profiles (Gonzales & Hancock, 2008; Toma, Hancock, & Ellison, 2008; Walther, 2007; Walther, Van Der Heide, Kim, Westerman, & Tong, 2008). A study might investigate how transformed self-representations in IVEs affect others' perceptions of credibility or interpersonal trust.

We have demonstrated the utility of VEs for studying various social scientific phenomena. For researchers, the possibilities for replications of previously conducted studies are endless, or they may want to explore novel ways of testing existing theories. Social identity theory, for example, looks at the processes and strategies involved in establishing and bolstering one's group identity (Tajfel & Turner, 1986). An interesting study might involve experimentally manipulating various features of avatars, assigning them to participants, and observing if this affects how ingroups and outgroups develop in a collaborative virtual environment or an online VE such as Second Life. Conflicts and competition could then be introduced to see if virtual groups behave similarly to those observed in the real world. Persuasion theories could also be studied within VEs. Researchers have been plagued by the inconsistency between attitudes and behaviors (Ajzen & Fishbein, 1977, 1980), which is often observed in health initiatives (Armitage & Conner, 2000; Fishbein & Cappella, 2006). A treatment can be successful in shifting attitudes, and perhaps even behavioral intentions, but these effects often do not carry over to behavior. A VE may help resolve that link by providing participants with the opportunity to perform the behavior virtually.

Online and networked VEs also present opportunities to study macro-level behaviors on the community level. Some research has been conducted on economics (Castronova, 2005), the role of law (Lastowka & Hunter, 2004), task-oriented social networking (Williams, 2006), relationship formation (Yee, 2006a,b), and the potential for democratic processes (Noveck, 2003) within virtual communities. With the ability to collect vast amounts of data over time, researchers have the opportunity to explore a number of evolving and emergent phenomena that are difficult to trace in the real world, particularly in real time.

Beyond explorations of the technology itself, social scientists may also be interested in collaborating with educators, doctors, military personnel, or industry to help create effective applications for use in the real world. There are many opportunities to help create, test, and implement virtual treatments and training environments using social scientific constructs and theories. For example, VEs have been developed for medical students to practice their communication skills in patient-provider scenarios. A social scientist could contribute to this effort by incorporating persuasion techniques to facilitate patients' compliance with medical advice. Similarly, if a nonprofit organization were creating a virtual workplace, a social scientist might suggest ways to use a virtual environment's capabilities to enhance small group performance, perhaps by implementing a tracking system to decrease social loafing or a rewards structure to facilitate goal-setting.

In this article, we have provided an overview of the technological aspects of VR and laid out the possibilities for social scientific research using virtual environments. Although we have presented a rich body of literature that has begun to explore the nature and utility of VR, there are a multitude of questions and future directions for study that have yet to be addressed. As in virtual reality, the only limits are the researcher's imagination.

Acknowledgments

The current work was partially supported by National Science Foundation (NSF) Grant IIS 0741753 and NSF Grant HSD 0527377. We would like to thank all of our coders for their hard work on this project: Liz Tricase, Deonne Castaneda, Amanda Zhang, Suejung Shin, Brandon Herzog, Amanda Le, Maddy Coon, Jeff Wear, and Nicole Fernandez.

References

Ajzen, I., & Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological Bulletin, 84,* 888–918.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior.* Englewood Cliffs, NJ: Prentice-Hall.

Alcañiz, M., Baños, R., Botella, C., & Rey, B. (2003). The EMMA Project: Emotions as a determinant of presence. *PsychNology Journal, 1,* 141–150.

Anderson, C.A., Gentile, D.A., & Buckley, K.E. (2007). *Violent videogame effects on children and adolescents: Theory, research, and public policy*. New York: Oxford University Press.

Armitage, C.J., & Conner, M. (2000). Social cognition models and health behavior: A structured review. *Psychology & Health, 15*, 173–189.

Badler, N.I., Phillips, C.B., & Webber, B.L. (1992). *Simulating humans: Computer graphics, animation, and control.* New York: Oxford University Press.

Bailenson, J.N. & Beall, A.C. (2006). Transformed social interaction: Exploring the digital plasticity of avatars. In R. Schroeder & A.-S. Axelsson (Eds.), *Avatars at work and play: Collaboration and interaction in shared virtual environments* (pp. 1–16). New York: Springer.

Bailenson, J.N., & Blascovich, J. (2004). Avatars. In W.S. Bainbridge (Ed.), *Encyclopedia of human-computer interaction* (pp. 64–68). Great Barrington, MA: Berkshire.

Bailenson, J.N., & Yee, N. (2005). Digital chameleons: Automatic assimilation of nonverbal gestures in immersive virtual environments. *Psychological Science, 16,* 814–819.

Bailenson, J.N., & Yee, N. (2006). A longitudinal study of task performance, head movements, subjective report, simulator sickness, and transformed social interaction in collaborative virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 15*, 699–716.

Bailenson, J.N., & Yee, N. (2007). Virtual interpersonal touch: Haptic interaction and copresence in collaborative virtual environments. *International Journal of Multimedia Tools & Applications, 37*, 5–14.

Bailenson, J.N., Beall, A.C., Blascovich, J., & Rex, C. (2004). Examining virtual busts: Are photogrammetrically generated head models effective for person identification? *PRESENCE: Teleoperators and Virtual Environments, 13*, 416–427.

Bailenson, J.N., Beall, A.C., Loomis, J., Blascovich, J., & Turk, M. (2004). Transformed social interaction: Decoupling representation from behavior and form in collaborative virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 13*, 428–441.

Bailenson, J.N., Beall, A.C., Loomis, J., Blascovich, J., & Turk, M. (2005). Transformed social interaction, augmented gaze, and social influence in immersive virtual environments. *Human Communication Research, 31,* 511–537.

Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J.M. (2001). Equilibrium theory revisited: Mutual gaze and personal space in virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 10*, 583–598.

Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J.M. (2003). Interpersonal distance in immersive virtual environments. *Personality & Social Psychology Bulletin, 29*, 819–833.

Bailenson, J.N., Garland, P., Iyengar, S., & Yee, N. (2006). Transformed facial similarity as a political cue: A preliminary investigation. *Political Psychology, 27,* 373–386.

Bailenson, J.N., Patel, K., Nielsen, A., Bajscy, R., Jung, S.-H., & Kurillo, G. (2008). The effect of interactivity on learning physical actions in virtual reality. *Media Psychology, 11,* 354–376.

Bailenson, J.N., Swinth, K., Hoyt, C., Persky, S., Dimov, A., & Blascovich, J. (2005). The independent and interactive effects of embodied agent appearance and behavior on self-report, cognitive, and behavioral markers of copresence in immersive virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 14*, 379–393.

Bailenson, J.N., Yee, N., Blascovich, J., Beall, A.C., Lundblad, N., & Jin, M. (2008). The use of immersive virtual reality in the learning sciences: Digital transformations of teachers, students, and social context. *Journal of the Learning Sciences, 17,* 102–141.

Bailenson, J.N., Yee, N., Brave, S., Merget, D., & Koslow, D. (2007). Virtual interpersonal touch: Expressing and recognizing emotions through haptic devices. *Human-Computer Interaction, 22,* 325–353.

Bailenson, J.N., Yee, N., Merget, D., & Schroeder, R. (2006). The effect of behavioral realism and form realism of real-time avatar faces on verbal disclosure, nonverbal disclosure, emotion recognition, and copresence in dyadic interaction. *PRESENCE: Teleoperators and Virtual Environments, 15*, 359–372.

Bainbridge, W.S. (2007). The scientific research potential of virtual worlds. *Science, 317,* 472–476.

Bandura, A. (1977). *Social learning theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (2001). Social cognitive theory of mass communication. *Media Psychology, 3,* 265–299.

Barab, S.A., Hay, K.E., Barnett, M., & Squire, K. (2001). Constructing virtual worlds: Tracing the historical development of learner practices. *Cognition & Instruction, 19,* 47–94.

Bartle, R.A. (2004). *Designing virtual worlds.* San Francisco: New Riders.

Basdogan, C., Ho, C.-H., Srinivasan, M.A., & Slater, M. (2000). An experimental study on the role of touch in virtual environments. *ACM Transactions on Computer-Human Interaction, 7,* 443–460.

Baumann, S., Neff, C., Fetzick, S., Stangl, G., Basler, L., Vereneck, R. et al. (2003). A virtual reality system for neurobehavior and functional MRI studies. *CyberPsychology and Behavior, 6,* 259–266.

Baumann, S.B., & Sayette, M.A. (2006). Smoking cues in a virtual world provoke craving in cigarette smokers. *Psychology of Addictive Behaviors, 20,* 484–489.

Baumgartner, T., Valko, L., Esslen, M., & Jäncke, L. (2006). Neural correlate of spatial presence in an arousing and noninteractive virtual reality: An EEG and psychophysiology study. *CyberPsychology and Behavior, 9,* 30–45.

Benford, S., Greenhalgh, C., Rodden, T., & Pycock, J. (2001). Collaborative virtual environments. *Communications of the ACM, 44*(7), 79–85.

Bente, G. (1989). Facilities for the graphical computer simulation of head and body movements. *Behavior Research Methods, Instruments, & Computers, 21*, 455–462.

Bente, G., Eschenburg, F., & Krämer, N.C. (2007). Virtual gaze: A pilot study on the effects of computer simulated gaze in avatar-based conversations. In R. Schumaker (Ed.), *Virtual reality* (pp. 185–194). Berlin: Springer-Verlag.

Bente, G., Feist, A., & Elder, S. (1996). Person perception effects of computer-simulated male and female head movement. *Journal of Nonverbal Behavior, 20*, 213–228.

Bente, G., Krämer, N.C., Petersen, A., & de Ruiter, J.P. (2001). Computer animated movement and person perception: Methodological advances in nonverbal behavior research. *Journal of Nonverbal Behavior, 25,* 151–166.

Bente, G., Petersen, A., Krämer, N.C., & de Ruiter, J.P. (2001). Transcript-based computer animation of movement: Evaluating a new tool for nonverbal behavior research. *Behavior Research Methods, Instruments, & Computers, 33*, 303–310.

Bente, G., Rüggenberg, S., Krämer, N.C., & Eschenburg, F. (2008). Avatar-mediated networking: Increasing social presence and interpersonal trust in net-based collaborations. *Human Communication Research, 34,* 287–318.

Bickmore, T., & Cassell, J. (2005). Social dialog with embodied conversational agents. In J.C.J. Kuppevelt, L. Dybkjaer, & N.O. Bernson (Eds.), *Advances in natural multimodal dialog systems* (pp. 1–32). New York: Springer.

Biocca, F. (1992a). Communication within virtual reality: Creating a space for research. *Journal of Communication, 42*(4), 5–22.

Biocca, F. (1992b). Virtual reality technology: A tutorial. *Journal of Communication, 42*(4), 23–72.

Biocca, F., & Delaney, B. (1995). Immersive virtual reality technology. In F. Biocca & M.R. Levy (Eds.), *Communication in the age of virtual reality* (pp. 57–124). Hillsdale, NJ: Erlbaum.

Biocca, F., & Levy, M.R. (1995). Communication applications of virtual reality. In F. Biocca & M.R. Levy (Eds.), *Communication in the age of virtual reality* (pp. 127–157). Hillsdale, NJ: Erlbaum.

Biocca, F., Harms, C., & Burgoon, J.K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *PRESENCE: Teleoperators and Virtual Environments, 12,* 456–480.

Blascovich, J. (2000). Using physiological indexes of psychological processes in social psychological research. In H.T. Reis & C.M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 117–137). New York: Cambridge University Press.

Blascovich, J. (2001). Immersive virtual environments and social behavior. *Science Briefs: Psychological Science Agenda, 14,* 8–9.

Blascovich, J., Loomis, J., Beall, A.C., Swinth, K.R., Hoyt, C.L., & Bailenson, J.N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological Inquiry, 13,* 103–124.

Botella, C., García-Palacios, A., Villa, H., Baños, R.M., Quero, S., Alcañiz, M. et al. (2007). Virtual reality exposure in the treatment of panic disorder and agoraphobia: A controlled study. *Clinical Psychology & Psychotherapy, 14,* 164–175.

Bouchard, S., St-Jacques, J., Robillard, G., & Renaud, P. (2008). Anxiety increases the feeling of presence in virtual reality. *PRESENCE: Teleoperators and Virtual Environments, 17,* 487–502.

Brough, J.E., Schwartz, M., Gupta, S.K., Anand, D.K., Kavetsky, R., & Pettersen, R. (2007). Toward the development of a virtual environment-based training system for mechanical assembly operations. *Virtual Reality, 11*, 189–206.

Bryant, J., & Oliver, M.B. (Eds.). (2008). *Media effects: Advances in theory and research* (3rd ed.). New York: Routledge.

Bryanton, C., Bossé, J., Brien, M., McLean, J., McCormick, A., & Sveistrup, H. (2006). Feasibility, motivation, and selective motor control: Virtual reality compared to conventional home exercise in children with cerebral palsy. *CyberPsychology and Behavior, 9,* 123–128.

Bullinger, A.H., Hemmeter, U.M., Stefani, O., Angehrn, I., Mueller-Spahn, F., Bekiaris, E. et al. (2005). Stimulation of cortisol during mental task performance in a provocative virtual environment. *Applied Psychophysiology and Biofeedback, 30,* 205–216.

Burdea, G.C., & Coiffet, P. (2003). *Virtual reality technology* (2nd ed.). New York: Wiley.

Cassell, J. (2000). Embodied conversational interface agents. *Communications of the ACM, 43*(4), 70–78.

Cassell, J., & Jenkins, H. (1998). *From Barbie to Mortal Kombat: Gender and computer games.* Cambridge, MA: MIT Press.

Castronova, E. (2004). The price of bodies: A hedonic pricing model of avatar attributes in a synthetic world. *KYKLOS, 57,* 173–196.

Castronova, E. (2005). *Synthetic worlds: The business and culture of online games*. Chicago: University of Chicago Press.

Chartrand, T.L., & Bargh, J.A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality & Social Psychology, 76,* 893–910.

Cho, S., Ku, J., Park, J., Han, K., Lee, H., Choi, Y.K. et al. (2008). Development and verification of an alcohol-craving induction tool using virtual reality: Craving characteristics in a social pressure situation. *CyberPsychology and Behavior, 11,* 302–309.

Chung, J.C., Harris, M.R., Brooks, F.P., Fuchs, H., Kelley, M.T., Hughes, J. et al. (1989). Exploring virtual worlds with head-mounted displays. *Proceedings of SPIE*, *1083,* 42–52.

Coelho, C.M., Santos, J.A., Silvério, J., & Silva, C.F. (2006). Virtual reality and acrophobia: One-year follow-up and case study. *CyberPsychology and Behavior, 9,* 336–341.

Cote, S., & Bouchard, S. (2005). Documenting the efficacy of virtual reality exposure with psychophysiological and information processing measures. *Applied Psychophysiology & Biofeedback, 30,* 217–232.

Cruz-Neira, C., Sandin, D.J., DeFanti, T.A., Kenyon, R.V., & Hart, J.C. (1992). The CAVE: Audio visual experience automatic virtual environment. *Communications of the ACM, 35*(6), 64–72.

Dahlquist, L.M., McKenna, K.D., Jones, K.K., Dillinger, L., Weiss, K.E., & Ackerman, C.S. (2007). Active and passive distraction using a head-mounted display helmet: Effects on cold pressor pain in children. *Health Psychology, 26,* 794–801.

De Kort, Y.A.W., & Ijsselsteijn, W.A. (2006). Reality check: The role of realism in stress reduction using media technology. *CyberPsychology and Behavior, 9,* 230–233.

De Leo, G., Ponder, M., Molet, T., Fato, M., Thalmann, D., Magnenat-Thalmann, N. et al. (2003). A virtual reality system for the training of volunteers involved in health emergency situations. *CyberPsychology and Behavior, 6,* 267–274.

Deaton, J.E., Barba, C., Santarelli, T., Rosenzweig, L., Souders, V., McCollum, C. et al. (2005). Virtual environment cultural training for operational readiness (VECTOR). *Virtual Reality, 8,* 156–167.

Dede, C. (2009). Immersive interfaces for engagement and learning. *Science, 323,* 66–69.

Deutsch, J.E., & Mirelman, A. (2007). Virtual reality-based approaches to enable walking for people poststroke. *Topics in Stroke Rehabilitation, 14,* 45–53.

Donath, J. (2007). Virtually trustworthy. *Science, 317,* 53–54.

Dotsch, R., & Wigboldus, D.H.J. (2008). Virtual prejudice. *Journal of Experimental Social Psychology, 44,* 1194–1198.

Eastgate, R.M., Griffiths, G.D., Waddingham, P.E., Moody, A.D., Butler, T.K.H., Cobb, S.V. et al. (2006). Modified virtual reality for treatment of amblyopia. *Eye, 20,* 370–374.

Eastwick, P.W., & Gardner, W.L. (2009). Is it a game? Evidence for social influence in the virtual world. *Social Influence, 4,* 18–32.

Fishbein, M., & Cappella, J.N. (2006). The role of theory in developing effective health communications. *Journal of Communication, 56,* S1–S17.

Fleiss, J.L. (1971). Measuring nominal scale agreement among many raters. *Psychological Bulletin, 76*, 378–382.

Fox, J., & Bailenson, J.N. (2009). Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychology*, *12,* 1–25.

Fox, J., & Bailenson, J.N. (2009). Virtual virgins and vamps: The effects of exposure to female characters' sexualized appearance and gaze in an immersive virtual environment. *Sex Roles, 61,* 147–157.

Fox, J., Bailenson, J.N., & Binney, J. (in press). Virtual experiences, physical behaviors: The effect of presence on imitation of an eating avatar. *PRESENCE: Teleoperators and Virtual Environments.*

Friedman, D., Steed, A., & Slater, M. (2007). Spatial social behavior in Second Life. In C. Pelachaud (Ed.), *Intelligent virtual agents* (pp. 252–263). New York: Springer.

Furness, T. (1987). Designing in virtual space. In W.B. Rouse & K.R. Boff (Eds.), *System design: Behavioral perspectives on designers, tools, & organization* (pp. 127–143). New York: North-Holland.

Garau, M., Slater, M., Pertaub, D.-P., & Razzaque, S. (2005). The responses of people to virtual humans in an immersive virtual environment. *PRESENCE: Teleoperators and Virtual Environments, 14,* 104–116.

Gilliath, O., McCall, C., Shaver, P.R., & Blascovich, J. (2008). What can virtual reality teach us about prosocial tendencies in real and virtual environments? *Media Psychology, 11,* 259–282.

Gold, J.I., Belmont, K.A., & Thomas, D.A. (2007). The neurobiology of virtual reality pain attenuation. *CyberPsychology and Behavior, 10,* 536–544.

Gonzales, A.L., & Hancock, J.T. (2008). Identity shift in computer-mediated environments. *Media Psychology, 11,* 167–185.

Gratch, J., & Marsella, S. (2005). Lessons from emotion psychology for the design of lifelike characters. *Applied Artificial Intelligence, 19,* 215–233.

Gregg, L., & Tarrier, N. (2007). Virtual reality in mental health: A review of the literature. *Social Psychiatry & Psychiatric Epidemiology, 42,* 343–354.

Groom, V., Bailenson, J.N., & Nass, C. (2009). The influence of racial embodiment on racial bias in immersive virtual environments. *Social Influence, 4,* 231–248.

Guadagno, R.E., Blascovich, J., Bailenson, J.N., & McCall, C. (2007). Virtual humans and persuasion: The effects of agency and behavioral realism. *Media Psychology, 10,* 1–22.

Gutiérrez-Maldonado, J., Ferrer-García, M., Caqueo-Urizar, A., & Letosa-Porta, A. (2006). Assessment of emotional reactivity produced by exposure to virtual environments in patients with eating disorders. *CyberPsychology and Behavior, 9,* 507–513.

Haans, A., & Ijsselsteijn, W. (2005). Mediated social touch: A review of current research and future directions. *Virtual Reality, 9,* 149–159.

Harris, S.R., Kemmerling, R.L., & North, M.M. (2002). Brief virtual reality therapy for public speaking anxiety. *CyberPsychology and Behavior, 5,* 543–550.

Hill, R.W., Jr., Gratch, J., Marsella, S., Rickel, J., Swartout, W., & Traum, D. (2003). Virtual humans in the mission rehearsal exercise system. *Künstliche Intelligenz, 17,* 5–12.

Hoffman, H.G., Patterson, D.R., Seibel, E., Soltani, M., Jewett-Leahy, L., & Sharar, S.R. (2008). Virtual reality pain control during burn wound debridement in the hydrotank. *Clinical Journal of Pain, 24,* 299–304.

Hoyt, C.L., & Blascovich, J. (2003). Transformational and transactional leadership in virtual and physical environments. *Small Group Research, 34,* 678–715.

Hoyt, C.L., & Blascovich, J. (2007). Leadership efficacy and women leaders' responses to stereotype activation. *Group Processes and Intergroup Relations, 10,* 595–616.

Hoyt, C.L., Blascovich, J., & Swinth, K.R. (2003). Social inhibition in virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 12,* 183–195.

Ijsselsteijn, W., de Ridder, H., Freeman, J., Avons, S.E., & Bouwhuis, D. (2001). Effects of stereoscopic presentation, image motion, and screen size on subjective and objective corroborative measures of presence. *PRESENCE: Teleoperators and Virtual Environments, 10,* 298–311.

Internet World Stats. (2009). *World Internet usage and population stats.* Retrieved March 18, 2009, from http://www.internetworldstats.com/stats.htm

Ivory, J.D., & Kalyanaraman, S. (2007). The effects of technological advancement and violent content in videogames on players' feelings of presence, involvement, physiological arousal, and aggression. *Journal of Communication, 57,* 532–555.

Johnsen, K., Dickerson, R., Rajj, A., Harrison, C., Lok, B., Stevens, A. et al. (2006). Evolving an immersive medical communication skills trainer. *PRESENCE: Teleoperators and Virtual Environments, 15,* 33–46.

Jordans, F. (2009, March 2). World's poor drive growth in global cell phone use. *Forbes Online*. Retrieved March 18, 2009, from http://www.forbes.com/feeds/ap/2009/03/02/ap6114172.html

Joslin, C., Di Giacomo, T., & Magnenat-Thalmann, N. (2004). Collaborative virtual environments: From birth to standardization. *IEEE Communications, 42*(4), 28–33.

Kalawsky, R.S. (1993). *The science of virtual reality and virtual environments*. Boston: Addison-Wesley.

Kamada, M., Ambe, M., Hata, K., Yamada, E., & Fujimura, Y. (2005). The effect of the emotion-related channel in 3D virtual communication environments. *PsychNology Journal, 3,* 312–327.

Kenny, P., Rizzo, A.A., Parsons, T.D., Gratch, J., & Swartout, W. (2007). A virtual human agent for training novice therapists clinical interviewing skills. *Annual Review of CyberTherapy and Telemedicine, 5,* 77–83.

Krippendorff, K. (1980). *Content analysis: An introduction to its methodology*. Beverly Hills, CA: Sage.

Landis, J.R., & Koch, G.G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33,* 159–174.

Lanier, J. (1992). Virtual reality: The promise of the future. *Interactive Learning International, 8,* 275–79.

Lanier, J. (1997). Beyond goggles and gloves. *Byte, 22*(9), 32.

Lanier, J., & Biocca, F. (1992). An insider's view of the future of virtual reality. *Journal of Communication, 42*, 150–172.

Lastowka, F.G., & Hunter, D. (2004). The laws of the virtual worlds. *California Law Review, 92*, 1–73.

Lee, K.M. (2004). Presence, explicated. *Communication Theory, 14,* 27–50.

Lombard, M., & Ditton, T. (1997). At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication, 3*(2). Retrieved on September 9, 2009, at http://jcmc.indiana.edu/vol3/issue2/lombard.html

Loomis, J.M. (1992). Distal attribution and presence. *PRESENCE: Teleoperators and Virtual Environments, 1,* 113–119.

Loomis, J.M., Blascovich, J.J., & Beall, A.C. (1999). Immersive virtual environment technology as a basic research tool in psychology. *Behavior Research Methods, Instruments, and Computers, 31,* 557–564.

Loomis, J.M., Hebert, C., & Cicinelli, J.G. (1990). Active localization of virtual sounds. *Journal of the Acoustical Society of America*, *88,* 1757–1764.

Macedonio, M.F., Parsons, T.D., Diguiseppe, R.A., Weiderhold, B.K., & Rizzo, A.A. (2007). Immersiveness and physiological arousal within panoramic video-based virtual reality. *CyberPsychology and Behavior, 10,* 508–515.

Mantovani, F., Castelnuovo, G., Gaggioli, A., & Riva, G. (2003). Virtual reality training for health-care professionals. *CyberPsychology and Behavior, 6,* 389–395.

Meehan, M., Razzaque, S., Insko, B., Whitton, M., & Brooks, F.P., Jr. (2005). Review of four studies on the use of physiological reaction as a measure of presence in stressful virtual environments. *Applied Psychophysiology and Biofeedback, 30*, 239–258.

Meyer, K., Applewhite, H.L., & Biocca, F.A. (1992). A survey of position trackers. *PRESENCE: Teleoperators and Virtual Environments, 1*, 173–200.

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments. *Educational Psychology Review, 19,* 309–326.

Mraz, R., Hong, J., Quintin, G., Staines, W.R., McIlroy, W.E., Zakzanis, K.K. et al. (2003). A platform for combining virtual reality experiments with functional magnetic resonance imaging. *CyberPsychology and Behavior, 6,* 359–368.

Nijholt, A. (2004). Where computers disappear, virtual humans appear. *Computers and Graphics, 28,* 467–476.

Normand, V., Babski, C., Raupp-Musse, A., Thalmann, D., Benford, S., Bullock, A. et al. (1999). The COVEN project: Exploring applicative, technical, and usage dimensions of collab-

orative virtual environments. *PRESENCE: Teleoperators and Virtual Environments, 8,* 218–236.
Noveck, B.S. (2003). Designing deliberative democracy in cyberspace: The role of the cyberlawyer. *Journal of Science and Technology Law, 9,* 1–91.
Nowak, K.L., & Rauh, C. (2006). The influence of the avatar on online perceptions of anthropomorphism, androgyny, credibility, homophily, and attraction. *Journal of Computer-Mediated Communication, 11,* 153–178.
NPD Group. (2009, February 2). *2008 videogame software sales across top global markets experience double-digit growth.* Retrieved on March 18, 2009, from http://www.npd.com/press/releases/press_090202.html
Okita, S.Y., Bailenson, J.N., & Schwartz, D.L. (2008). The mere belief in social interaction improves learning. In S. Barab, K. Hay, & D. Hickey (Eds.), *Proceedings of the 8th International Conference for the Learning Sciences.* Mahwah, NJ: Erlbaum.
O'Toole, R., Playter, R., Krummel, T., Blank, W., Cornelius, N., Roberts, W. et al. (1998). Assessing skill and learning in surgeons and medical students using a force feedback surgical simulator. In W. Wells, A. Colchester, & S. Delp (Eds.), *Proceedings of the International Conference for Medical Image Computing and Computer-Assisted Intervention (MICCAI).* Berlin: Springer-Verlag.
Park, S., & Catrambone, R. (2007). Social facilitation effects of virtual humans. *Human Factors, 49,* 1054–1060.
Parsons, T.D., & Rizzo, A.A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of Behavior Therapy and Experimental Psychiatry, 39,* 250–261.
Pausch, R., Crea, T., & Conway, M. (1992). A literature survey for virtual environments: Military flight simulator visual systems and simulator sickness. *PRESENCE: Teleoperators and Virtual Environments, 1*, 344–363.
Persky, S., & Blascovich, J. (2008). Immersive virtual videogame play and presence: Influences on aggressive feelings and behavior. *PRESENCE: Teleoperators and Virtual Environments, 17,* 57–72.
Petersen, A., & Bente, G. (1991). Situative und technologische Determinanten des Erlebens virtueller Realität [Situational and technological determinants of virtual reality experience]. *Zeitschrift für Medienpsychologie, 13*, 138–145.
Powers, M.B., & Emmelkamp, P.M.G. (2008). Virtual reality exposure therapy for anxiety disorders: A meta-analysis. *Journal of Anxiety Disorders, 22,* 561–569.
Price, M., & Anderson, P. (2007). The role of presence in virtual reality exposure therapy. *Journal of Anxiety Disorders, 21,* 742–751.
Ratan, R., Santa Cruz, M., & Vorderer, P. (2008). Multitasking, presence, and self-presence on the Wii. In L. Moreno (Ed.), *Proceedings of the 10th Annual International Workshop on Presence* (pp. 167–190). Barcelona, Spain: Starlab Barcelona.
Read, S.J., Miller, L.C., Appleby, P.R., Nwosu, M.E., Reynaldo, S., Lauren, A. et al. (2006). Socially optimized learning in a virtual environment: Reducing risky sexual behavior among men who have sex with men. *Human Communication Research, 32,* 1–34.
Reeves, B., & Nass, C. (1996). *The media equation.* New York: Cambridge.
Reeves, B., Malone, T.W., & O'Driscoll, T. (2008). Leadership's online labs. *Harvard Business Review, 86*(5), 58–66.
Reger, G.M., & Gahm, G.A. (2008). Virtual reality exposure therapy for active duty soldiers. *Journal of Clinical Psychology, 64,* 940–946.
Rheingold, H. (1991). *Virtual reality.* New York: Simon & Schuster.
Riva, G. (2005). Virtual reality in psychotherapy: Review. *CyberPsychology and Behavior, 8,* 220–230.
Riva, G., Davide, F., & Ijsselsteijn, W.A. (Eds.). (2003). *Being there: Concepts, effects, and measurement of user presence in synthetic environments.* Amsterdam: Ios Press.
Riva, G., Mantovani, F., Capideville, C.S., Preziosa, A., Morganti, F., Villani, D. et al. (2007). Affective interactions using virtual reality: The link between presence and emotions. *CyberPsychology and Behavior, 10,* 45–56.
Rizzo, A.A., Neumann, U., Enciso, R., Fidaleo, D., & Noh, J.Y. (2001). Performance-driven facial animation: Basic research on human judgments of emotional state in facial avatars. *CyberPsychology and Behavior, 4,* 471–487.
Rothbaum, B.O., Hodges, L.F., & Kooper, R. (1997). Virtual reality exposure therapy. *Journal of Psychotherapy Practice and Research, 6,* 219–226.
Rothbaum, B.O., Hodges, L., Smith, S., Lee, J.H., & Price, L. (2000). A controlled study of virtual reality exposure therapy for the fear of flying. *Journal of Consulting and Clinical Psychology, 68,* 1020–1026.
Rothbaum, B.O., Ruef, A.M., Litz, B.T., Han, H., & Hodges, L. (2003). Virtual reality exposure therapy of combat-related PTSD: A case study using psychophysiological indicators of outcome. *Journal of Cognitive Psychotherapy, 17,* 163–177.
Roy, S., Klinger, E., Legeron, P., Lauer, F., Chemin, I., & Nugues, P. (2003). Definition of a VR-based protocol to treat social phobia. *CyberPsychology and Behavior, 6,* 411–420.
Sacau, A., Laarni, J., & Hartmann, T. (2008). Influence of individual factors on presence. *Computers in Human Behavior, 24,* 2255–2273.
Salisbury, J.K., & Srinivasan, M.A. (1997). Phantom-based haptic interaction with virtual objects. *IEEE Computer Graphics and Applications, 17*(5), 6–10.
Schroeder, R. (Ed.). (2002). *The social life of avatars: Presence and interaction in shared virtual environments.* London: Springer-Verlag.
Schroeder, R., & Axelsson, A.-S. (Eds.). (2006). *Avatars at work and play: Collaboration and interaction in shared virtual environments*. New York: Springer.
Schroeder, R., Heldal, I., & Tromp, J. (2006). The usability of collaborative virtual environments and methods for the analysis of interaction. *PRESENCE: Teleoperators and Virtual Environments, 15,* 655–667.
Schultheis, M.T., & Rizzo, A.A. (2001). The application of virtual reality technology in rehabilitation. *Rehabilitation Psychology, 46,* 296–311.
Sharples, S., Cobb, S., Moody, A., & Wilson, J.R. (2008). Virtual reality induced symptoms and effects (VRISE): Comparison of head mounted display (HMD), desktop, and projection display systems. *Displays, 29,* 58–69.
Skalski, P., & Tamborini, R. (2007). The role of social presence in interactive agent-based persuasion. *Media Psychology, 10,* 385–413.
Slater, M., & Steed, A. (2000). A virtual presence counter. *PRESENCE: Teleoperators and Virtual Environments, 9,* 413–434.
Slater, M., Antley, A., Davison, A., Swapp, D., Guger, C., Barker, C. et al. (2006). A virtual reprise of the Stanley Milgram obe-

dience experiments. *PLoSONE 1*(1): e39. doi: 10.1371/journal.pone.0000039

Slater, M., Guger, C., Edlinger, G., Leeb, R., Pfurtscheller, G., Antley, A. et al. (2006). Analysis of physiological responses to a social situation in an immersive virtual environment. *PRESENCE: Teleoperators and Virtual Environments, 15,* 553–569.

Slater, M., Pertaub, D.-P., Baker, C., & Clark, D.M. (2006). An experimental study on fear of public speaking using a virtual environment. *CyberPsychology and Behavior, 9,* 627–633.

Slater, M., Sadagic, A., Usoh, M., & Schroeder, R. (2000). Small group behavior in a virtual and real environment: A comparative study. *PRESENCE: Teleoperators and Virtual Environments, 9,* 37–51.

Spitzer, V.M., & Ackerman, M.J. (2008). The Visible Human® at the university of Colorado 15 years later. *Virtual Reality, 12,* 191–200.

Stanney, K., & Salvendy, G. (1998). Aftereffects and sense of presence in virtual environment: Formulation of a research and development agenda. *International Journal of Human-Computer Interaction, 10,* 135–187.

Stanney, K.M., Hale, K.S., Nahmens, I., & Kennedy, R.S. (2003). What to expect from immersive virtual environment exposure: Influences of gender, body mass index, and past experience. *Human Factors, 45,* 504–520.

Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of Communication, 42,* 73–93.

Sutcliffe, A., Gault, B., Fernando, T., & Tan, K. (2006). Investigating interaction in CAVE virtual environments. *ACM Transactions on Computer-Human Interaction, 13,* 235–267.

Sutherland, I.E. (1968). A head mounted three dimensional display. *Proceedings of the Fall Joint Computer Conference, 33,* 757–764.

Sveistrup, H., McComas, J., Thornton, M., Marshall, S., Finestone, H., McCormick, A. et al. (2003). Experimental studies of virtual reality-delivered compared to conventional exercise programs for rehabilitation. *CyberPsychology and Behavior, 6,* 245–249.

Tajfel, H., & Turner, J.C. (1986) . The social identity theory of intergroup behavior. In S. Worchel & W. Austin (Eds.), *Psychology of intergroup relations* (pp. 7–24). Chicago: Nelson-Hall.

Tan, H.Z., & Pentland, A. (1997). Tactual displays for wearable computing. *Personal Technologies*, *1,* 225–230.

Toma, C.L., Hancock, J.T., & Ellison, N.B. (2008). Separating fact from fiction: An examination of deceptive self-presentation in online dating profiles. *Personality and Social Psychology Bulletin, 34,* 1023–1036.

Turk, M., & Robertson, G. (2000). Perceptual user interfaces. *Communications of the ACM, 43*(3), 33–34.

Västfjäll, D. (2003). The subjective sense of presence, emotion recognition, and experienced emotions in auditory virtual environments. *CyberPsychology and Behavior, 6,* 181–188.

Villani, D., Riva, F., & Riva, G. (2007). New technologies for relaxation: The role of presence. *International Journal of Stress Management, 14,* 260–274.

Vorderer, P., & Bryant, J. (Eds.). (2006). *Playing videogames: Motives, responses, and consequences.* Mahwah, NJ: Erlbaum.

Waller, D., Bachmann, E., Hodgson, E., & Beall, A.C. (2007). The HIVE: A huge immersive environment for research in spatial cognition. *Behavior Research Methods, 39,* 835–843.

Walther, J.B. (2007). Selective self-presentation in computer-mediated communication: Hyperpersonal dimensions of technology, language, and cognition. *Computers in Human Behavior, 23,* 2538–2557.

Walther, J.B., Van Der Heide, B., Kim, S.-Y., Westerman, D., & Tong, S.T. (2008). The role of friends' appearance and behavior on evaluations of individuals on Facebook: Are we known by the company we keep? *Human Communication Research, 34,* 28–49.

Welch, G.F. (2009). History: The use of the Kalman filter for human motion tracking in virtual reality. *PRESENCE: Teleoperators and Virtual Environments, 18,* 72–91.

Williams, D. (2006). Why study games now? Gamers don't bowl alone. *Games & Culture, 1,* 13–16.

Williams, D., Caplan, S., & Xiong, L. (2007). Can you hear me now? The impact of voice in an online gaming community. *Human Communication Research, 33,* 427–449.

Wilson, J.R., & D'Cruz, M. (2006). Virtual and interactive environments for work of the future. *International Journal of Human-Computer Studies, 64*, 158–169.

Wirth, W., Hartmann, T., Böcking, S., Vorderer, P., Klimmt, C., Schramm, H. et al. (2007). A process model of the formation of spatial presence experiences. *Media Psychology, 9,* 493–525.

Witmer, B.G., & Singer, M.J. (1998). Measuring presence in virtual environments: A presence questionnaire. *PRESENCE: Teleoperators and Virtual Environments, 7,* 225–240.

Yee, N. (2006a). The demographics, motivations and derived experiences of users of massively multiuser online graphical environments. *PRESENCE: Teleoperators and Virtual Environments*, *15,* 309–329.

Yee, N. (2006b). The psychology of MMORPGs: Emotional investment, motivations, relationship formation, and problematic usage. In R. Schroeder & A. Axelsson (Eds.), *Avatars at work and play: Collaboration and interaction in shared virtual environments* (pp. 187–207). New York: Springer.

Yee, N., & Bailenson, J.N. (2007). The Proteus effect: Self transformations in virtual reality. *Human Communication Research*, *33,* 271–290.

Yee, N., & Bailenson, J.N. (2008). A method for longitudinal behavioral data collection in Second Life. *PRESENCE: Teleoperators and Virtual Environments, 17,* 594–596.

Yee, N., Bailenson, J.N., & Ducheneaut, N. (2009). The Proteus effect: Implications of transformed digital self-representation on online and offline behavior. *Communication Research*, *36,* 285–312.

Yee, N., Bailenson, J.N., Urbanek, M., Chang, F., & Merget, D. (2007). The unbearable likeness of being digital: The persistence of nonverbal social norms in online virtual environments. *CyberPsychology and Behavior, 10,* 115–121.

Zahorik, P. (2002). Assessing auditory distance perception using virtual acoustics. *Journal of the Acoustical Society of America*, *111*, 1832–1846.

Zanbaka, C., Ulinski, A., Goolkasian, P., & Hodges, L.F. (2007). Responses to virtual humans: Implications for future interface design. *Proceedings of the Conference on Computer-Human Interaction (CHI) 2007*, 1561–1570.

Date of acceptance: June 3, 2009

Jesse Fox (B.A., University of Kentucky; M.A., University of Arizona) is a Ph.D. candidate at Stanford University. Her research interests include new media effects; sex, gender, and sexualization in media; mediated interpersonal communication; and health communication, particularly the use of new media in health behavior change.

Jesse Fox
Department of Communication
Stanford University
450 Serra Mall, Bldg. 120
Stanford, CA 94305-2050
USA
E-mail jafox@stanford.edu

Dylan Arena (B.S. Symbolic Systems, Stanford University; M.A. Philosophy, Stanford University) is a Ph.D. candidate in Learning Sciences and Technology Design at Stanford University. His primary research interests are the use of games in learning contexts and the teaching and learning of statistics.

Jeremy Bailenson is founding director of Stanford University's Virtual Human Interaction Lab and an assistant professor in the Department of Communication at Stanford. His main area of interest is the phenomenon of digital human representation, especially in the context of immersive virtual reality.

The Uncanny Valley

By Masahiro Mori (Translated by Karl F. MacDorman and Norri Kageki)

Editor's note: More than 40 years ago, Masahiro Mori, a robotics professor at the Tokyo Institute of Technology, wrote an essay [1] on how he envisioned people's reactions to robots that looked and acted almost like a human. In particular, he hypothesized that a person's response to a humanlike robot would abruptly shift from empathy to revulsion as it approached, but failed to attain, a lifelike appearance. This descent into eeriness is known as the *uncanny valley*. The essay appeared in an obscure Japanese journal called *Energy* in 1970, and in subsequent years, it received almost no attention. However, more recently, the concept of the uncanny valley has rapidly attracted interest in robotics and other scientific circles as well as in popular culture. Some researchers have explored its implications for human–robot interaction and computer-graphics animation, whereas others have investigated its biological and social roots. Now interest in the uncanny valley should only intensify, as technology evolves and researchers build robots that look human. Although copies of Mori's essay have circulated among researchers, a complete version hasn't been widely available. The following is the first publication of an English translation that has been authorized and reviewed by Mori. (See "Turning Point" in this issue for an interview with Mori.)

A Valley in One's Sense of Affinity

The mathematical term *monotonically increasing function* describes a relation in which the function $y = f(x)$ increases continuously with the variable x. For example, as effort x grows, income y increases, or as a car's accelerator is pressed, the car moves faster. This kind of relation is ubiquitous and easily understood. In fact, because such monotonically increasing functions cover most phenomena of everyday life, people may fall under the illusion that they represent all relations. Also attesting to this false impression is the fact that many people struggle through life by persistently pushing without understanding the effectiveness of pulling back. That is why people usually are puzzled when faced with some phenomenon that this function cannot represent.

An example of a function that does not increase continuously is climbing a mountain—the relation between the distance (x) traveled by a hiker toward the summit and the hiker's altitude (y)—owing to the intervening hills and valleys. I have noticed that, in climbing toward the goal of making robots appear like a human, our affinity for them increases until we come to a valley (Figure 1), which I call the *uncanny valley*.

Nowadays, industrial robots are increasingly recognized as the driving force behind reductions in factory personnel. However, as is well known, these robots just extend, contract, and rotate their arms; without faces or legs, they do not look human. Their design policy is clearly based on functionality. From this standpoint, the robots must perform functions similar to those of human factory workers, but whether they look similar does not matter. Thus, given their lack of resemblance to human beings, in general, people hardly feel any affinity for them. (Note: However, industrial robots are considerably closer in appearance to humans than general machinery, especially in their arms.) If we plot the industrial robot on a graph of affinity versus human likeness, it lies near the origin in Figure 1.

In contrast, a toy robot's designer may focus more on the robot's appearance than its functions. Consequently, despite its being a sturdy mechanical figure, the robot will start to have a roughly human-looking external form with a face, two arms, two legs, and a torso. Children seem to feel deeply attached to these toy robots. Hence, the toy robot is shown more than halfway up the first hill in Figure 1.

Since creating an artificial human is itself one of the objectives of robotics, various efforts are underway to build humanlike robots. (Note: Others believe that the true appeal of robots is their potential to exceed and augment humans.) For example, a robot's arm may be composed of a metal cylinder with many bolts, but by covering it with skin and adding a bit of fleshy plumpness, we can achieve a more humanlike appearance. As a result, we naturally respond to it with a heightened sense of affinity.

Many of our readers have experience interacting with persons with physical disabilities, and all must have felt sympathy for those missing a hand or leg and wearing a prosthetic limb. Recently, owing to great advances in fabrication technology, we cannot distinguish at a glance a prosthetic hand from a real one. Some models simulate wrinkles, veins, fingernails, and even fingerprints. Though similar to a real hand, the prosthetic hand's color is

Digital Object Identifier 10.1109/MRA.2012.2192811
Date of publication: 6 June 2012

pinker as if it had just come out of the bath.

One might say that the prosthetic hand has achieved a degree of resemblance to the human form, perhaps on par with false teeth. However, once we realize that the hand that looked real at first sight is actually artificial, we experience an eerie sensation. For example, we could be startled during a handshake by its limp boneless grip together with its texture and coldness. When this happens, we lose our sense of affinity, and the hand becomes uncanny. In mathematical terms, this can be represented by a negative value. Therefore, in this case, the appearance of the prosthetic hand is quite humanlike, but the level of affinity is negative, thus placing the hand near the bottom of the valley in Figure 1.

I don't think that, on close inspection, a *bunraku* puppet appears similar to a human being. Its realism in terms of size, skin texture, and so on, does not even reach that of a realistic prosthetic hand. But when we enjoy a puppet show in the theater, we are seated at a certain distance from the stage. The puppet's absolute size is ignored, and its total appearance, including hand and eye movements, is close to that of a human being. So, given our tendency as an audience to become absorbed in this form of art, we might feel a high level of affinity for the puppet.

From the preceding discussion, the readers should be able to understand the concept of the uncanny valley. Now let us consider in detail the relation between the uncanny valley and movement.

The Effect of Movement

Movement is fundamental to animals—including human beings—and thus to robots as well. Its presence changes the shape of the uncanny valley graph by amplifying the peaks and valleys (Figure 2). For illustration, when an industrial robot is switched off, it is just a greasy machine. But once the robot is programmed to move its gripper like a human hand, we start to feel a certain level of affinity for it. (In this case, the velocity, acceleration, and deceleration must approximate human movement.) Conversely, when a prosthetic hand that is near the bottom of the uncanny valley starts to move, our sensation of eeriness intensifies.

Some readers may know that recent technology has enabled prosthetic hands to extend and contract their fingers automatically. The best commercially available model, shown in Figure 3, was developed by a manufacturer in Vienna. To explain how it works, even if a person's forearm is missing, the intention to move the fingers produces a faint current in the arm muscles, which can be detected by an electromyogram. When the prosthetic hand detects the current by means of electrodes on the skin's surface, it amplifies the signal to activate a small motor that moves its fingers. As this myoelectric hand makes movements, it could make healthy people feel uneasy. If someone wearing the hand in a dark

I predict that it is possible to create a safe level of affinity by deliberately pursuing a nonhuman design.

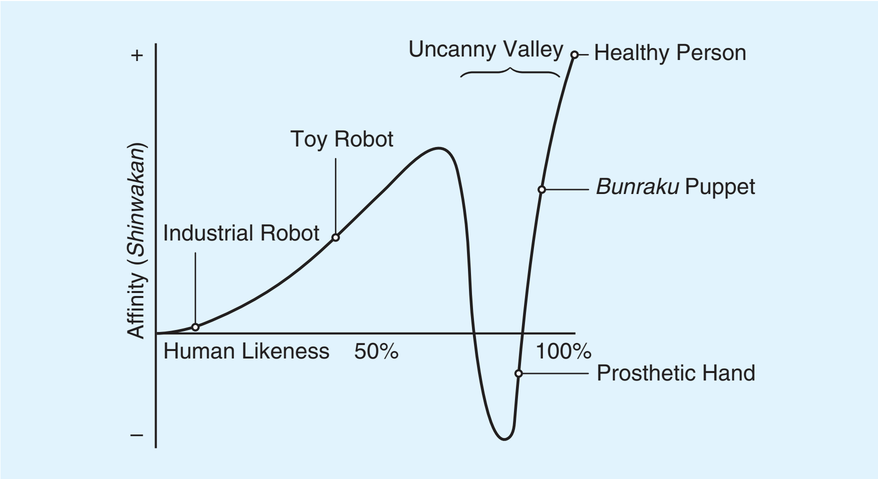


Figure 1. The graph depicts the uncanny valley, the proposed relation between the human likeness of an entity, and the perceiver's affinity for it. [Translators' note: *Bunraku* is a traditional Japanese form of musical puppet theater dating to the 17th century. The puppets range in size but are typically a meter in height, dressed in elaborate costumes, and controlled by three puppeteers obscured only by their black robes (see front cover).]

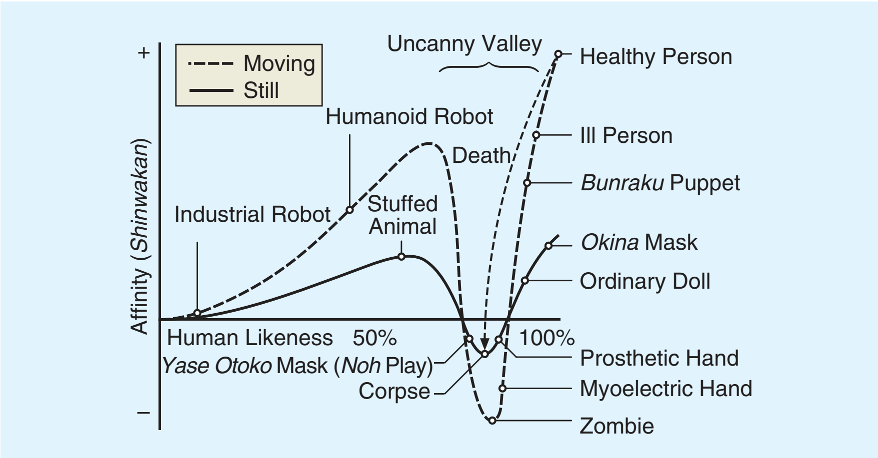


Figure 2. The presence of movement steepens the slopes of the uncanny valley. The arrow's path represents the sudden death of a healthy person. [Translators' note: *Noh* is a traditional Japanese form of musical theater dating to the 14th century in which actors commonly wear masks. The *yase otoko* mask bears the face of an emaciated man and represents a ghost from hell. The *okina* mask represents an old man.]

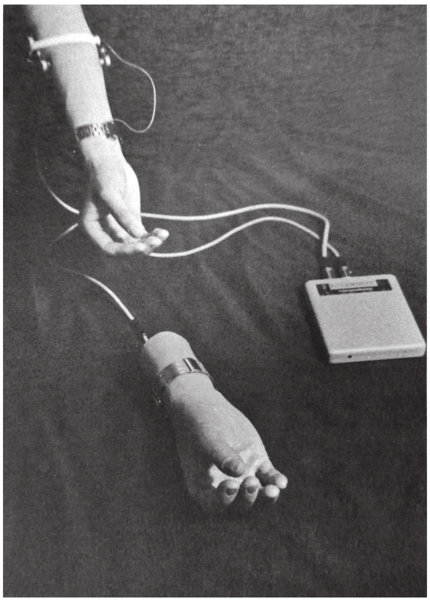


Figure 3. A human arm (top left) controls a *realistic* myoelectric hand, called the "Vienna Hand." Reprinted from [1] with permission.

place shook a woman's hand with it, the woman would assuredly shriek.

Since the negative effects of movement are apparent even with a prosthetic hand, to build a whole robot would magnify the creepiness. This is just one robot. Imagine a craftsman being awakened suddenly in the dead of the night. He searches downstairs for something among a crowd of mannequins in his workshop. If the mannequins started to move, it would be like a horror story.

Movement-related effects could be observed at the 1970 World Exposition in Osaka, Japan. Plans for the event had prompted the construction of robots with some highly sophisticated designs. For example, one robot had 29 pairs of artificial muscles in the face (the same number as a human being) to make it smile in a humanlike fashion. According to the designer, a smile is a dynamic sequence of facial deformations, and the speed of the deformations is crucial. When the speed is cut in half in an attempt to make the robot bring up a smile more slowly, instead of looking happy, its expression turns creepy. This shows how, because of a variation in movement, something that has come to appear close to human—like a robot, puppet, or prosthetic hand—could easily tumble down into the uncanny valley.

Escape by Design

We hope to design and build robots and prosthetic hands that will not fall into the uncanny valley. Thus, because of the risk inherent in trying to increase their degree of human likeness to scale the second peak, I recommend that designers instead take the first peak as their goal, which results in a moderate degree of human likeness and a considerable sense of affinity. In fact, I predict that it is possible to create a safe level of affinity by deliberately pursuing a nonhuman design. I ask designers to ponder this. To illustrate the principle, consider eyeglasses. Eyeglasses do not resemble real eyeballs, but one could say that their design has created a charming pair of new eyes. So we should follow the same principle in designing prosthetic hands. In doing so, instead of pitiful-looking realistic hands, stylish ones would likely become fashionable.

As another example, consider this model of a human hand created by a woodcarver who sculpts statues of Buddhas (Figure 4). The fingers bend freely at the joints. The hand lacks fingerprints, and it retains the natural color of the wood, but its roundness and beautiful curves do not elicit any eerie sensation. Perhaps this wooden hand could also serve as a reference for design.

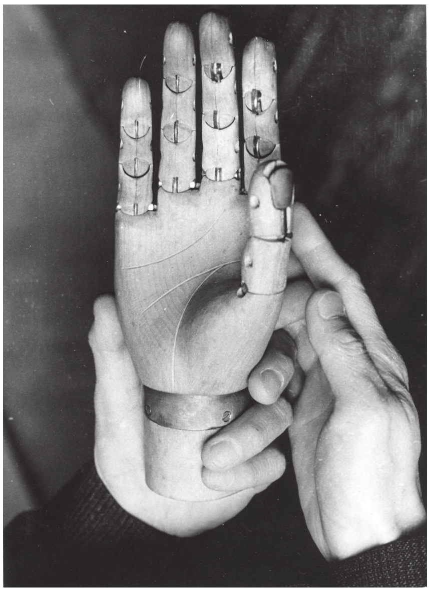


Figure 4. A model of a hand created by a woodcarver of Buddha statues. Reprinted from [1] with permission.

An Explanation of the Uncanny

As healthy persons, we are represented at the second peak in Figure 2 (moving). Then when we die, we are unable to move; the body goes cold, and the face becomes pale. Therefore, our death can be regarded as a movement from the second peak (moving) to the bottom of the uncanny valley (still), as indicated by the arrow's path in Figure 2. We might be glad that this arrow leads down into the still valley of the corpse and not the valley animated by the living dead.

I think this descent explains the secret lying deep beneath the uncanny valley. Why were we equipped with this eerie sensation? Is it essential for human beings? I have not yet considered these questions deeply, but I have no doubt it is an integral part of our instinct for self-preservation. (Note: The sense of eeriness is probably a form of instinct that protects us from proximal, rather than distal, sources of danger. Proximal sources of danger include corpses, members of different species, and other entities we can closely approach. Distal sources of danger include windstorms and floods.)

We should begin to build an accurate map of the uncanny valley so that through robotics research we can begin to understand what makes us human. This map is also necessary to create—using nonhuman designs—devices to which people can relate comfortably. (Notes given in parentheses are footnotes in the original article.)

Reference

[1] M. Mori, "The uncanny valley," *Energy*, vol. 7, no. 4, pp. 33–35, 1970 (in Japanese).

Karl F. MacDorman is an associate professor at the School of Informatics, Indiana University.

Norri Kageki is a business and technology writer based in Silicon Valley and the founder of GetRobo.com.

Human Communication Research ISSN 0360-3989

ORIGINAL ARTICLE

The Proteus Effect: The Effect of Transformed Self-Representation on Behavior

Nick Yee & Jeremy Bailenson

Department of Communication, Stanford University, Stanford, CA 94305

Virtual environments, such as online games and web-based chat rooms, increasingly allow us to alter our digital self-representations dramatically and easily. But as we change our self-representations, do our self-representations change our behavior in turn? In 2 experimental studies, we explore the hypothesis that an individual's behavior conforms to their digital self-representation independent of how others perceive them—a process we term the Proteus Effect. *In the first study, participants assigned to more attractive avatars in immersive virtual environments were more intimate with confederates in a self-disclosure and interpersonal distance task than participants assigned to less attractive avatars. In our second study, participants assigned taller avatars behaved more confidently in a negotiation task than participants assigned shorter avatars. We discuss the implications of the Proteus Effect with regards to social interactions in online environments.*

doi:10.1111/j.1468-2958.2007.00299.x

The notion of transforming our appearances permeates our culture. On the one hand, minor alterations such as haircuts, makeup, and dressing up are seen as socially acceptable, if not socially desirable. On the other hand, the ability to truly transform oneself has been regarded in myths and legends as both dangerous and powerful. Consider, for example, werewolves and vampires from Europe, the kitsune (foxes that can take on human form) from Japan, the God Loki from Norse mythology, and the God Proteus from Greek mythology. The Greek God Proteus is notable for being the origin of the adjective "protean"—the ability to take on many different self-representations. And although extreme self-transformations are expensive (e.g., cosmetic surgery) or difficult to perform (e.g., gender reassignment surgery) on our physical bodies, nowhere is self-representation more flexible and easy to transform than in virtual environments where users can choose or customize their own *avatars*—digital representations of themselves. For example, the documentation for the online

Corresponding author: Nick Yee; e-mail: nyee@stanford.edu
This article was accepted under the editorship of James Dillard.

social world *Second Life* notes that "using over 150 unique sliders, they can change everything from their foot size to their eye color to the cut of their shirt" (Linden Labs, 2006). In other words, the mutability of our self-representations in online environments is a fundamental aspect of what it means to have a virtual identity (Turkle, 1995).

Even though the plasticity of our self-representations is an important part of our online identities, the quantitative research in computer-mediated communication (CMC) has tended to focus instead on the impact of technical affordances on social interaction in online environments. For example, it has been argued that lack of social presence (Hiltz, Johnson, & Turoff, 1986; Short, Williams, & Christie, 1976) or the lack of social cues (Culnan & Markus, 1987; Kiesler, Siegel, & McGuire, 1984) creates an impoverished social environment, whereas others have shown that relationships develop slower in CMC but are not impoverished in the long term (Walther, 1996; Walther, Anderson, & Park, 1994). Other research has looked at how the narrow communication channels in CMC impacts impression formation (Hancock & Dunham, 2001; Jacobson, 1999; Trevino & Webster, 1992; Walther, Slovacek, & Tidwell, 2001). And although there has been research on self-representation in online environments, the focus has been on the impact of anonymity and authenticity (Anonymous, 1998; Flanagin, Tiyaamornwong, O'Connor, & Seibold, 2002; Jarvenpaa & Leidner, 1998; Postmes & Spears, 2002)—in other words, the gap between the real and virtual self and how that difference changes social interactions. In the current work, we were instead interested in exploring how our avatars change how we behave online. As we change our self-representations, do our self-representations change our behaviors in turn? As we choose or create our avatars online and use them in a social context, how might our new self-representations change how we interact with others? Thus, we were interested in the impact of our actual self-representations on our behaviors in virtual environments rather than the effects of anonymity or authenticity.

Behavioral confirmation

There is good reason to believe that our avatars change how we interact with others. Behavioral confirmation offers one potential pathway for this change. Behavioral confirmation is the process whereby the expectations of one person (typically referred to as the *perceiver*) cause another person (typically referred to as the *target*) to behave in ways that confirm the perceiver's expectations (Snyder, Tanke, & Berscheid, 1977). In the seminal study by Snyder et al. (1977), male and female undergraduate students interacted over a telephone. Male perceivers who believed that a female target was attractive caused her to behave in a more charming and friendly manner regardless of how attractive the target actually was. Thus, in an online environment, a perceiver interacting with a target who is using an attractive avatar may cause the target to behave in a more friendly and charming manner. In fact, the study by Snyder et al. itself occurred in a mediated context (i.e., over the telephone). It is important to note that the source of behavioral change from the effects of behavioral confirmation stem from the perceiver rather than the target. It is the perceiver's behavior that in turn causes a change in the target's behavior.

Self-perception theory and deindividuation theory

Behavioral confirmation provides one potential pathway for avatars to change how a person behaves online, but might our avatars change how we behave independent of how others perceive us? When given an attractive avatar, does a user become more friendly and sociable regardless of how others interact with them? Another line of research suggests a potential explanation for why this might occur. Bem (1972) has argued that people observe their own behaviors to understand what attitudes may have caused them (i.e., self-perception theory). For example, people given extrinsic rewards to do something they already enjoy doing are more likely to view the behavior as less intrinsically appealing (i.e., the overjustification effect) because this is what an impartial observer would have concluded as well. Other researchers have shown the far-reaching implications of this theory. In a study by Valins (1966), when participants were made to believe their heartbeat had increased while viewing a photograph of a person, they came to believe the person in the photograph was more attractive. In a study by Frank and Gilovich (1988), subjects that wore black uniforms behaved more aggressively than subjects in white uniforms. According to Frank and Gilovich, wearing a black uniform is a behavior that the subjects used to infer their own dispositions—"Just as observers see those in black uniforms as tough, mean, and aggressive, so too does the person wearing that uniform" (p. 83). The subjects then adhere to this new identity by behaving more aggressively. And finally, this effect has been replicated more recently in a digital environment, where users given avatars in a black robe expressed a higher desire to commit antisocial behaviors than users given avatars in a white robe (Merola, Penas, & Hancock, 2006).

Another line of research has shown that the impact of identity cues is particularly strong when people are deindividuated. Zimbardo (1969) originally used deindividuation theory to argue that urban or crowded areas cause deindividuation that leads to antisocial behavior; however, it has also been shown that deindividuation can lead to affiliative behavior as well (Gergen, Gergen, & Barton, 1973). When dyads were placed in a darkened room for an hour, many deliberately touched or hugged the other person. On the other hand, dyads in the fully lit room talked politely and did not engage in physical contact. Thus, the effects of deindividuation are not necessarily antisocial. The argument that deindividuation can lead to both prosocial and antisocial behavior has also been demonstrated in another well-known study. In a teacher–learner paradigm with electric shock as punishment, subjects in costumes that resembled Ku Klux Klan robes delivered significantly longer shocks than subjects in nurse uniforms (Johnson & Downing, 1979). It was also found that these effects were stronger when subjects were made anonymous in the study. Thus, deindividuation does not necessarily always lead to antisocial behavior as Zimbardo originally argued but may in fact cause a greater reliance on identity cues whether they are antisocial or prosocial.

In the CMC literature, the social identity model of deindividuation effects (SIDE) (Postmes, Spears, & Lea, 1998; Spears & Lea, 1994) argued that factors that lead to deindividuation, such as anonymity, might thus reinforce group salience and conformity to group norms. In this light, deindividuation does not, in and of itself, always lead to antinormative behavior, but rather, behavioral changes depend on the local group norms (Postmes, Spears, & Lea, 2000). More importantly, behavior that is typically seen as antinormative, such as flaming on message boards (Lea, O'Shea, & Spears, 1992), may in fact turn out to be normative and expected in particular contexts (Postmes et al., 1998).

The Proteus Effect

Online environments that afford anonymity are like digital versions of a darkened room where deindividuation might occur, and indeed, many researchers have suggested that deindividuation occurs online due to anonymity or reduced social cues (Kiesler et al., 1984; McKenna & Bargh, 2000). And in online environments, the avatar is not simply a uniform that is worn, the avatar is our entire self-representation. Although the uniform is one of many identity cues in the studies mentioned earlier, the avatar is the primary identity cue in online environments. Thus, we might expect that our avatars have a significant impact on how we behave online. Users who are deindividuated in online environments may adhere to a new identity that is inferred from their avatars. And in the same way that subjects in black uniforms conform to a more aggressive identity, users in online environments may conform to the expectations and stereotypes of the identity of their avatars. Or more precisely, in line with self-perception theory, they conform to the behavior that they believe others would expect them to have. We term this the Proteus Effect.

Although the Proteus Effect is similar to SIDE theory, there are several important theoretical differences. Most importantly, SIDE theory emphasizes conformity to local group norms (e.g., becoming more hostile on a hostile message board). On the other hand, the Proteus Effect emphasizes conformity to individual identity cues (e.g., becoming friendlier in an attractive avatar). Thus, theoretically, it would also be possible to pit one against the other—that is, having an attractive avatar on a hostile message board. We would also argue that having an attribute (e.g., "being attractive") is conceptually different from being among a group of individuals who have that attribute (e.g., "being in a group of attractive people"), whereas SIDE theory literature tends to conflate the two. Thus, in a situation where Person A in a black uniform interacts with Person B in a white uniform, SIDE theory might predict that the social identity of Person A would default to the black uniform (i.e., become more aggressive) or the combined colors of the group in question—in other words, gray (i.e., remain neutral). The Proteus Effect would only predict the former. Another point of differentiation is that although the SIDE theory operates on the basis of an existing local group and its social norms, the Proteus Effect should operate even when the user is alone. This is because self-perception theory is not predicated on the actual presence of other people but simply that a person evaluates him or herself from a third-person perspective (i.e., an imagined third party).

Collaborative virtual environments and transformed social interaction

In designing of our studies, it was crucial that we isolate the impact of the Proteus Effect from that of behavioral confirmation. If participants were perceived to be attractive and believed themselves to be attractive at the same time, it would be impossible for us to claim that the Proteus Effect occurred independent of behavioral confirmation. To isolate the potential effect of the Proteus Effect, we employed a novel methodological paradigm. In the current set of studies, we utilized collaborative virtual environments (CVEs, see Normand et al., 1999) to study the effects of the Proteus Effect. CVEs are communication systems in which multiple interactants share the same three-dimensional digital space despite occupying remote physical locations. In a CVE, immersive virtual environment technology monitors the movements and behaviors of individual interactants and renders those behaviors within the CVE via avatars. These digital representations are tracked naturalistically by optical sensors, mechanical devices, and cameras. Because these avatars are constantly redrawn for each user during interaction, unique possibilities for social interaction emerge (Blascovich et al., 2002; Loomis, Blascovich, & Beall, 1999).

Unlike telephone conversations and videoconferences, the physical appearance and behavioral actions of avatars can be systematically filtered in immersive CVEs idiosyncratically for other interactants, amplifying or suppressing features and nonverbal signals in real time for strategic purposes. Theoretically, these transformations should impact interactants' persuasive and instructional abilities. Previously, we outlined a theoretical framework for such strategic filtering of communicative behaviors called *Transformed Social Interaction* (Bailenson, Beall, Blascovich, Loomis, & Turk, 2005). In a CVE, every user perceives their own digital rendering of the world and each other, and these renderings need not be congruent. In other words, the target may perceive his or her own avatar as being attractive, whereas the perceiver sees the target as being unattractive.

Previous work on transformed social interaction has demonstrated quite resoundingly that changing one's representation has large implications on other's in terms of social influence (Bailenson, 2006). In other words, transforming Avatar A strategically causes Avatar B to behave consistently with the representation of Avatar A (as opposed to the actual representation of Avatar A). In the current set of studies, this decoupling of representation allowed us to test a separate question relating to transforming a representation. Instead of seeing the strategic outcome of a transformation, we examined whether our changes in self-representations—independent of how others perceive us—cause the people behind the avatars to behave differently.

Overview of studies and hypotheses

In the current work, we conducted two experimental studies to explore the Proteus Effect. Participants interacted with a confederate's avatar in a virtual reality (VR) environment. In the first study, we manipulated the attractiveness of the participant's avatar while the confederate was blind to condition. Studies have shown that attractive individuals are perceived to possess a constellation of positive traits (Dion, Berscheid, & Walster, 1972) and are evaluated more favorably by jurors in courtrooms (Friend & Vinson, 1974).

Interpersonal distance

According to nonverbal expectancy violations theory (Burgoon, 1978), when attractive individuals violate nonverbal expectancies, such as moving too close to someone, the positive valence that is created can be socially advantageous (Burgoon & Walther, 1990; Burgoon, Walther, & Baesler, 1992). Given that attractive individuals have higher confidence (Langlois et al., 2000), we hypothesized that

> H1: Participants in the attractive condition walk closer to the confederate than the participants in the unattractive condition.

Self-disclosure

Friendliness was one of the measures used in Snyder et al.'s (1977) original study, and in this study, we used self-disclosure as a behavioral operationalization. Because attractive individuals tend to be more extraverted and more friendly (Langlois et al., 2000), we hypothesized that

> H2: Participants in the attractive condition would exhibit higher self-disclosure and present more pieces of information about themselves than participants in the unattractive condition.

In the second study, we manipulated the height of the participant's avatar again with the confederate blind to the condition. Similar to the attractiveness literature, taller people are perceived to be more competent (Young & French, 1996), more desirable as romantic partners (Freedman, 1979; Harrison & Saeed, 1977), and more likely to emerge as leaders (Stogdill, 1948). In this study, we implemented a negotiation task to best gauge confidence.

> H3: Participants in taller avatars would behave in a more confident manner and negotiate more aggressively than participants in shorter avatars.

Experiment 1

Design

In a between-subjects design, participants were randomly assigned to have an avatar with an attractive or unattractive face of his or her own gender and then interact with a confederate. We followed the paradigm in the study by Snyder et al. (1977) and always used a confederate of the opposite gender. The confederate was blind to the attractiveness condition such that the participant's avatar appeared to the confederate with an untextured face—one which was structurally human but left uncolored.

Participants

Thirty-two undergraduate students at Stanford (16 men and 16 women) participated in the study for course credit.

Materials

Facial attractiveness pretest

We ran a pretest to get subjective determinations of attractive and unattractive faces (for the participants), and also average attractiveness faces (for the confederates). To minimize the chances that our findings would be driven by idiosyncrasies of a particular face, we chose two faces in each of these three attractiveness conditions. Thus, there were two attractive faces, two unattractive faces, and two average faces for each gender. In total, we used 12 faces in the study.

To generate these 12 faces, digital photographs of 34 undergraduate students (17 male and 17 female) from a different academic institution from the main study were used in a pretest. The chances of participant recognition of these faces were thus minimized. To reduce other variations in facial features, only Caucasians were used in the pretest.[1] Frontal and profile photographs of these 34 undergraduate students were converted into digital, three-dimensional head busts using 3DMeNow software. These three-dimensional head busts were then converted into Vizard 2.17 models, our CVE platform, and attached to generic male and female bodies. Finally, a frontal and three-quarter screenshot of every face was taken (see Figure 1). Thus, altogether, 68 screenshots were generated.

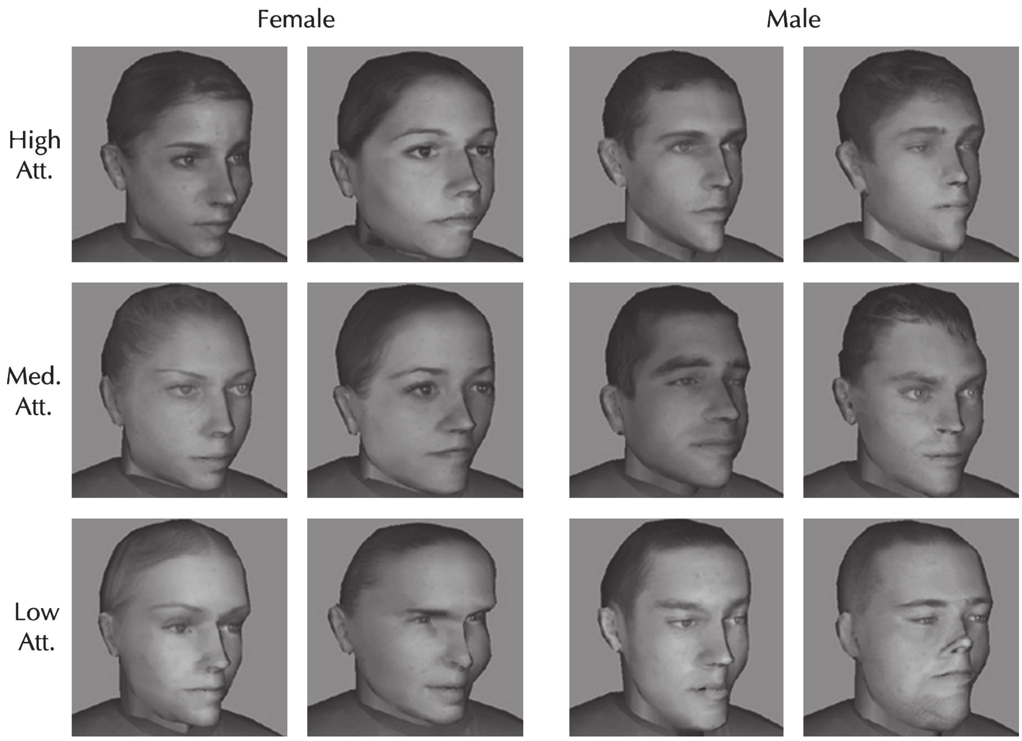


Figure 1 Faces with high, medium, and low attractiveness ratings by gender.

Fourteen undergraduates from a separate subject pool from the main study used a web-based survey to rate the attractiveness of every screenshot's face on a unipolar seven-point fully labeled construct-specific scale (from *not attractive at all* to *extremely attractive*). The frontal and three-quarter screenshot of every face were thus rated separately. Each screenshot was shown by itself and the order of faces was uniquely randomized for every rater.

The ratings of the frontal and three-quarter image of every face were averaged. Then six faces were selected for each gender, where the two attractive faces were each rated as significantly more attractive than the two average faces, and the two average faces were each rated as significantly more attractive than the two unattractive faces. All pairwise t tests had a p value less than .05 (dfs = 26). The 12 faces used in the study are shown in Figure 1. The means and standard deviations of their attractiveness ratings are shown in Table 1. In the entire sample of faces we pretested, the mean attractiveness was 3.09 with a standard deviation of 1.30. The faces we chose for the high-attractiveness condition had a mean of 4.63 and a standard deviation of 1.22, whereas the faces in the low-attractiveness condition had a mean of 1.61 and a standard deviation of 0.83. Thus, our faces in the high-and-low attractiveness conditions varied from the average by about one standard deviation.

The physical lab setting

The lab consisted of two rooms with an open doorway. In the room where the study took place, a black curtain divided the room. To ensure that confederates and participants were not biased by the attractiveness of each other's real faces, confederates stayed behind this black curtain until the VR interaction began and thus never saw the participant's real face and vice versa.

The virtual setting

The virtual setting was a white room that had the same exact dimensions as the physical room participants were in (see Figure 2). Two meters behind the participant was a *virtual mirror* that reflected the head orientation (rotations along pitch, yaw, and roll) and body translation (translation on X, Y, and Z) of the participant with the designated face (see Figure 2). Thus, the mirror image tracked and reflected six degrees of freedom such that when the participant moved in physical space, his or her avatar moved in perfect synchrony in the mirror. The confederate's avatar was

Table 1 Means and Standard Deviations of Attractiveness Ratings for Avatar Faces

	Female		Male	
Attractiveness	Face 1 *M* (*SD*)	Face 2 *M* (*SD*)	Face 1 *M* (*SD*)	Face 2 *M* (*SD*)
High	5.50 (1.35)	4.32 (1.25)	4.64 (1.19)	4.04 (1.10)
Medium	3.39 (1.47)	3.50 (1.40)	3.11 (1.34)	2.93 (1.65)
Low	2.29 (1.15)	1.18 (0.55)	1.75 (1.11)	1.21 (0.50)

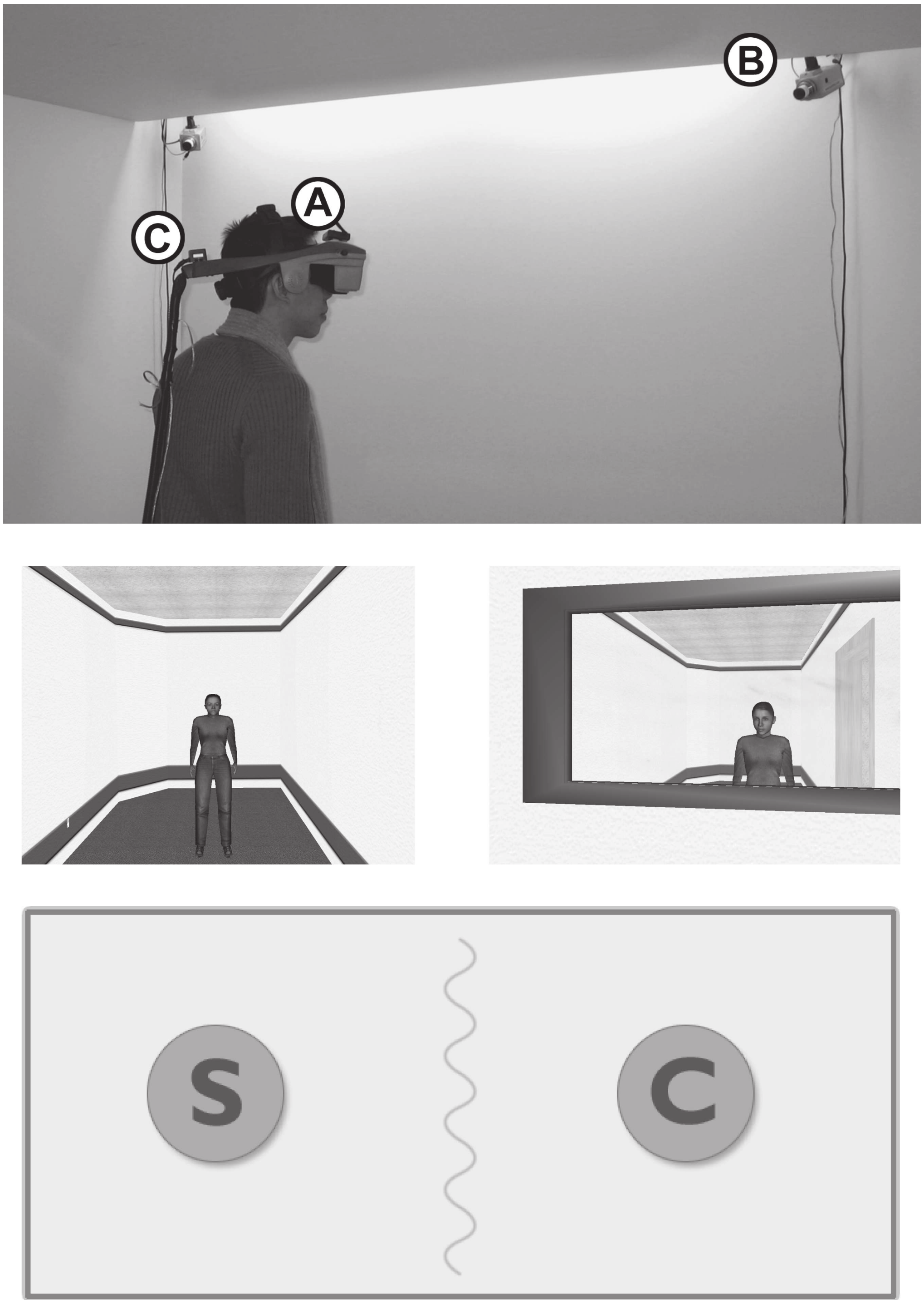


Figure 2 The equipment setup is shown in the top panel. In the lab space, the participant wears the head-mounted display (HMD) (A). The orientation device (B) attached to the HMD tracks rotation, whereas the cameras (C) are used for optical tracking of the participant's position in the room. The virtual room with the confederate is shown in the middle left panel. In the middle right panel is the participant's view of the mirror. In the bottom panel is a diagram showing the layout of the room, the position of the Subject (S), the position of the Confederate (C), and the curtain.

located 5 m in front of the participant, facing the participant, and remained invisible until the conversational portion of the experiment began. The confederate's avatar also had an automated blink animation based on human blinking behavior and lip movement that matched the volume of the confederate's speech.

Apparatus

Perspectively correct stereoscopic images were rendered at an average frame rate of 60 Hz. The simulated viewpoint was continually updated as a function of the participants' head movements, which were tracked by a three-axis orientation sensing system. The position of the participant along the *x*, *y*, and *z* planes were tracked via an optical tracking system. Participants wore an nVisor SX head-mounted display (HMD) that featured dual 1,280 horizontal by 1,024 vertical pixel resolution panels that refreshed at 60 Hz. See Figure 2 for the equipment setup.

Procedure

Three researcher assistants were present during each trial—the lead research assistant, the male confederate, and the female confederate. The confederate in the trial was always the opposite gender of the participant and remained blind to condition. Participants were told that the goal of the experiment was to study social interaction in virtual environments and that they would be having a conversation with another person in a virtual environment. Once the virtual world was loaded, participants saw themselves in a room that was exactly the same dimensions as the physical lab room, as depicted in Figure 2.

Participants were then asked by the lead research assistant to turn around 180° and asked to verify that they saw a mirror in front of them. After verbal affirmation, participants were then told that this is how they appeared to others in the virtual room. Several exercises (head tilting and nodding in front of the mirror) were used to make sure participants had enough time to observe their avatars' faces. Every participant was thus exposed to the designated face for between 60 and 75 seconds.

Participants were then asked to turn back around to face the front (i.e., their original orientation). Slightly ahead of time, the lead research assistant had triggered the program to make the confederate's avatar visible to the participant in the virtual world. The lead research assistant then introduced the confederate to the participant. The confederate followed a strict script that was displayed in their HMD so they could follow the specific verbal procedures while interacting with the participant inside the CVE. Their behaviors were not scripted, and they were instructed to use natural head movements when interacting with the participant. First, participants were greeted and asked to walk closer to the confederate. When the participant stopped or asked whether the distance was close enough, the confederate would then ask them to move a little closer. The confederate then asked the participants to introduce themselves. When the participants stopped or asked whether what they said was enough, the confederate asked the participants to say a little more. If the participants ever asked the confederate any other question, the confederate would reply with "I'm sorry. I can't answer that question. Let's continue."

Measures

Interpersonal distance

The distance between the participant and the confederate was automatically tracked by the VR system. Previous research has validated the interpersonal distance measure inside CVEs (Bailenson, Blascovich, Beall, & Loomis, 2003).

Self-disclosure

The amount of self-disclosure was measured by counting the number of pieces of information that participants gave during the two introduction prompts near the beginning of the conversational portion of the study (e.g., "Tell me a little bit about yourself" and "Tell me a little more"). Two blind coders were asked to count the number of pieces of information given by the participants. Every tape recording was coded by two blind coders, and the coder interreliability was .84.

Results and discussion

To ensure that our attractiveness manipulation was not so obvious as to elicit strong demand characteristics, we asked all participants to write a paragraph and guess the intent of the experiment. Two coders blind to experimental condition read through these responses. Most participants guessed that the goal was to study conversational dynamics in VR as compared with face-to-face interactions. According to both coders, no participant mentioned attractiveness or mentioned that they thought the avatar's attractiveness was manipulated in the study.

Interpersonal distance

We ran a t test with attractiveness as the between-subject variable[2] and the final distance as the dependent variable. Participants in the attractive condition walked significantly closer to the confederate ($M = 0.98$, $SD = 0.36$) than participants in the unattractive condition ($M = 1.74$, $SD = 1.20$), $t(30) = -2.42$, $p = .02$, $d = .40$.

Self-disclosure

We performed a t test using attractiveness as the between-subject variable and the self-disclosure count as the dependent variable. Participants in the attractive condition revealed significantly more pieces of information ($M = 7.19$, $SD = 2.77$) than participants in the unattractive condition ($M = 5.42$, $SD = 1.56$), $t(30) = 2.23$, $p = .03$, $d = .38$.

The results from the first experiment provided support for the Proteus Effect—that our self-representations shape our behaviors in turn. Participants in the attractive condition were willing to move closer to the confederate and disclosed more information to the confederate than participants in the unattractive condition. More importantly, this effect was measurable and significant immediately after only a brief exposure to the mirror task. The effect size in the current study—interpersonal distances changes of almost a meter—are quite large, much more so than effects found in previous studies on interpersonal distance (Bailenson et al., 2003), which were less than 15 cm. The reason the current manipulation produced such a drastic effect is most likely due to the personal nature of the social interaction.

Experiment 2

In the second experiment, we replicated the Proteus Effect with another manipulation—height. Because height is more often associated with self-esteem and competence rather than friendliness (Young & French, 1996), we employed a different behavioral measure. Instead of a proximity and self-disclosure task, a negotiation task—the "ultimatum game" (Forsythe, Horowitz, Savin, & Sefton, 1994)—was used as a behavioral measure of confidence. In the ultimatum game, two individuals take turns to decide how a pool of money should be split between the two of them. One individual makes the split, and the other must choose to either accept or reject the split. If the split is accepted, the money is shared accordingly. If the split is rejected, neither of them gets the money. We hypothesized that participants with taller avatars would be more confident and be more willing to make unfair splits than participants in shorter avatars.

Design

In a between-subjects design, participants were randomly assigned to have an avatar that was shorter, taller, or the same height as a confederate who was of the opposite gender. We relied on demographic data to assign the base height and height differences in the study. From the National Health and Nutrition Examination Study (NHANES) 2003–2004 data set (National Center for Health Statistics [NCHS], 2004), we calculated the mean and standard deviation of height among Caucasians aged 18–22 in the U.S. population. The mean height was 171.5 cm (or 5 feet and 7.5 inches) with a standard deviation of 10.2 cm. Although men and women have different average heights, we decided to use the same base height across all conditions to avoid confounding height with gender in the experimental design. In our study, the confederate had a base height of 172 cm. In the short condition, participants were 10 cm shorter than the confederate. In the tall condition, participants were 10 cm taller than the confederate. In the same height condition, participants were the same height as the confederate. Thus, the size of our manipulations in the short and tall conditions was about one standard deviation in height. In our study, the confederate was blind to the height condition and the participant's avatar always appeared to the confederate as the same height.[3] In other words, confederates did not know the experimental condition and always perceived the participant as the same height as themselves.

Participants

Participants were 50 undergraduate students at Stanford who were paid $10 for their participation.

Materials

The physical lab and the virtual setting of Experiment 2 were identical to the ones described in Experiment 1 except there was no mirror in the virtual room.

Apparatus

The apparatus used in Experiment 2 was identical to the apparatus described in Experiment 1.

Procedure

Three researcher assistants were present during each trial—the lead research assistant, the male confederate, and the female confederate. The confederate was always the opposite gender of the participant and was blind to condition. Participants were told that the goal of the experiment was to study social interaction in VR environments and that they would be having a conversation with another person in VR. Once the VR world was loaded, participants saw themselves in a room that was exactly the same dimensions as the physical lab room they were in. The confederate's avatar was visible across the virtual room.

The confederate followed a strict verbal script that was displayed in their HMD. Their behaviors were not scripted, and they were instructed to use natural head movements when interacting with the participant. First, participants were greeted by the confederate. The confederate then asked the participants to introduce themselves. After the introductory phase, the lead research assistant explained the money-sharing task. A hypothetical pool of $100 was to be split between the confederate and the participant. One of the two would designate a split. The other would either accept or reject the split. If the split was accepted, the money would be shared accordingly. If the split was rejected, neither would receive any money. The participant was told there would be four rounds of this game and that the lead research assistant would alternate as to who would be making the split for each round.

The participant always designated the split in the first and third rounds. The confederate was instructed to always accept a split as long as it did not exceed $90 in favor of the participant. The confederate always designated a split of 50/50 in the second round and 75/25 (in the confederate's favor) in the fourth round. These two ratios were chosen to represent a fair and unfair split. After the money-sharing task, the participant was taken out of the virtual setting.

Measures

Monetary splits

The split offers were recorded by the research assistant during the negotiation task.

Results and discussion

To ensure that our height manipulation was not so obvious as to elicit strong demand characteristics, we asked all participants to guess the intent of the experiment. Two coders blind to condition read through the responses. Most participants guessed that the goal was to study conversational dynamics in VR as compared with face-to-face interactions. According to both coders, no participant mentioned height or guessed that height was manipulated in the study.

Negotiation behavior

There were three measures of interest: amount offered by participant in the first round (from hereon referred to as Split 1), amount offered by participant in the third round (from hereon referred to as Split 2), and whether the participant accepted the unfair split by the confederate in the final round (from hereon referred to as final split). Three outliers (more than three standard deviations from the mean) in Split 1 and Split 3 were excluded from analysis. The cutoffs were 88.5 and 84.2, respectively.

We ran an analysis of variance (ANOVA) with height as the between-subject factor and Split 1 as the dependent variable. The effect of height was not significant, $F(2, 47) = 0.63$, $p = .53$, $\eta^2 = .03$, see Table 2.

We then ran an ANOVA with height as the between-subject factor and Split 3 as the dependent variable. There was a main effect of height, $F(2, 46) = 5.64$, $p = .006$, $\eta^2 = .20$. A post hoc test using Tukey's Honest Significant Difference (HSD) showed that participants in the tall condition split the money significantly more in their own favor ($M = 60.63$, $SD = 6.55$) than participants in the short condition ($M = 52.06$, $SD = 7.30$), $p = .004$. See Table 2 for all means and standard deviations of the splits by condition.

Finally, to test the effect of height on the acceptance rate of the final unfair offer, we ran a logistic regression using acceptance rate as the dependent variable and height (recoded short as 1, normal as 2, and tall as 3) as the independent variable. Height was a significant predictor of acceptance rate, $\chi^2(1, N = 50) = 4.41$, $p = .04$. Prediction success for acceptance of the unfair offer was 54%, and it was 80% for rejection of the unfair offer. Participants in the short condition were about twice as likely to accept the unfair offer (72%) as participants in the normal (31%) and tall condition (38%).

We were surprised that the effect of height on negotiation did not emerge until the second split. Informal discussion with the research assistants and review of the

Table 2 The Means and Standard Deviations of Interpersonal Distance and Split 1 Across Height Conditions

Height	Split 1	Split 2	Final Split
Short	54.99 (12.47)	52.06 (7.30)	0.72 (0.46)
Normal	58.69 (15.85)	55.69 (8.10)	0.31 (0.48)
Tall	53.75 (10.25)	60.63 (6.55)	0.38 (0.50)

recordings suggest that many participants were "testing the waters" in the first split but became more bold in the second split. In any case, the effect of height on the second split was highly significant and suggests that the manipulation of height does affect negotiation behavior, but that these effects may emerge over time.

In summary, our findings from Experiment 2 extended the Proteus Effect with a different manipulation. Participants in the tall condition were significantly more likely to offer an unfair split than participants in the normal and short conditions. At the same time, participants in the short condition were significantly more likely to accept an unfair split than participants in the normal and tall condition. Thus, our findings from the negotiation task support the Proteus Effect.

General discussion

Across different behavioral measures and different representational manipulations, we observed the effect of an altered self-representation on behavior. Participants who had more attractive avatars exhibited increased self-disclosure and were more willing to approach opposite-gendered strangers after less than 1 minute of exposure to their altered avatar. In other words, the attractiveness of their avatars impacted how intimate participants were willing to be with a stranger. In our second study, participants who had taller avatars were more willing to make unfair splits in negotiation tasks than those who had shorter avatars, whereas participants with shorter avatars were more willing to accept unfair offers than those who had taller avatars. Thus, the height of their avatars impacted how confident participants became. These two studies show the dramatic and almost instantaneous effect that avatars have on behavior in digital environments.

In our experimental studies, we purposefully excluded the effect of behavioral confirmation even though it too clearly plays a crucial role in social interactions—both online and offline. The advantage of this exclusion was that it enabled us to isolate the effect of changing an individual's self-representation. The disadvantage is the inability to understand how these changes may unfold in an actual situation where the Proteus Effect interacts with behavioral confirmation. What is striking about the current data is that we demonstrated drastic changes in behavior even though there was absolutely no way for behavioral conformation to occur, as the confederates always were blind to experimental condition. Another limitation was that we were unable to explore the role of choice in the Proteus Effect. In our studies, participants were given avatars rather than being able to choose their own avatar—the typical situation in online environments. However, it bears pointing out that the range of avatar choice in many online environments is not truly diverse. For example, in the social online world *There.com*, users can only create youthful avatars. Old people do not exist in *There*. In other words, there may be many features of our avatars that we actually do not have control over in online environments.

Another limitation in our studies was the lack of a direct manipulation check. Because our theoretical claim is based partly on self-perception theory, our results would have been more convincing if participants in the attractive condition rated their avatar as indeed more attractive than participants in the unattractive condition. And finally, our reliance on the opposite-gender paradigm may have limited our studies to a certain class of interactional behavior (e.g., with a romantic or sexual tone). It would be interesting to carry out additional studies in same-gender pairings to examine this potential bias.

Future research in this area might focus on several other things. First, the Proteus Effect may generalize to other fundamental aspects of self-representation, such as gender or race. For example, when male participants employ female avatars, they may behave in a more gender-stereotypical manner. Second, examining whether or not there are long-term consequences of the Proteus Effect, which carry over into the physical world, is obviously an important research agenda. Do users who frequently use tall and attractive avatars become more confident and friendly in real life? If so, virtual environments may be an excellent venue for therapeutic purposes. Third, examining the role of choice in the Proteus Effect might reveal that choice either augments or diminishes the effect. Also, while we argued in the theoretical framing that the Proteus Effect could occur even if participants were alone and not in a group setting, this was something we did not directly test for in our experimental designs. It would be interesting to devise similar experiments where participants were not in a group setting.

And finally, we suggest that the most interesting area of research lies in the mismatch of self-representation and how others perceive us. In the traditional behavioral confirmation paradigm, the false assumptions of the perceiver are unknown to the target. Unlike the target-centric paradigm that denies the target of their awareness of how others may stereotype them, we have shown that an individual's false self-concept (i.e., self-stereotyping) has a significant impact on their behavior. More importantly, the false self-concept may override behavioral confirmation. In our studies, participants using attractive avatars became more intimate and friendly with strangers. This initial friendliness may elicit more positive responses from the interactant and lead to a more positive interaction overall. Thus, we hypothesize that the precise reverse of behavioral confirmation—a target's false self-concept causes them to interact with the perceiver in a way such that the perceiver behaves in a way that confirms the target's false self-concept—can occur. The most interesting test of this hypothesis may be to pit the Proteus Effect against behavioral confirmation. In other words, future work should examine an experimental paradigm in which participants believe that they are attractive, whereas other interactants perceive them as unattractive. A similar research agenda has been proposed by Blascovich and colleagues (Blascovich et al., 2002).

The Proteus Effect is a particularly important theoretical framework in understanding behavior in virtual environments where users are able to choose or customize their avatar's appearances. In our experimental studies, dyads interacted after one interactant had their self-representation manipulated. In virtual communities, thousands of users interact with altered self-representations. In many of these environments, the only avatar choices are youthful, in shape, and attractive. If having an attractive avatar can increase a person's confidence and their degree of self-disclosure within minutes, then this has substantial implications for users in virtual environments. First, the Proteus Effect may impact behavior on the community level. When thousands of users interact, most of whom have chosen attractive avatars, the virtual community may become more friendly and intimate. This may impact the likelihood of relationship formation online (Parks & Floyd, 1996). As graphical avatars become the dominant mode of self-representation in virtual environments, the Proteus Effect may play a substantial role in encouraging hyperpersonal interaction (see Walther, 1996). And second, these behavioral changes may carry over to the physical world. If users spend more than 20 hours a week in these environments (Yee, 2006), in an avatar that is tall and attractive, is an equilibrium state reached or do two separate behavioral repertoires emerge?

The set of studies presented in this paper makes clear that our self-representations have a significant and instantaneous impact on our behavior. The appearances of our avatars shape how we interact with others. As we choose our self-representations in virtual environments, our self-representations shape our behaviors in turn. These changes happen not over hours or weeks but within minutes. Every day, millions of users interact with each other via graphical avatars in real time in online games (Chan & Vorderer, 2006). All of them are using an avatar that differs from their physical appearance. In fact, most of them are using avatars that are attractive, powerful, youthful, and athletic. Although most research in CMC has focused on the technical affordances of the medium (lack of social cues, social presence, anonymity, etc.), we argue that theoretical frameworks of self-representation cannot be ignored because choosing who we are is a fundamental aspect of virtual environments. More importantly, who we choose to be in turn shapes how we behave. Although avatars are usually construed as something of our own choosing—a one-way process—the fact is that our avatars come to change how we behave.

Acknowledgments

The current work was partially supported by National Science Foundation (NSF) Grant 0527377. The authors would like to thank Claire Carlson, Gerron Crochet, and Kathryn Rickertsen for their assistance in conducting the experiment, as well as Jim Blascovich for providing helpful feedback on an earlier draft of the paper.

Notes

1 In the analysis of Experiment 1, there was no significant interaction effect with the race of the participant. In Experiment 2, participants do not see their own avatar, so this was not an issue.

2 In both studies, the effect of subject gender was not significant, and including this factor in the ANOVA did not change the reported significance of the results.

3 In the cases where this caused a mismatch between the perceived and actual height of the participant's avatar, real-time algorithms using trigonometry were used to correct the eye-gaze angle between the participant and the confederate to preserve the possibility of making eye contact.

References

Anonymous. (1998). To reveal or not to reveal: A theoretical model of anonymous communication. *Communication Theory*, **8**, 381–407.

Bailenson, J. (2006). Transformed social interaction in collaborative virtual environments. In P. Messaris & L. Humphreys (Eds.), *Digital media: Transformations in human communication* (pp. 255–264). New York: Peter Lang.

Bailenson, J., Beall, A., Blascovich, J., Loomis, J., & Turk, M. (2005). Transformed social interaction, augmented gaze, and social influence in immersive virtual environments. *Human Communication Research*, **31**, 511–537.

Bailenson, J., Blascovich, J., Beall, A., & Loomis, J. (2003). Interpersonal distance in immersive virtual environments. *Personality and Social Psychology Bulletin*, **29**, 1–15.

Bem, D. (1972). Self perception theory. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 6). New York: Academic Press.

Blascovich, J., Loomis, J., Beall, A., Swinth, K., Hoyt, C., & Bailenson, J. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological Inquiry*, **13**(2), 103–124.

Burgoon, J. (1978). A communication model of personal space violation: Explication and an initial test. *Human Communication Research*, **4**, 129–142.

Burgoon, J., & Walther, J. (1990). Nonverbal expectancies and the evaluative consequences of violations. *Human Communication Research*, **17**, 232–265.

Burgoon, J., Walther, J., & Baesler, E. (1992). Interpretations, evaluations, and consequences of interpersonal touch. *Human Communication Research*, **19**, 237–263.

Chan, E., & Vorderer, P. (2006). Massively multiplayer online games. In P. Vorderer & J. Bryant (Eds.), *Playing computer games—Motives, responses, and consequences*. Mahwah, NJ: Lawrence Erlbaum.

Culnan, M. J., & Markus, M. L. (1987). Information technologies. In F. M. Jablin & L. L. Putnam (Eds.), *Handbook of organizational communication: An interdisciplinary perspective* (pp. 420–443). Thousand Oaks, CA: Sage Publications.

Dion, K., Berscheid, E., & Walster, E. (1972). What is beautiful is good. *Journal of Personality and Social Psychology*, **24**, 285–290.

Flanagin, A. J., Tiyaamornwong, V., O'Connor, J., & Seibold, D. R. (2002). Computer-mediated group work: The interaction of member sex and anonymity. *Communication Research*, **29**, 66–93.

Forsythe, R., Horowitz, J., Savin, N., & Sefton, M. (1994). Fairness in simple bargaining experiments. *Games and Economic Behavior*, **6**, 347–369.

Frank, M., & Gilovich, T. (1988). The dark side of self and social perception: Black uniforms and aggression in professional sports. *Journal of Personality and Social Psychology*, **54**, 74–85.

Freedman, D. G. (1979). *Human sociobiology*. New York: Free Press.

Friend, R. M., & Vinson, M. (1974). Leaning over backward: Jurors responses to defendants' attractiveness. *Journal of Communication*, **24**, 124–129.

Gergen, K., Gergen, M., & Barton, W. H. (1973). Deviance in the dark. *Psychology Today*, **11**, 129–130.

Hancock, J., & Dunham, P. (2001). Impression formation in computer-mediated communication revisited: An analysis of the breadth and intensity of impressions. *Communication Research*, **28**, 325–347.

Harrison, A. A., & Saeed, L. (1977). Let's make a deal: An analysis of revelations and stipulations in lonely hearts advertisements. *Journal of Personality and Social Psychology*, **35**, 257–264.

Hiltz, S., Johnson, K., & Turoff, M. (1986). Experiments in group decision making: Communication processes and outcome in face-to-face versus computerized conferences. *Human Communication Research*, **13**, 225–252.

Jacobson, D. (1999). Impression formation in cyberspace: Online expectations and offline experiences in text-based virtual communities. *Journal of Computer-Mediated Communication*, **5**. Retrieved April 26, 2007, from http://jcmc.indiana.edu/vol5/issue1/jacobson.html

Jarvenpaa, S., & Leidner, D. (1998). Communication and trust in global virtual teams. *Journal of Computer-Mediated Communication*, **3**. Retrieved April 26, 2007, from http://jcmc.indiana.edu/vol3/issue4/jarvenpaa.html

Johnson, R., & Downing, L. (1979). Deindividuation and valence of cues: Effects on prosocial and antisocial behavior. *Journal of Personality and Social Psychology*, **37**, 1532–1538.

Kiesler, S., Siegel, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. *American Psychologist*, **39**, 1123–1134.

Langlois, J., Kalakanis, L., Rubenstein, A., Larson, A., Hallam, M., & Smoot, M. (2000). Maxims or myths of beauty?: A meta-analytic and theoretical review. *Psychological Bulletin*, **126**, 390–423.

Lea, M., O'Shea, T., & Spears, R. (1992). "Flaming" in computer-mediated communication. In M. Lea (Ed.), *Contexts of computer-mediated communication* (pp. 89–112). New York: Harvester Wheatsheaf.

Linden Labs (2006). *What is second life?* Retrieved May 5, 2006, from lindenlab.com/ProductFactSheet.pdf

Loomis, J., Blascovich, J., & Beall, A. (1999). Immersive virtual environments as a basic research tool in psychology. *Behavior Research Methods, Instruments, and Computers*, **31**, 557–564.

McKenna, K., & Bargh, J. (2000). Plan 9 from cyberspace: The implications of the Internet for personality and social psychology. *Personality and Social Psychology Review*, **4**, 57–75.

Merola, N., Penas, J., & Hancock, J. (2006). *Avatar color and social identity effects: On attitudes and group dynamics in virtual realities*. Paper presented at the ICA 2006, Dresden, Germany.

National Center for Health Statistics (2004). National health and nutrition examination survey 2003-2004. Retrieved September 5, 2006, from http://www.cdc.gov/nchs/about/major/nhanes/nhanes2003-2004/nhanes03_04.htm

Normand, V., Babski, C., Benford, S., Bullock, A., Carion, S., Chrysanthou, Y, et al. (1999). The COVEN project: Exploring applicative, technical, and usage dimensions of collaborative virtual environment. *Presence: Teleoperators and Virtual Environments*, **8**, 218–236.

Parks, M. R., & Floyd, K. (1996). Making friends in cyberspace. *Journal of Communication*, **46**, 80–96.
Postmes, T., & Spears, R. (2002). Behavior online: Does anonymous computer communication reduce gender inequality? *Personality & Social Psychology Bulletin*, **28**, 1073–1083.
Postmes, T., Spears, R., & Lea, M. (1998). Breaching or building social boundaries? *Communication Research*, **25**, 689–699.
Postmes, T., Spears, R., & Lea, M. (2000). The formation of group norms in computer-mediated communication. *Human Communication Research*, **26**, 341–371.
Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications*. London: Wiley.
Snyder, M., Tanke, E. D., & Berscheid, E. (1977). Social perception and interpersonal behavior: On the self-fulfilling nature of social stereotypes. *Journal of Personality & Social Psychology*, **35**, 656–666.
Spears, R., & Lea, M. (1994). Panacea or panopticon? The hidden power in computer-mediated communication. *Communication Research*, **21**, 427–459.
Stogdill, R. M. (1948). Personal factors associated with leadership: A survey of the literature. *Journal of Psychology*, **25**, 35–71.
Trevino, L., & Webster, J. (1992). Flow in computer-mediated communication: electronic mail and voice mail evaluation and impacts. *Communication Research*, **19**, 539–573.
Turkle, S. (1995). *Life on the screen: Identity in the age of the Internet*: New York: Simon and Schuster.
Valins, S. (1966). Cognitive effects of false heart-rate feedback. *Journal of Personality and Social Psychology*, **4**, 400–408.
Walther, J. (1996). Computer-mediated communication: Impersonal, interpersonal, and hyperpersonal interaction. *Communication Research*, **23**(1), 3–43.
Walther, J., Anderson, J., & Park, D. (1994). Interpersonal effects in computer-mediated interaction: A meta-analysis of social and anti-social communication. *Communication Research*, **21**, 460–487.
Walther, J., Slovacek, C., & Tidwell, L. (2001). Is a picture worth a thousand words?: Photographic images in long-term and short-term computer-mediated communication. *Communication Research*, **28**, 105–134.
Yee, N. (2006). The demographics, motivations, and derived experiences of users of massively multi-user online graphical environments. *Presence: Teleoperators and Virtual Environments*, **15**, 309–329.
Young, T. J., & French, L. A. (1996). Height and perceived competence of U.S. Presidents. *Perceptual and Motor Skills*, **82**, 1002.
Zimbardo, P. (1969). The human choice: Individuation, reason, and order vs. deindividuation, impulse and chaos. In W. J. Arnold & D. Levine (Eds.), *Nebraska symposium on motivation* (Vol. 17, pp. 237–307). Lincoln: University of Nebraska Press.

Personality and Individual Differences 133 (2018) 56–66

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

An empirical study on the motivations underlying augmented reality games: The case of Pokémon Go during and after Pokémon fever

Ágnes Zsila [a,b,1], Gábor Orosz [b,c,*,1], Beáta Bőthe [a,b], István Tóth-Király [a,b], Orsolya Király [b], Mark Griffiths [d], Zsolt Demetrovics [b]

[a] Doctoral School of Psychology, Eötvös Loránd University, Budapest, Hungary
[b] Institute of Psychology, Eötvös Loránd University, Budapest, Hungary
[c] Institute of Cognitive Neuroscience and Psychology, Hungarian Research Centre for Natural Sciences, Budapest, Hungary
[d] Nottingham Trent University, Psychology Department, Nottingham, United Kingdom

ARTICLE INFO

Article history:
Received 24 September 2016
Received in revised form 26 May 2017
Accepted 15 June 2017
Available online 21 June 2017

Keywords:
Augmented reality games
Confirmatory factor analysis (CFA)
Gaming motivation
MOGQ-PG
Pokémon Go
Psychometric scale development

ABSTRACT

In 2016, Pokémon Go became the most popular game in the history of smartphone games and was among the first games to feature geo-located augmented reality (AR) elements. The goal of the present research was to obtain a deeper understanding concerning the motivations underlying Pokémon Go use and to create a measure that assesses these motivations. By extending the framework of the Motives for Online Gaming Questionnaire, three new factors – Outdoor Activity, Nostalgia, and Boredom – were added based on the findings of qualitative analysis, and which led to the creation of the Motives for Online Gaming Questionnaire - Pokémon Go extension (MOGQ-PG). Confirmatory factor analysis was carried out on a sample of Pokémon Go players ($N = 621$). Results demonstrated that the final 37-item, first-order, 10-factor model had appropriate factor structure and internal consistency. A second follow-up study on Pokémon Go players ($N = 510$) examined associations between gaming motivations, problematic use, and impulsivity. Results demonstrated that impulsivity was not related to the MOGQ-PG motives. Results also showed that competition and fantasy motivations predicted problematic gaming behavior. The present research is the first empirical contribution to the assessment and understanding of the motivational background of playing AR games such as Pokémon Go.

1. Introduction

1.1. The Pokémon Go phenomenon

Over the last 15 years, most videogames have traditionally been played online or offline. Recently, new forms of games (most notably Pokémon Go), implementing augmented reality, have become popular worldwide. Over 100 million users from 30 countries downloaded Pokémon Go within a few weeks, and were reported to be playing it for 26 min in an average day (Smith, 2016). Considering the unparalleled popularity of this new game, the popular media has asked what the key motivations are behind playing this game (Griffiths, 2016). The primary goal of the present study was to identify the motivational factors that explain this new playing phenomenon. In order to achieve this goal, the pre-existing theoretical framework of online motivational literature was extended (Demetrovics et al., 2011) with new motives that appeared to be relevant in the playing and popularity of augmented reality games.

In recent years, smartphones became more advanced with the inclusion of a built-in camera, GPS for navigation, and Internet connectivity (Chou & ChanLin, 2012). This technological evolution facilitated the emergence of augmented reality (AR) technology. AR mixes the real and the virtual world by creating a user-centered environment, where the real world is augmented or complemented with computer-generated elements (such as graphical objects), leading to a deeper immersion (Baranowski, 2016; Chou & ChanLin, 2012; Graham, Zook, & Boulton, 2013). This technology has already been employed in campus and library touring (e.g., Chou & ChanLin, 2012; Hahn, 2012), tourism (Yovcheva, Buhalis, & Gatzidis, 2012), education and learning (e.g., Dunleavy & Dede, 2014; Wu, Lee, Chang, & Liang, 2013), and more recently, gaming.

As noted above, arguably one the most popular augmented reality games at present is Pokémon Go. The Pokémon franchise was originally created by a Japanese videogame designer, Satoshi Tajiri. In the mid-1990s, Tajiri developed videogames for Nintendo's Game Boy devices, introducing the world of 'Pocket Monsters', in which the players are

* Corresponding author at: Institute of Psychology, Eötvös Loránd University, Izabella utca 46., Budapest, H-1064, Hungary.
E-mail address: orosz.gabor@ppk.elte.hu (G. Orosz).

[1] Ágnes Zsila and Gábor Orosz contributed equally to this work and their order was determined at random. Both should be considered first authors.

http://dx.doi.org/10.1016/j.paid.2017.06.024

instructed to collect all the Pokémon species they find in virtual cities. In the early 2000s, the story of Pokémon videogames was adapted into an anime series, and which also became increasingly popular outside Japan (Somorjai, 2000). Ever since the adventures of Ash Ketchum (an ambitious Pokémon Master of the animated series) attracted many young viewers, the Pokémon franchise has expanded rapidly. As a result, movies, comics, trading cards, toys, and other productions were manufactured as part of the "Gotta Catch 'Em All" global media sensation. The latest wave of this phenomenon was initiated by The Pokémon Company in the summer of 2016, when Pokémon Go was introduced to millions of smartphone users.

In this game, the user creates an avatar and then chooses a team to fight with. The game takes into consideration the user's geographical location and by moving around in real world surroundings, the player can find and capture "wild" Pokémon. Furthermore, while on the move, the player can find other resources that can be useful in developing the captured Pokémon species. For instance, one can find eggs containing Pokémon that will hatch over time, and different items that can help in capturing them. Players can participate in battles in which they can improve their skills by challenging other players who have control over the Pokémon gym (i.e., the battle arena). The main purpose of the game is to collect all the Pokémon species and improve their abilities.

1.2. The motivational background of playing Pokémon Go

Despite the fact that research regarding AR gaming motivation has a relatively short history (as indicated by Baranowski, 2016), the comprehensive theoretical model of online gaming motivations posited by Demetrovics et al. (2011) was considered by the present authors to be the most appropriate approach to assess the motivation of playing AR games such as Pokémon Go. Motivation can be defined as "*the process of starting, directing and maintaining physical and psychological activities; includes mechanisms involved in preferences for one activity over another and the vigour and persistence of responses*" (Gerrig, Zimbardo, Campbell, Cumming, & Wilkes, 2010, p. 409).

In the present study, consideration of previous research examining online gaming motivations that have a strong inductive (empirical) or deductive (theoretical) background and good psychometric properties were taken into account. The basis of the present assessment was the Motives for Online Gaming Questionnaire (MOGQ; Demetrovics et al., 2011) which includes seven motivational factors for playing online games. The *Social* dimension of the MOGQ reflects on the motivation of playing with others, and sharing the experiences. *Escapism* contains items focusing on the escapist motivation of players to dissociate themselves from reality and real-life problems. The *Competition* dimension represents the motivation to defeat others and win. The *Coping* dimension comprises items emphasizing the role of games in coping with distress and getting into a better mood. *Skill Development* refers to motives of improving coordination, concentration, and other cognitive skills. *Fantasy* refers to the motives of stepping outside the boundaries of the real world. Finally, the three items of the *Recreation* factor emphasize the entertaining and relaxing aspects of gaming.

1.3. Pokémon Go playing motivations, impulsivity, and problematic gaming

To the best of the authors' knowledge, very little prior research has focused on the role of impulsivity in problematic gaming (e.g., Liau et al., 2015; Metcalf & Pammer, 2014; Nuyens et al., 2016). However, in the existing literature, a diverse conceptualization of impulsivity exists (e.g., Patton, Stanford, & Barratt, 1995; Rodriguez, Mischel, & Shoda, 1989; see also Whiteside & Lynam, 2001). Whiteside and Lynam (2001) developed the multidimensional UPPS Impulsive Behavior Scale in order to examine the multifaceted concept of impulsivity. According to Whiteside et al., (2005), impulsivity refers to feeling pressured to engage in a behavior or feeling like having to give in to it.

Impulsivity appears to be a risk factor for engaging in maladaptive, deviant, and problematic behaviors. For instance, positive correlations have been found between dimensions of impulsivity and problematic online behaviors such as problematic internet use (Burnay, Billieux, Blairy, & Larøi, 2015; Mottram & Fleming, 2009). Within online-related activities, problematic gaming has been found to be positively related to impulsivity (Liau et al., 2015; Metcalf & Pammer, 2014; Nuyens et al., 2016). However, no prior studies have examined how gaming motivations are related to impulsivity. Thepresent study attempted to identify which motivational aspects of playing Pokémon Go are related to impulsivity. Based on the association between gaming motivations and problematic gaming (Király et al., 2015), as well as considering the previously explored links between impulsivity and problematic gaming (Liau et al., 2015; Metcalf & Pammer, 2014; Nuyens et al., 2016), it was expected that specific motivational variables would be related to impulsivity that were found to be predictors of problematic gaming (i.e., escapism and competition).

1.4. The aims of the study

Building on the motivational framework of the MOGQ (Demetrovics et al., 2011), the aim of the present research was to explore the motivational background of playing Pokémon Go. More specifically, Study 1 explored whether there are additional motivational factors underlying the playing of Pokémon Go, whereas Study 2 investigated the associations between the motivational factors, problematic gaming, and different aspects of impulsivity as personality-related variables.

2. Study 1

The aim of the first study was to create a short assessment instrument to assess Pokémon Go playing motivations. The construction of relevant factors was considered on the basis of prior findings regarding the motivational background of playing online games (Demetrovics et al., 2011). Furthermore, qualitative research was conducted to explore possible additional motives for playing Pokémon Go.

2.1. Methods

2.1.1. Item construction

The aim of the present study was to identify possible additional motives of gaming motivations specific to Pokémon Go (compared to the original MOGQ motives). To attain this, a qualitative exploration was performed on a sample of 37 participants (35.14% female; M_{age} = 22.03 years, SD = 5.10) who were regular players of Pokémon Go. The participants were recruited from a Hungarian Pokémon Go-themed online community that had >2000 members. The administrator advertised the call for participation. Using an online questionnaire, participants were invited to complete the following sentence: "*I play Pokémon Go because…*". A total of 117 motivations were collected, of which 114 were considered as the basis for the creation of new motivational factors (those omitted were the ones that did not make any sense to the research team).

Following this, three expert raters independently selected responses that could not be categorized into any of the original seven motivational dimensions of the MOGQ (27.35% of the responses). All raters were psychologists with prior experience in the field of motivation research and qualitative methods. If consensus could not be achieved regarding the classification of a response statement, raters were then allowed to discuss the statement (5% of the responses). Based on the motivational factors identified in previous online gaming literature (Demetrovics et al., 2011), responses that did not reflect any of the original MOGQ motivational dimensions (31 responses) were coded to form three new categories on the basis of content analysis: Outdoor Activity (13 responses which emphasized that Pokémon Go encourages players to walk out of their rooms and breathe some fresh air), Nostalgia (seven responses which referred to the experience of viewing the anime series entitled 'Pokémon' in the early 2000s, and wishing to revive old memories), and Boredom (11 responses which referred to the motive of passing time playing when there is nothing else to do). After the exclusion of duplicates (i.e., matching content), 15 Pokémon Go-specific items (five per factor) remained that were rephrased by the research team to conceptually reflect the respective factor in a wide variety of different ways, and were added to the original 27 items of the MOGQ.

2.1.2. Participants and procedure

A total of 1068 participants completed the online survey. In the analysis, individuals who did not provide an informed consent ($n = 104$) were excluded, along with responses (i) that had severe inconsistencies ($n = 1$), (ii) by under-aged participants ($n = 45$), and (iii) that indicated they had not played Pokémon Go ($n = 297$). Therefore, the final sample comprised 621 participants aged between 18 and 54 years ($M_{age} = 22.57$ years, $SD = 4.37$).

The average amount of time spent playing Pokémon Go was 10.42 h during the week preceding the data collection ($SD = 12.22$). Nearly half of the participants ($n = 303$) played Pokémon Go daily on their mobile phones (48.79%), whereas 240 played 2–6 times per week (38.63%), and 78 played only weekly or rarely. Only 14 participants reported to play on other platforms than their mobile phones (2.25%). A multiple-choice question (in which participants could endorse more than one category) revealed that the majority of participants ($n = 382$) played Pokémon Go alone (61.51%), whereas some individuals played with their friends (55.87%), partner (32.36%), random people who played Pokémon Go at the same place (24.32%), brothers or sisters (22.71%), and parents (4.51%).

The study was carried out with the approval of the Institutional Review Board of the research team's university and performed in accordance with the Declaration of Helsinki. Participants were recruited from the largest Hungarian communities on social networking sites that thematically focused on online games ($n = 3$) and anime ($n = 4$) in July 2016 when the popularity of Pokémon Go use was at its peak in Hungary. Two of the anime communities comprised about 200 members, whereas the other five groups had 2000–8000 members. Since the Pokémon franchise gained much attention in the early 2000s in Hungary, the present authors considered that anime enthusiasts who were fans of the Pokémon anime series would also be affected in the Pokémon Go phenomenon. Before completing an online survey, participants were informed about the aims of the study and were asked to provide informed consent by ticking a box if they were over 18 years and agreed to the terms of the study. The participation in the survey was voluntary and anonymous.

2.1.3. Measures

2.1.3.1. Pokémon Go-specific variables. The Pokémon Go playing activity (i.e., time spent playing, platform, social connectedness) of the participants were recorded. Furthermore, two questions assessed participants' attitude and exposure to Pokémon anime. First, participants were asked to indicate the frequency of viewing Pokémon prior to the introduction of Pokémon Go (1 = never, 2 = rarely, 3 = some of the time, 4 = often, 5 = very often). Second, they were asked how much they liked Pokémon prior to the introduction of Pokémon Go (1 = I did not like it at all, 2 = I rather disliked it, 3 = I was neutral, 4 = I rather liked it, 5 = I liked it very much). For further analysis, players were separated into two categories based on their previous experiences with Pokémon. Players who reported a high frequency of viewing Pokémon anime prior to the introduction of Pokémon Go (often or very often) and exhibited the most positive attitudes toward it (indicated by the highest degree of liking) were categorized as old Pokémon fans ($n = 351$), whereas players who had only sometimes, rarely or never viewed Pokémon prior to the introduction of Pokémon Go and indicated a relatively low degree of liking (e.g., 'I was neutral', 'I did not like it at all') were categorized as new Pokémon fans ($n = 270$).

2.1.3.2. Motives for Online Gaming Questionnaire - Pokémon Go extension (MOGQ-PG). Gaming motives were assessed using the 27-item MOGQ and the 15 new items that were created for the purpose of this research. The MOGQ was adapted for Pokémon Go playing by changing "online games" to "Pokémon Go" in the instructions. The original seven motivational factors were the following: Social (four items; e.g., "because I can meet many different people"), Escape (four items; e.g., "because gaming helps me to forget about daily hassles"), Competition (four items; e.g., "because I enjoy competing with others"), Coping (four items; e.g., "because it helps me get rid of stress"), Skill development (four items; e.g., "because it improves my skills"), Fantasy (four items; e.g., "because I can be in another world"), and Recreation (three items; e.g., "because it is entertaining"). Respondents indicated the frequency of motives on a five-point Likert scale (ranging from 1 = 'almost never/never' to 5 = 'almost always/always').

2.1.4. Statistical analysis

Confirmatory factor analysis (CFA) was performed to assess the psychometric properties of this new measure that integrated the original and the additional gaming motivation dimensions. For this analysis, Mplus 7.3 was used (Muthén & Muthén, 1998–2015) with the weighted least squares mean- and variance-adjusted (WLSMV) estimator.

2.2. Results

2.2.1. Confirmatory factor analysis – Creation of the Motives for Online Gaming Questionnaire – Pokémon Go extension (MOGQ-PG)

Before testing the 10-factor structure of the MOGQ-PG, further item selection was performed based on methodological considerations. After the first item selection, which was based on the content of qualitative responses, the research team limited the number of items in each factor in order to construct a short tool for assessing Pokémon Go playing motives. Given that four items can adequately define a latent construct (similar to that of Demetrovics et al., 2011), a maximum of four items in each factor was determined as the upper limit. In order to preserve the content validity of the subscales, the item selection was performed focusing on both the factor loadings and the content of the items. Here, the aim was—by using the qualitative statements—to select those items that conceptually represented the content of the factors in a wide variety, and strongly loaded on their respective factors. Subsequently, two items were excluded from the Boredom and the Nostalgia factors due to the relatively low item-total correlations. Regarding the Outdoor Activity factor, four items were selected that reflect on the two aspects of this motivation, namely playing to become healthier by walking and playing to spend time in the nature. This final solution resulted in 37 items and 10 factors and was examined with CFA to test its appropriateness.

This final model (see Table 1) indicated an adequate fit to the data ($\chi^2 = 1755.421$; degrees of freedom = 584; $p < 0.001$; CFI = 0.963; TLI = 0.958; RMSEA = 0.057 [0.054–0.060]). All factor loadings were high ($\lambda = 0.68$ to 0.95), while inter-factor correlations were moderate ($r = 0.26$ to 0.84). Cronbach's alpha values were also good ($\alpha = 0.77$ to 0.92). According to these results, the final 10-factor model demonstrated an adequate fit and internal consistency, reflecting the structural construct of the theoretical model. The final, 37-item list comprises all 27 MOGQ-items, and 10 items of the three new, Pokémon Go-specific factors. A second study investigated the relationships between the motivational factors, problematic gaming, and impulsivity.

2.2.2. Associations between Pokémon Go playing motives and demographic characteristics

The highest mean scores were found in the Recreation and Nostalgia motives, whereas the lowest scores were observed in Escape and Skill

Table 1
Parameter estimates, descriptive statistics and reliability indices for the Online Gaming Questionnaire-Pokémon Go extension (MOGQ-PG) on Sample 1 ($N = 621$).

I play Pokémon go…	α	Descriptive statistics			Factor loadings
		Range	Mean	SD	
Social	0.89	1–5	2.34	1.11	
1. … because I can get to know new people					0.90
10. … because I can meet many different people					0.94
21. … because it is a good social experience					0.82
32. … because gaming gives me company					0.90
Escape	0.85	1–5	2.02	1.06	
2. … because gaming helps me to forget about daily hassles					0.80
12. … because it makes me forget real life					0.86
22. … because gaming helps me escape reality					0.93
33. … to forget about unpleasant things or offences					0.84
Competition	0.92	1–5	2.45	1.24	
4. … because I enjoy competing with others					0.85
13. … because I like to win					0.91
23. … because it is good to feel that I am better than others					0.91
34. … for the pleasure of defeating others					0.95
Coping	0.80	1–5	2.27	0.96	
6. … because gaming helps me get into a better mood					0.77
15. … because it helps me get rid of stress					0.83
25. … because it helps me channel my aggression					0.78
35. … because it reduces tension					0.85
Skill development	0.87	1–5	1.95	0.95	
7. … because gaming sharpens my senses					0.79
17. … because it improves my skills					0.88
26. … because it improves my concentration					0.88
36. … because it improves my coordination skills					0.87
Fantasy	0.86	1–5	2.23	1.16	
8. … because I can do things that I am unable to do or I am not allowed to do in real life					0.68
18. … to feel as if I was somebody else					0.86
28. … to be somebody else for a while					0.94
37. … because I can be in another world					0.89
Recreation	0.77	1–5	4.00	0.87	
9. … for recreation					0.77
19. … because it is entertaining					0.81
30. … because I enjoy gaming					0.89
Outdoor activity	0.92	1–5	3.00	1.24	
11. … because it gets me moving					0.89
24. … because I spend more time in the fresh air					0.86
29. … because it provides the daily dose of exercise					0.90
31. … because I can get out of the house					0.92
Nostalgia	0.92	1–5	3.57	1.32	
5. … because it reminds me of my childhood					0.94
16. … it is nostalgic					0.94
27. … it brings up old memories					0.89
Boredom	0.78	1–5	2.80	1.12	
3. … at least I am not bored meanwhile					0.79
14. … otherwise I would be bored					0.94
20. … time goes faster					0.89

Note. α = Cronbach's alpha value; SD = standard deviation. The instruction was the following: People play Pokémon Go for different reasons. Some reasons are listed below. Please indicate how often you play Pokémon Go for the reasons listed below by clicking on the appropriate response – almost never/never (1), some of time (2), half of the time (3), most of the time (4), almost always/always (5). There is no right or wrong answer! We are only interested in your motives for playing.

Development motives (see Table 2). Only one motive (Recreation) had higher scores than the three new motivational factors. There were significant mean differences across gender on the Social $t(562) = 3.97$, $p < 0.001$ and Competition motives, $t(557) = 4.83$, $p < 0.001$ with men having significantly higher scores than women. Men also reported to play Pokémon Go more frequently than women $t(593) = 3.06$, $p = 0.002$. Regarding residence, it was found that players who lived in county towns, other towns and villages yielded higher scores on the Skill Development ($F(620) = 2.66$, $p = 0.05$) and Boredom ($F(620) = 3.21$, $p = 0.02$) motives than those who lived in the capital city. Participants with higher educational levels played less and showed lower motivational levels in the majority on the MOGQ-PG motivational dimensions, except for the Recreation, Outdoor Activity and Nostalgia. In line with this result, weak but significant associations showed between age and the Social, Escape, Competition, Coping, Fantasy, Nostalgia, and Boredom motives (the strength of correlations were between -0.10 and -0.23, $p < 0.05$). Finally, those who had been fans of Pokémon anime prior to the introduction of Pokémon Go (Old Pokémon Fans), played more and scored higher on all motivational factors except for the Competition motive, in which the mean score-difference between Old Pokémon Fans and New Pokémon Fans was not statistically significant. The greatest difference in the mean scores of these two groups was

Table 2
Descriptive statistics and group comparisons in Sample 1 ($N = 621$).

	Total ($N = 621$)	Gender			Residence					Education				Fan groups		
		Male ($n = 280$)	Female ($n = 341$)	t	Capital city ($n = 171$)	County towns ($n = 72$)	Other towns ($n = 274$)	Villages ($n = 104$)	F	Higher education ($n = 102$)	High school degree ($n = 410$)	Primary school degree ($n = 109$)	F	Old Pokémon fans ($n = 351$)	New Pokémon fans ($n = 270$)	t
Frequency of playing	10.42 (12.22)	12.07 (12.16)	9.07 (12.12)	3.06**	10.95 (12.25)a	8.32 (8.11)a	11.03 (13.34)a	9.42 (11.39)a	1.27	8.14 (8.35)a	11.51 (13.56)b	8.51 (9.18)ab	4.77**	11.39 (14.13)	9.16 (9.02)	−2.40*
Social	2.34 (1.11)	2.53 (1.17)	2.18 (1.03)	3.97***	2.28 (1.08)a	2.52 (1.05)a	2.33 (1.11)a	2.33 81.19)a	0.86	2.07 (1.07)a	2.38 (1.12)b	2.41 (1.05)ab	3.56*	2.48 (1.14)	2.15 (1.04)	−3.74***
Escape	2.02 (1.06)	1.95 (1.10)	2.08 (1.03)	−1.56	1.91 (0.97)a	2.04 (1.01)a	2.08 (1.12)a	2.03 (1.07)a	0.94	1.71 (0.82)a	2.07 (1.09)b	2.13 (1.10)b	5.46**	2.14 (1.11)	1.87 (0.98)	−3.24**
Competition	2.45 (1.24)	2.71 (1.30)	2.23 (1.13)	4.83***	2.37 (1.22)a	2.36 (1.23)a	2.51 (1.28)a	2.48 (1.15)a	0.54	2.16 (1.12)a	2.48 (1.27)b	2.61 (1.19)b	3.77*	2.52 (1.25)	2.35 (1.21)	−1.67
Coping	2.27 (0.96)	2.23 (0.97)	2.30 (0.95)	−0.80	2.14 (0.89)a	2.24 (0.81)a	2.32 (1.03)a	2.35 (0.99)a	1.54	1.93 (0.77)a	2.32 (0.97)b	2.38 (1.02)b	8.06***	2.39 (0.97)	2.11 (0.93)	−3.60***
Skill Development	1.95 (0.95)	1.92 (0.96)	1.98 (0.95)	−0.74	1.79 (0.89)a	1.99 (0.90)b	1.99 (0.98)b	2.09 (0.99)b	2.66*	1.72 (0.89)a	1.98 (0.97)b	2.08 (0.91)b	4.24*	2.07 (1.02)	1.80 (0.84)	−3.53***
Fantasy	2.23 (1.16)	2.20 (1.15)	2.25 (1.16)	−0.53	2.06 (1.09)a	2.21 (1.15)a	2.29 (1.18)a	2.38 (1.18)a	2.04	1.91 (1.01)a	2.27 (1.18)b	2.40 (1.15)b	5.36**	2.42 (1.18)	1.99 (1.08)	−4.80***
Recreation	4.00 (0.87)	3.93 (0.89)	4.06 (0.85)	−1.79	4.02 (0.87)a	4.08 (0.71)a	3.96 (0.92)a	4.02 (0.86)a	0.44	3.98 (0.93)a	4.03 (0.87)a	3.93 (0.83)a	0.57	4.14 (0.80)	3.82 (0.93)	−4.58***
Outdoor Activity	3.00 (1.24)	2.90 (1.24)	3.08 (1.24)	−1.83	2.89 (1.22)a	3.19 (1.13)a	3.00 (1.27)a	3.04 (1.27)a	1.09	2.92 (1.30)a	3.05 (1.23)a	2.86 (1.22)a	1.28	3.10 (1.21)	2.87 (1.27)	−2.32*
Nostalgia	3.57 (1.32)	3.53 (1.30)	3.61 (1.33)	−0.81	3.43 (1.40)a	3.74 (1.26)a	3.58 (1.29)a	3.68 (1.28)a	1.23	3.40 (1.42)a	3.63 (1.29)a	3.50 (1.31)a	1.45	4.21 (0.94)	2.74 (1.29)	−15.79***
Boredom	2.80 (1.12)	2.76 (1.19)	2.83 (1.06)	−0.78	2.66 (1.04)a	2.88 (1.11)b	2.77 (1.16)b	3.08 (1.12)b	3.21*	2.48 (1.05)a	2.80 (1.13)b	3.13 (1.09)c	8.98***	2.90 (1.11)	2.68 (1.12)	−2.48*

Different subscript letters (a, b, c) in the same row represent significant ($p < 0.05$) difference between the mean scores, whereas same subscript letters in the same row represent non-significant difference between the mean scores according to the post-hoc Tukey test of one-way ANOVA.

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 3
Descriptive statistics and group comparisons in Sample 2 ($N = 510$).

	Total ($N = 510$)	Gender			Residence					Education				Fan groups		
		Male ($n = 285$)	Female ($n = 225$)	t	Capital city ($n = 175$)	County towns ($n = 58$)	Other towns ($n = 196$)	Villages ($n = 81$)	F	Higher education ($n = 145$)	High school degree ($n = 317$)	Primary school degree ($n = 48$)	F	Old Pokémon fans ($n = 257$)	New Pokémon fans ($n = 187$)	t
Frequency of playing	12.05 (13.79)	13.10 (14.52)	10.74 (12.73)	1.92	11.97 (13.00)a	12.02 (13.13)a	12.60 (15.94)a	10.94 (10.04)a	0.28	11.68 (12.34)a	11.96 (14.32)a	13.83 (14.62)a	0.45	12.38 (14.34)	11.44 (13.76)	−0.69
Social	2.06 (1.01)	2.12 (1.02)	1.98 (1.00)	1.52	1.90 (0.91)a	2.16 (1.00)a	2.17 (1.05)a	2.07 (1.10)a	2.44	1.88 (0.91)a	2.10 (1.02)ab	2.36 (1.15)b	4.77**	2.10 (1.03)	2.10 (1.01)	0.01
Escape	1.84 (1.00)	1.80 (0.95)	1.90 (1.06)	−1.14	1.76 (0.94)a	2.05 (1.10)a	1.79 (0.95)a	1.99 (1.16)a	1.97	1.78 (0.98)a	1.86 (1.02)a	1.89 (0.97)a	0.40	1.95 (1.08)	1.69 (0.87)	−2.76**
Competition	2.57 (1.19)	2.77 (1.21)	2.22 (1.11)	5.28***	2.32 (1.09)a	2.66 (1.27)b	2.56 (1.19)b	2.81 (1.28)b	3.57*	2.39 (1.16)a	2.59 (1.20)a	2.54 (1.25)a	1.41	2.63 (1.21)	2.43 (1.15)	−1.71
Coping	2.27 (0.97)	2.21 (0.97)	2.34 (0.96)	−1.49	2.19 (0.93)a	2.36 (0.94)a	2.23 (0.95)a	2.48 (1.00)a	2.05	2.20 (0.93)a	2.29 (0.98)a	2.33 (0.97)a	0.50	2.39 (1.02)	2.10 (0.88)	−3.21**
Skill Development	1.84 (0.95)	1.85 (0.97)	1.82 (0.92)	0.29	1.62 (0.78)a	1.95 (0.94)ab	1.90 (1.00)b	2.09 (1.07)b	5.79**	1.68 (0.85)a	1.88 (0.98)ab	2.05 (0.96)b	3.55*	1.97 (1.02)	1.70 (0.81)	−3.12**
Fantasy	1.88 (1.04)	1.93 (1.06)	1.81 (1.00)	1.26	1.73 (0.90)a	1.94 (1.09)a	1.89 (1.06)a	2.10 (1.18)a	2.43	1.72 (0.90)a	1.90 (1.07)ab	2.22 (1.13)b	4.51*	2.05 (1.10)	1.75 (0.96)	−3.05**
Recreation	4.26 (0.73)	4.18 (0.75)	4.36 (0.70)	−2.78**	4.31 (0.69)a	4.41 (0.69)a	4.16 (0.77)a	4.26 (0.72)a	2.37	4.23 (0.93)a	4.26 (0.73)a	4.32 (0.75)a	0.25	4.34 (0.70)	4.13 (0.76)	−3.12**
Outdoor Activity	3.01 (1.24)	2.92 (1.20)	3.13 (1.28)	−1.95*	2.81 (1.24)a	2.99 (1.21)b	3.09 (1.23)b	3.26 (1.21)b	2.92*	3.05 (1.27)a	3.00 (1.24)a	3.00 (1.10)a	0.08	3.09 (1.26)	2.90 (1.20)	−1.60
Nostalgia	3.06 (1.43)	3.18 (1.45)	2.89 (1.49)	2.21*	2.86 (1.49)a	3.17 (1.50)a	3.07 (1.48)a	3.36 (1.37)a	2.28	2.74 (1.47)a	3.18 (1.45)b	3.17 (1.50)ab	4.59*	3.89 (1.16)	2.51 (1.26)	−11.93***
Boredom	2.59 (1.07)	2.60 (1.06)	2.57 (1.10)	0.24	2.34 (1.00)a	2.57 (1.04)abc	2.63 (1.08)b	3.02 (1.13)c	7.87***	2.46 (1.12)a	2.65 (1.07)a	2.56 (0.96)a	1.59	2.71 (1.06)	2.59 (1.03)	−1.14

Notes. Different subscript letters (a, b, c) in the same row represent significant ($p < 0.05$) difference between the mean scores, whereas same subscript letters in the same row represent non-significant difference between the mean scores according to the post-hoc Tukey test of one-way ANOVA.

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

observed in the Nostalgia motivation ($M_{Old\ Pokémon\ Fans}$ = 4.21, SD = 0.94; $M_{New\ Pokémon\ Fans}$ = 2.74, SD = 1.29).

3. Study 2

3.1. Introduction

The aim of the second study was to explore the associations between Pokémon Go playing motivations, impulsivity, and problematic gaming. The associations between online gaming motivations and problematic online gaming, and the relationships between impulsivity and problematic online gaming have already been explored separately (Király et al., 2015; Liau et al., 2015; Metcalf & Pammer, 2014; Nuyens et al., 2016). However, no prior studies have examined impulsivity, motivations, and problematic gaming simultaneously. Therefore, the second aim of the present study was to test an integrated regression model including impulsivity as a personality-related predictor, and the motivations of playing Pokémon Go as a more proximal predictor of problematic Pokémon Go playing.

3.2. Methods

3.2.1. Participants and procedure

Data was gathered in the same online groups as that in Study 1 in November 2016, after the peak Pokémon Go's popularity had subsided in Hungary. In the present study, after reading the informed consent and agreeing to participate, respondents were first presented with demographic and Pokémon Go-specific questions, followed by scales assessing gaming motivations, problematic use, and impulsivity.

A total of 510 Hungarian participants (females = 225, 44.12%) participated in the research. Participants were aged between 18 and 63 years (M_{age} = 26.64, SD_{age} = 7.80). All of them were active Pokémon Go players at the time of the study (see the frequency of gaming in Table 3).

3.2.2. Measures

3.2.2.1. MOGQ-PG. The same measure—with 37 items and 10 factors—was administered as in Study 1.

3.2.2.2. Problematic Online Gaming Questionnaire – Short Form (POGQ-SF). Problematic Pokémon Go playing was assessed with the 12-item version of the POGQ (Demetrovics et al., 2011), assessing the six components of problematic gaming (i.e., preoccupation, immersion, withdrawal, overuse, interpersonal conflicts, and social isolation) on the basis of both empirical and theoretical content. For the purpose of the present study, the items were adapted specifically to assess the problematic use of Pokémon Go (e.g., How often do you neglect other activities because you would rather play Pokémon Go?" Participants were asked to answer on a five-point scale (1 = never; 5 = always). The items were summed to have a single score of problematic use with higher scores indicating more serious problems (α = 0.88).

3.2.2.3. UPPS-P Impulsivity Scale – Short Version (UPPS-P). This version of the scale (Billieux et al., 2012) contains 20 items and assesses the impulsivity of the respondents on the basis of five dimensions: Negative Urgency (four items, e.g., "When I am upset I often act without thinking", α = 0.86), Positive Urgency (four items, e.g., "When I am really excited, I tend not to think on the consequences of my actions.", α = 0.77), Sensation Seeking (four items, e.g., "I generally seek new and exciting experiences and activities", α = 0.76), Lack of Premeditation (four items, e.g., "I usually think carefully before doing anything", α = 0.81), and Lack of Perseverance (four items, e.g., "I finish what I start.", α = 0.80) with latter two factors being reverse scored. Participants answered on a four-point scale (1 = agree strongly; 4 = disagree strongly).

3.2.3. Statistical analysis

The structural analyses were performed with Mplus 7.3, while the rest of the analyses were performed using SPSS 22 (IBM SPSS Inc., Chicago, Illinois). Regression analyses were chosen to investigate the effects of the predictor variables (i.e., Pokémon Go playing motivations and impulsivity) on the outcome variable (i.e., problematic Pokémon Go playing). Preliminary analyses were conducted to ensure that the assumptions of these analyses (i.e., normality and multicollinearity of the data) were not violated.

3.3. Results

3.3.1. Descriptive statistics

Similar to the results from the first sample, the highest mean scores were found in the Recreation and Nostalgia motives (see Table 3). Significant gender differences were observed in the Competition ($t(497) = 5.28$, $p < 0.001$) and Nostalgia motives ($t(508) = 2.21$, $p = 0.03$) with men having higher scores, whereas female participants scored higher on the Recreation ($t(508) = -2.78$, $p = 0.006$) and Outdoor Activity ($t(508) = -1.95$, $p = 0.05$) motives compared to male players. Furthermore, significant differences were found in the motivational levels of players regarding residence. Again, players who lived in county towns, other towns, and villages had higher scores on the Skill Development ($F(509) = 5.79$, $p = 0.001$) and Boredom ($F(509) = 7.87$, $p < 0.001$) motives than those who lived in the capital city as well as on the Competition ($F(509) = 3.57$, $p = 0.01$) and Outdoor Activity motives ($F(509) = 2.92$, $p = 0.03$). Similar to the results in the first data collection, it was found that highly educated players had significantly lower scores on the Social ($F(509) = 4.77$, $p = 0.009$), Skill Development ($F(509) = 3.55$, $p = 0.03$) and Fantasy motives ($F(509) = 4.51$, $p = 0.01$) as well as on the Nostalgia motive ($F(509) = 4.59$, $p = 0.01$). Age was significantly associated with four motivational factors: Social ($r = -0.21$, $p < 0.001$), Fantasy ($r = -0.14$, $p = 0.002$), Nostalgia ($r = -0.39$, $p < 0.001$), and Boredom ($r = -0.25$, $p < 0.001$). As in Study 1, Old Pokémon Fans again scored higher on the majority of Pokémon Go playing motivations, and the greatest mean score-difference was observed in the Nostalgia motivation ($M_{Old\ Pokémon\ Fans}$ = 3.89, SD = 1.16; $M_{New\ Pokémon\ Fans}$ = 2.51, SD = 1.26).

3.3.2. Cross-validation of the factorial structure of the MOGQ-PG

For the purposes of further confirmation of the factor structure and internal consistency, before assessing the associations between the central construct (i.e., motivations) and other related constructs (i.e., problematic use and impulsivity), the factor structure of the MOGQ-PG was examined. This examination further supported the adequacy of this scale (χ^2 = 1459.383; degrees of freedom = 584; $p < 0.001$; CFI = 0.965; TLI = 0.960; RMSEA = 0.054 [0.051–0.058]). Factor loadings (λ = 0.64 to 0.99), inter-factor correlations (r = 0.12 to 0.86) and internal consistency indices (α = 0.69 to 0.94) were similar to that of Study 1 (see Table 4).

3.3.3. Associations between Pokémon Go playing motivations, problematic use, and impulsivity

Correlations between the examined variables can be seen in Table 5. They indicate relatively weak associations between motivational dimensions and the different aspects of impulsivity. In order to examine the associations between impulsivity in general and Pokémon Go playing motivations, a hierarchical regression analysis was carried out in which the predictor variables were three demographic variables (age, gender, level of education) in the first step, then in the second step the Pokémon Go motivational variables were inserted and the outcome variable was the composite score of the UPPS-P Impulsivity Scale. On the basis of the regression results, it can be seen that none of the Pokémon Go motivational variables were significantly related to impulsivity (see Table 6). According to the correlations in Table 5, escapism, competition, coping, skill development, and fantasy motivations were

Table 4
Parameter estimates, descriptive statistics and reliability indices for the Online Gaming Questionnaire-Pokémon Go extension (MOGQ-PG) on Sample 2 ($N = 510$).

I play Pokémon Go…	α	Descriptive statistics			Factor loadings
		Range	Mean	SD	
Social	0.86	1–5	2.06	1.01	
1. … because I can get to know new people					0.91
10. … because I can meet many different people					0.95
21. … because it is a good social experience					0.74
32. … because gaming gives me company					0.91
Escape	0.86	1–5	1.84	1.00	
2. … because gaming helps me to forget about daily hassles					0.83
12. … because it makes me forget real life					0.85
22. … because gaming helps me escape reality					0.91
33. … to forget about unpleasant things or offences					0.87
Competition	0.90	1–5	2.57	1.19	
4. … because I enjoy competing with others					0.85
13. … because I like to win					0.87
23. … because it is good to feel that I am better than others					0.88
34. … for the pleasure of defeating others					0.95
Coping	0.80	1–5	2.27	0.97	
6. … because gaming helps me get into a better mood					0.73
15. … because it helps me get rid of stress					0.78
25. … because it helps me channel my aggression					0.82
35. … because it reduces tension					0.85
Skill development	0.87	1–5	1.84	0.95	
7. … because gaming sharpens my senses					0.83
17. … because it improves my skills					0.83
26. … because it improves my concentration					0.91
36. … because it improves my coordination skills					0.85
Fantasy	0.82	1–5	1.88	1.04	
8. … because I can do things that I am unable to do or I am not allowed to do in real life					0.64
18. … to feel as if I was somebody else					0.87
28. … to be somebody else for a while					0.89
37. … because I can be in another world					0.86
Recreation	0.69	1–5	4.26	0.73	
9. … for recreation					0.80
19. … because it is entertaining					0.78
30. … because I enjoy gaming					0.74
Outdoor activity	0.91	1–5	3.01	1.24	
11. … because it gets me moving					0.89
24. … because I spend more time in the fresh air					0.88
29. … because it provides the daily dose of exercise					0.89
31. … because I can get out of the house					0.91
Nostalgia	0.94	1–5	3.06	1.43	
5. … because it reminds me of my childhood					0.80
16. … it is nostalgic					0.94
27. … it brings up old memories					0.90
Boredom	0.76	1–5	2.59	1.07	
3. … at least I am not bored meanwhile					0.69
14. … otherwise I would be bored					0.87
20. … time goes faster					0.77

Note. α = Cronbach's alpha value; SD = standard deviation. The instruction and scoring was the same as in the case of Study 1.

more strongly related to problematic gaming than the impulsivity dimensions.

In the next step of the analyses, hierarchical regression analysis (see Table 7) was performed in which problematic Pokémon Go use was the outcome variable and impulsivity factors were entered in the first step, whereas Pokémon Go playing motivations were entered in the second step as predictors. The total explained variance of the first and the second model was 4.4% and 25.7%, respectively. In the overall model, the strongest predictor was the Competition motivation ($\beta = 0.19$, $p < 0.001$), followed by the Fantasy motivation ($\beta = 0.12$, $p < 0.05$) and Lack of Perseverance ($\beta = 0.09$, $p < 0.05$), while other variables had tendentious or non-significant effect on problematic Pokémon Go playing.

4. General discussion

Pokémon Go is the first augmented reality game to attract millions of players worldwide within a few weeks after its release on Android and iOS devices. Indeed, Pokémon has emerged as the second most successful videogame-based franchise after the Mario Brothers (Boyes, 2007). The popularity of Pokémon Go raises the question as to what motives drive players to engage in this augmented reality game. The aim of the present study was to explore the motivations underlying the playing of Pokémon Go, building on the previously established online gaming motives alongside new Pokémon Go-specific motivational dimensions. Due to the comprehensive nature of the MOGQ (Demetrovics et al., 2011) providing a wide range of online gaming motives, this assessment instrument was used to explore the motivations of Pokémon Go players in addition to the new factors derived from the qualitative component of the study prior to survey administration.

Based on theoretical considerations and the qualitative data collected from Pokémon Go players, three further motivational factors were identified in addition to the existing dimensions of the MOGQ. In order to test the psychometric properties of the integration of the original MOGQ factors along with the new ones, confirmatory factor analysis was performed on the 10-factor model of Pokémon Go gaming motivations, and results showed that all factors had good internal consistency and demonstrated adequate fit to the data. Therefore, the present study was able to identify, define, and confirm the factor structure of the more comprehensive scale of Pokémon Go playing motivations. In addition to the seven original factors of the MOGQ, three new factors were identified: Outdoor Activity, Nostalgia, and Boredom. These motivations based on empirical research also matched those listed in speculative populist articles on the reasons why Pokémon Go is so popular with players (e.g., Griffiths, 2016).

Similar to previous studies (e.g., Demetrovics et al., 2011; Király et al., 2015), the strongest motive for Pokémon Go players was recreation, which was one of the seven motivational dimensions of the original MOGQ. This factor refers to players' motivation to relax and enjoy the entertaining aspects of the game. Conversely, the lowest scores were observed in the case of skill development and escapism motives (similar to Király et al., 2015). Therefore, escaping from reality was not a strong motivation for the respondents to engage in this augmented reality game. Besides escapism, skill development had similarly low scores, reflecting that players had not been playing Pokémon Go primarily for developing their cognitive, visual, and/or other skills. However, Pokémon Go players scored high on the newly identified motivational dimensions, highlighting the importance of these factors in the understanding of the motives for playing this game.

Additionally, it was found that men consistently showed higher motivational levels for competing behaviors in Pokémon Go than women across the two studies. This result was consistent with those findings reported by Demetrovics et al. (2011). Furthermore, players who lived in the capital city had lower motivational levels in skill development and boredom compared to those who lived in towns or villages. This result may be explained by the limited opportunities for leisure activities there. Moreover, highly educated and older players were less motivated

Table 5
Inter-correlations between the examined variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Social	–															
(2) Escape	0.34**	–														
(3) Competition	0.31**	0.28**	–													
(4) Coping	0.35**	0.70**	0.29**	–												
(5) Skill Development	0.44**	0.50**	0.34**	0.57**	–											
(6) Fantasy	0.31**	0.64**	0.28**	0.53**	0.58**	–										
(7) Recreation	0.25**	0.24**	0.20**	0.41**	0.31**	0.24**	–									
(8) Outdoor	0.36**	0.33**	0.15**	0.41**	0.43**	0.23**	0.31**	–								
(9) Nostalgia	0.21**	0.20**	0.10*	0.24**	0.26**	0.35**	0.21**	0.15**	–							
(10) Boredom	0.23**	0.35**	0.16**	0.33**	0.25**	0.29**	0.16**	0.25**	0.20**	–						
(11) Neg. Urgency	0.08	0.13**	0.13**	0.11*	0.10*	0.08	0.02	0.04	0.05	0.10*	–					
(12) Pos. Urgency	0.13**	0.15**	0.14**	0.17**	0.14**	0.13**	0.05	0.03	0.06	0.07	0.69**	–				
(13) Lack of Premed.	0.10*	0.08	−0.01	0.07	0.03	0.01	−0.03	−0.01	−0.03	0.01	0.33**	0.31**	–			
(14) Lack of Persev.	0.12**	0.13**	−0.02	0.11*	0.05	0.07	−0.01	0.07	−0.06	0.06	0.14**	0.14**	0.48**	–		
(15) Sens. Seeking	0.18**	0.02	0.22**	0.08	0.20**	0.09	0.02	−0.03	0.08	0.02	0.30**	0.41**	−0.04	−0.16**	–	
(16) Impulsivity	0.18***	0.16***	0.15**	0.15**	0.17***	0.12*	0.02	0.03	0.04	0.08	0.81***	0.82***	0.61***	0.44***	0.50***	–
(17) POGQ	0.31**	0.38**	0.34**	0.39**	0.38**	0.36**	0.18**	0.26**	0.07	0.20**	0.15**	0.17**	0.12**	0.17**	0.09	0.21***

Note. Neg. Urgency = UPPS, Negative Urgency; Pos. Urgency = UPPS Positive Urgency; Lack of Premed. = UPPS Lack of Premeditation; Sens. Seeking = UPPS Sensation Seeking; Impulsivity = All UPPS subscales; POGQ = Problematic Online Gaming Questionnaire;
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

in several aspects of playing motives in both studies (e.g., social, fantasy, nostalgia, and boredom motivations).

Regarding the newly identified motives in the MOGQ-PG, the factor of Outdoor Activity comprised items emphasizing the positive effects of moving, walking out of the house, and breathing some outside fresh air when playing the game. Portable handheld devices are practical, and allow players to walk in the park, or travel by public transportation while seeking out Pokémon species to catch in the game. This is supported by the meta-analysis of Fanning, Mullen, and McAuley (2012) who found that mobile devices were effective in enhancing physical activities. The authors provided an overview of 11 studies on the use of mobile devices for maintaining physical health, and concluded that smartphone technology can promote physical health behaviors by monitoring users' physical activity, and thus providing feedback for their physical health status, which facilitates further health efforts. Regarding this factor, gender difference was observed only in the second study, which was conducted after the Pokémon Go fever. This motive was relatively important for the players as it had the third highest mean score out of the 10 motivational factors in both studies.

Second, Nostalgia was an important motive for those who had been fans of Pokémon prior to the introduction of Pokémon Go. These players emphasized that Pokémon Go revived old memories of their childhood. Indeed, the animated television series building on the Pokémon franchise was very popular among Hungarian children at the age of 4–7 years in the early 2000s (Somorjai, 2000). At this time, the Pokémon

Table 6
Regression model of impulsivity with demographic variables and Pokémon Go motivations as predictors.

	Unstandardized		Standardized	
	B	Std. error	β	t
Step 1 (Adjusted R^2 = 0.033)				
(Constant)	2.55	0.10		25.67
Gender	0.02	0.04	0.02	0.54
Age	0.07	0.01	−0.13**	−2.88
Level of education	−0.06	0.02	−0.13**	−2.82
Step 2 (Adjusted R^2 = 0.067)				
(Constant)	2.41	0.17		14.54
Gender	0.04	0.04	0.04	0.88
Age	−0.01	0.01	0.12*	−2.40
Level of education	−0.05	0.02	−0.10*	−2.30
MOGQ-PG social	0.04	0.02	0.10^{a}	1.89
MOGQ-PG escapism	0.02	0.03	0.05	0.78
MOGQ-PG competition	0.03	0.02	0.08	1.61
MOGQ-PG coping	0.04	0.03	0.11^{a}	1.70
MOGQ-PG skill development	0.04	0.03	0.08	1.31
MOGQ-PG fantasy	−0.03	0.03	−0.06	−0.94
MOGQ-PG recreation	−0.03	0.03	−0.06	−1.13
MOGQ-PG outdoor activity	−0.03	0.02	−0.07	1.38
MOGQ-PG nostalgia	−0.02	0.02	−0.05	−0.97
MOGQ-PG boredom	−0.01	0.02	−0.01	−0.19

Note. UPPS-P = UPPS-P Impulsivity Scale; MOGQ = Motives for Online Gaming Questionnaire.
[a] $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 7
Regression model of Pokémon Go motivations, problematic gaming, and impulsivity.

	Unstandardized		Standardized	
	B	Std. error	β	t
Step 1 (Adjusted R^2 = 0.044)				
(Constant)	1	0.14		6.97
UPPS-P Negative Urgency	0.02	0.04	0.03	0.52
UPPS-P Positive Urgency	0.08	0.05	0.10	1.56
UPPS-P Lack of Premeditation	0.01	0.05	0.01	0.22
UPPS-P Lack of perseverance	0.16	0.05	0.15**	3.06
UPPS-P Sensation Seeking	0.05	0.04	0.06	1.22
Step 2 (Adjusted R^2 = 0.257)				
(Constant)	0.56	0.19		2.93
UPPS-P Negative Urgency	0.01	0.04	0.02	0.36
UPPS-P Positive Urgency	0.04	0.05	0.05	0.85
UPPS-P Lack of Premeditation	0.03	0.04	0.03	0.73
UPPS-P Lack of Perseverance	0.09	0.05	0.09*	2.00
UPPS-P Sensation Seeking	−0.01	0.04	−0.01	−0.28
MOGQ-PG Social	0.05	0.03	0.09^{a}	1.93
MOGQ-PG Escapism	0.05	0.04	0.08	1.23
MOGQ-PG Competition	0.10	0.02	0.19***	4.55
MOGQ-PG Coping	0.06	0.04	0.10^{a}	1.68
MOGQ-PG Skill Development	0.06	0.04	0.09	1.62
MOGQ-PG Fantasy	0.07	0.03	0.12*	2.04
MOGQ-PG Recreation	−0.01	0.04	−0.01	−0.23
MOGQ-PG Outdoor Activity	0.03	0.02	0.06	1.37
MOGQ-PG Nostalgia	−0.03	0.02	−0.08^{a}	−1.79
MOGQ-PG Boredom	0.01	0.02	0.02	0.52

Note. UPPS-P = UPPS-P Impulsivity Scale; MOGQ = Motives for Online Gaming Questionnaire.
[a] $p < 0.10$
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

series attracted millions of young viewers worldwide (Tobin, 2004). In line with this, the results of a recent survey indicated that 78% of Pokémon Go players were between 18 and 34 years (Smith, 2016), explaining the importance of this source of motivation for this age cohort. Similar to Pokémon Go, nostalgia has been identified as a driving force in other types of games that also have a history (e.g., platform games such as Mario Brothers) (Sloan, 2015; Suominen, 2008). Moreover, the Nostalgia factor had the second highest mean score out of the other motivation factors in both studies.

Finally, Boredom was identified as the third new motivational factor related to Pokémon Go. This motivational dimension comprises items describing individuals who choose to play Pokémon Go in order to avoid being bored. In online gaming research, mainly qualitative studies have emphasized the importance of boredom as a source of playing motivation (e.g., Hussain & Griffiths, 2009; Wan & Chiou, 2006). Given that Pokémon Go is mostly played on mobile devices, this function of passing time during walking, or when they have nothing better to do is similar to the motives reported by Hjorth and Richardson (2009), who found that 80% of respondents preferred playing mobile games while they were traveling and in a state of boredom. In relation to demographic variables, no gender difference was found on this motive. Finally, the mean score of the Boredom factor was higher than the mean scores on six of the seven original motivational dimensions but lower than the scores of the Recreation, Nostalgia, and Outdoor Activity factors in both studies.

Similar to the inter-correlations of factors observed in the original seven motivational factor structure (Demetrovics et al., 2011), all factors in the new instrument were significantly related, and the pattern of associations were similar to the original relations. Considering the findings of Table 5, relatively strong correlations were found between Coping, Escapism, and Fantasy. According to a previous study (Király et al., 2015), these three motivational factors were the strongest predictors of problematic gaming (for an overview, see Kuss & Griffiths, 2012). It is possible that in the case of Pokémon Go, these three factors may also be useful in assessing the motivational basis of problematic use.

According to the correlational results, the UPPS-P factors were weakly related to the MOGQ-PG motivational factors. The results supported the hypothesized expectations (based on Király et al., 2015) because escapism and competition were both positively related to the majority of the impulsivity factors. However, the correlation pattern did not show a clear-cut distinction between adaptive and less adaptive motivational dimensions such as Social, Coping, and Skill Development factors were similarly positively correlated with the majority of the assessed impulsivity dimensions. Furthermore, according to the regression results, no motivational variables were significantly related to the composite score of the UPPS impulsivity measure. In sum, impulsivity did not show a strong and consistent relationship pattern with the Pokémon Go motives because it was rather unrelated to these motives.

Regarding the personality background of problematic Pokémon Go use, the examined impulsivity dimensions were not found to be strong predictors. In the regression model, among the five UPPS-P factors (Billieux et al., 2012), only Lack of Perseverance showed a positive but weak relationship with problematic Pokémon Go use. Lack of Perseverance refers to giving up monotonous and boring tasks easily. According to the present results, playing Pokémon Go—as an appealing and stimulating game—can become a problematic activity for those players who tend to give up boring tasks requiring perseverance.

Among the motivational variables, only Competition and Fantasy were weak predictors of the POGQ. These results partly supported the hypothesized expectations because competition was a predictor of problematic use. However, escapism was unrelated to problematic Pokémon Go use, despite the fact that prior research has identified escapism as the strongest predictor of problematic gaming in the case of MMORPG players (Király et al., 2015). According to previous research, players who displayed high level of psychiatric distress tend to use online gaming as a source of achievement. For instance, as Király et al. (2015) indicated, it is also possible that problematic players may replace "real life" competition achievement with competition within the game and achievement. However, alternative explanations are also possible.

For instance, in the MOGQ-PG, the wording of competition items includes resultorientation (e.g., "I like to win"), overcoming the opponent (e.g., "for the pleasure of defeating others"), feeling superior to others (e.g. "it is good to feel that I am better than others"), and one item refers to the enjoyment of competition. These items include both hypercompetitive and self-developmental attitudes (Ryckman, Hammer, Kaczor, & Gold, 1990, 1996) with the dominance of hypercompetitive aspects. Further research should distinguish the role of these competitive attitudes in the competition motive of playing online and augmented reality games.

Although the present study has many strengths (such as the diverse online sample and the exhaustive statistical analyses), this study is not without limitations. First, the research was cross-sectional and survey-based that could result in possible biases (e.g., recall bias, social desirability bias). Longitudinal research would be beneficial because the popularity of Pokémon Go has begun to fall since its peak at the time of the first release. Furthermore, the present results need to be replicated in culturally diverse countries in order to draw a more solid conclusion about the relevance of the new motivational dimensions. The playing habits related to Pokémon Go and other AR games could also be examined among adolescents, and studying this cohort may also help to identify the potential health-related benefits of augmented reality games such as Pokémon Go. For instance, seeking out Pokémon species outside while engaged in walking activities could contribute to the mental and physical health of players. The temporal stability of motivational patterns could also be investigated in different stages of the popularity of this game and across different age groups. Finally, the results of the present research may not be generalizable to all AR games, for instance, to those games that do not have a longstanding historical background like the Pokémon franchise.

Despite the specific nature of the MOGQ-PG, the present study serves as the first step in the understanding of the underlying motivations of playing AR games. Future studies identifying specific motivational factors related to upcoming AR games may further contribute to the deeper understanding of gamers' motivations.

5. Conclusion

Despite the increasing popularity of AR games such as Pokémon Go, relatively little research attention has been paid to examining the underlying motivations of playing AR games. The present study explored the motivational patterns of playing Pokémon Go, by extending the motivational dimensions of an existing assessment tool, the MOGQ (Demetrovics et al., 2011) with three new motivational dimensions emerging (i.e., Outdoor Activity, Nostalgia, Boredom). This new measure, the MOGQ-PG, demonstrated good psychometric properties. Recreation, Outdoor Activity, Nostalgia, and Boredom were found to be the main motivations for players. Although the results suggest that the motivation of Pokémon Go players decreased in multiple aspects, the motives of competition and skill development as well as the need for recreation increased. Based on the relative importance of the uncovered new motivational factors, future studies should pay attention to these new gaming motives that appear with the widespread presence of geo-located smartphone applications. Among these potential motivations three were identified and assessed in the present study. If future AR games are similar to Pokémon Go, going outside, experiencing nostalgia, and avoiding boredom are also likely to be important motivational factors underlying engagement in these games.

Funding sources

The study was supported by the Hungarian National Research, Development and Innovation Office (Grant numbers: PD106027, PD116686, K111938), the Hungarian Academy of Sciences (Lendület Project LP2012-36), and the ÚNKP-16-3 New National Excellence Program of the Ministry of Human Capacities.

Conflict of interest

The authors declare no conflict of interest.

References

Baranowski, T. (2016). Pokémon Go, go, go, gone? *Games for Health Journal*, *5*(5). http://dx.doi.org/10.1089/g4h.2016.01055.tbp.

Billieux, J., Rochat, L., Ceschi, G., Carré, A., Offerlin-Meyer, I., & Defeldre, A. C. (2012). Validation of a short French version of the UPPS-P Impulsive Behavior Scale. *Comprehensive Psychiatry*, *53*(5), 609–615.

Boyes, E. (2007). *UK paper names top game franchises.* GameSpot UK (Retrieved on August 26, 2016, from) http://www.gamespot.com/articles/uk-paper-names-top-game-franchises/1100-6164012/.

Burnay, J., Billieux, J., Blairy, S., & Larøi, F. (2015). Which psychological factors influence Internet addiction? Evidence through an integrative model. *Computers in Human Behavior*, *43*, 28–34.

Chou, T. L., & ChanLin, L. J. (2012). Augmented reality smartphone environment orientation application: A case study of the Fu-Jen University mobile campus touring system. *Procedia - Social and Behavioral Sciences*, *46*, 410–416. http://dx.doi.org/10.1016/j.sbspro.2012.05.132.

Demetrovics, Z., Urbán, R., Nagygyörgy, K., Farkas, J., Zilahy, D., Mervó, B., ... Harmath, E. (2011). Why do you play? The development of the motives for online gaming questionnaire (MOGQ). *Behavior Research Methods*, *43*(3), 814–825. http://dx.doi.org/10.3758/s13428-011-0091-y.

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology* (pp. 735–745). New York, NY: Springer. http://dx.doi.org/10.1007/978-1-4614-3185-5_59.

Fanning, J., Mullen, S. P., & McAuley, E. (2012). Increasing physical activity with mobile devices: A meta-analysis. *Journal of Medical Internet Research*, *14*(6), e161. http://dx.doi.org/10.2196/jmir.2171.

Gerrig, R. J., Zimbardo, P. G., Campbell, A. J., Cumming, S. R., & Wilkes, F. J. (2010). *Psychology and life.* Australia: Pearson Higher Education.

Graham, M., Zook, M., & Boulton, A. (2013). Augmented reality in urban places: Contested content and the duplicity of code. *Transactions of the Institute of British Geographers*, *38*(3), 464–479. http://dx.doi.org/10.1111/j.1475-5661.2012.00539.x.

Griffiths, M. D. (2016). Test augmentation: 10 Reasons why 'Pokemon Go' is so appealing. (July 22; Retrieved September 21, 2016, from) https://drmarkgriffiths.wordpress.com/2016/07/22/test-augmentation-10-reasons-why-pokemon-go-is-so-appealing/.

Hahn, J. (2012). Mobile augmented reality applications for library services. *New Library World*, *113*(9/10), 429–438. http://dx.doi.org/10.1108/03074801211273902.

Hjorth, L., & Richardson, I. (2009). The waiting game: Complicating notions of (tele) presence and gendered distraction in casual mobile gaming. *Australian Journal of Communication*, *36*(1), 23–35.

Hussain, Z., & Griffiths, M. D. (2009). The attitudes, feelings, and experiences of online gamers: A qualitative analysis. *Cyberpsychology & Behavior*, *12*(6), 747–753. http://dx.doi.org/10.1089/cpb.2009.0059.

Király, O., Urbán, R., Griffiths, M. D., Ágoston, C., Nagygyörgy, K., Kökönyei, G., & Demetrovics, Z. (2015). The mediating effect of gaming motivation between psychiatric symptoms and problematic online gaming: An online survey. *Journal of Medical Internet Research*, *17*(4), e88. http://dx.doi.org/10.2196/jmir.3515.

Kuss, D. J., & Griffiths, M. D. (2012). Internet gaming addiction: A systematic review of empirical research. *International Journal of Mental Health and Addiction*, *10*(2), 278–296. http://dx.doi.org/10.1007/s11469-011-9318-5.

Liau, A. K., Neo, E. C., Gentile, D. A., Choo, H., Sim, T., Li, D., & Khoo, A. (2015). Impulsivity, self-regulation, and pathological video gaming among youth: Testing a mediation model. *Asia-Pacific Journal of Public Health*, *27*(2), NP2188–NP2196.

Mottram, A. J., & Fleming, M. J. (2009). Extraversion, impulsivity, and online group membership as predictors of problematic internet use. *Cyberpsychology & Behavior*, *12*(3), 319–321. http://dx.doi.org/10.1089/cpb.2007.0170.

Muthén, L., & Muthén, B. (1998-2015). *Mplus User's Guide*Los Angeles, CA: Muthén & Muthén.

Nuyens, F., Deleuze, J., Maurage, P., Griffiths, M. D., Kuss, D. J., & Billieux, J. (2016). Impulsivity in multiplayer online battle arena gamers: Preliminary results on experimental and self-report measures. *Journal of Behavioral Addictions*, *5*(2), 351–356. http://dx.doi.org/10.1556/2006.5.2016.028.

Patton, J. H., & Stanford, M. S. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology*, *51*(6), 768–774.

Rodriguez, M. L., Mischel, W., & Shoda, Y. (1989). Cognitive person variables in the delay of gratification of older children at risk. *Journal of Personality and Social Psychology*, *57*(2), 358–367.

Ryckman, R. M., Hammer, M., Kaczor, L. M., & Gold, J. A. (1990). Construction of a hypercompetitive attitude scale. *Journal of Personality Assessment*, *55*(3/4), 630–639. http://dx.doi.org/10.1080/00223891.1990.9674097.

Ryckman, R. M., Hammer, M., Kaczor, L. M., & Gold, J. A. (1996). Construction of a personal development competitive attitude scale. *Journal of Personality Assessment*, *66*(2), 374. http://dx.doi.org/10.1207/s15327752jpa6602_15.

Sloan, R. J. (2015). Videogames as remediated memories: Commodified nostalgia and hyperreality in far cry 3: Blood dragon and gone home. *Games and Culture*, *10*(6), 525–550. http://dx.doi.org/10.1177/1555412014565641.

Smith, C. (2016). *Hot game: Amazing Pokémon Go statistics.* DMR (Retrieved on August 26, 2016, from) http://expandedramblings.com/index.php/pokemon-go-statistics/.

Somorjai, L. (2000). Gyerekek víziója [Vision of children]. *Hetek [Weeks]*, *4*(41) (Retrieved on August 26, 2016, from) http://epa.oszk.hu/00800/00804/00134/8707.html.

Suominen, J. (2008). The past as the future? Nostalgia and retrogaming in digital culture. *Fibreculture*, *11* (RetrievedAugust 26, 2016, from) http://www.journal.fibreculture.org/issue11/issue11_suominen_print.html.

Tobin, J. (Ed.). (2004). *Pikachu's global adventure: The rise and fall of Pokémon*. Durham, NC: Duke University Press.

Wan, C. S., & Chiou, W. B. (2006). Why are adolescents addicted to online gaming? An interview study in Taiwan. *Cyberpsychology & Behavior*, *9*(6), 762–766. http://dx.doi.org/10.1089/cpb.2006.9.762.

Whiteside, S. P., & Lynam, D. R. (2001). The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences*, *30*(4), 669–689.

Whiteside, S. P., Lynam, D. R., Miller, J. D., & Reynolds, S. K. (2005). Validation of the UPPS impulsive behaviour scale: a four-factor model of impulsivity. *European Journal of Personality*, *19*(7), 559–574.

Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, *62*, 41–49. http://dx.doi.org/10.1016/j.compedu.2012.10.024.

Yovcheva, Z., Buhalis, D., & Gatzidis, C. (2012). Overview of smartphone augmented reality applications for tourism. *e-Review of Tourism Research (eRTR)*, *10*(2), 63–66.