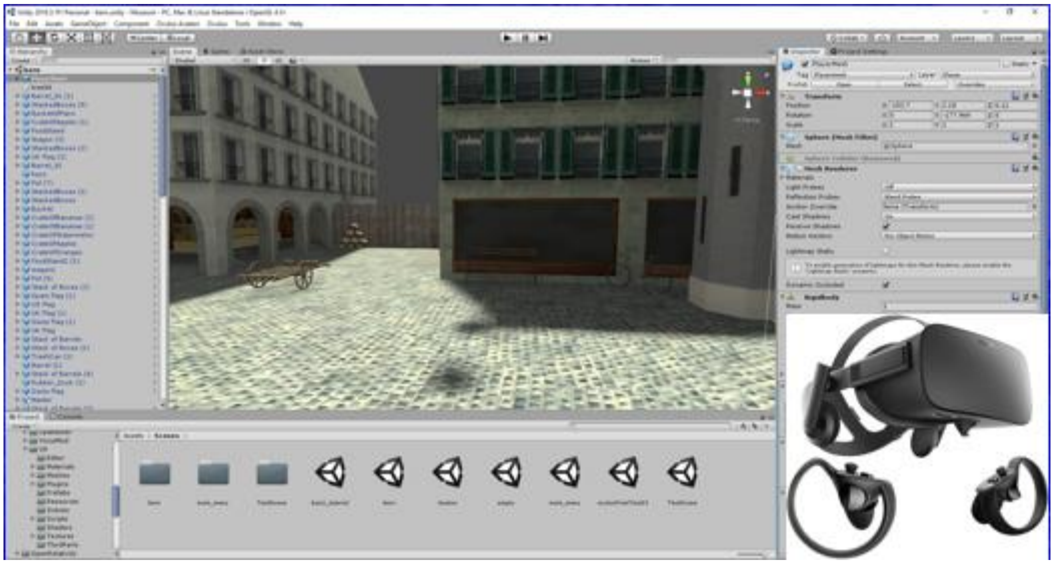
A Virtual Tour in Einstein's Playground



Introduction

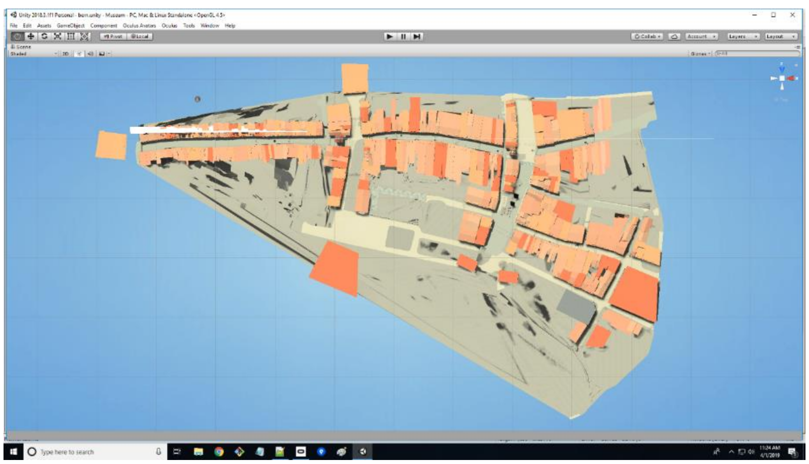
When Albert Einstein working on the special theory of relativity, his motivation was to reconcile the discrepancy between the Galilean transformation in classical mechanics and the Lorentz transformation in electrodynamics rather than interpret any experimental observation. In fact, relativistic effects are so small that they can be safely neglected in essentially all the phenomena observed in our daily life. It puts forward a challenge for students who do not have adequate background knowledge in theoretical physics to appreciate Einstein's revolutionary idea on time and space.

On the other hand, innovative technologies such as virtual reality (VR) allow us to have an immersive experience in a virtual world which can be "unrealistic" [1]: One can dive into the deep ocean to have an intimate contact with a blue whale; One can sneak into a living cell to explore ribosomes, chondriosomes, and cytolysosomes; One can time travel to the ancient Egypt to witness the building of the Great Pyramid; One can even experience the surreal fantasy of Dali's dreams. The goal of this project is to exploit the power of VR to render an exotic relativistic world so that learners can develop an intuition about the abstract theory.

The starting point of the project is the first-person video game, Einstein's playground, developed in the MIT game lab using the OpenRelativity library [2]. Instead of accelerating the speed of moving objects, the game empowers the players to slowdown the speed of light so that relativistic effects can be observed in daily scenes. In the game, one can visit Bern Switzerland in 1905 when Albert Einstein was a patent office clerk and was pondering the theory of special relativity. By walking along the city streets, one can observe how buildings, trams, birds, and fireworks would change once the speed of light is comparable to that of moving objects. Seeing and experiencing relativity in a video (VD) game can be a new tool for teaching the theory of special relativity [3].

We are curious whether enable VR in the video game would enhance or hinder the learning experiences. Possible pros include: (1) VR is known to be powerful in presenting spatial concepts and hence might be relevant for rendering the sophisticated timespace relationship in Einstein's theory; (2) VR is an immersive medium that gives players an illusion of being there and prompts them to make a connection between the theory and their life experiences. Possible cons include: (1) Players have to move fast to observe relativistic effects which may result in motion sickness if the game is not designed properly; (2) The time difference between the light reaching two eyes may result in blurry and interference. To investigate these pros and cons, we have implemented VR to the VD version of Einstein's playground and carried out experiments to investigate the issues.

Experiment Design



The experiment is composed of seven sections, including one survey section, one lecture section, two game play sections, three interview sections. Each experiment takes about an hour, carried out by one participant and one facilitator. The VR equipment is Oculus Rift provided by the MIT game lab.

Before the experiment starts, the participant is warned about the potential discomfort for playing the VR game and privacy issues associated with the recorded interviews. Then the facilitator would explain briefly the background of the research to the participant:

In 1905, Albert Einstein was working in a patent office at Bern, Switzerland (see the map). On the way between his home and the office, he thought about relativistic effect. When objects moving at a high speed comparable to the speed of light, how would they look like? The answer to the question eventually led to the theory of special relativity. Now imagine you are Albert Einstein and you have the magic power to slow down the speed of light. We would like to know if such a virtual tour would motivate you to learn Einstein's theory.

After going through the process, the participant is invited to sign a consent form to acknowledge that he/she has been adequately informed potential risks involved in the experiment and agrees to share the outcome of the experiment for research purpose.

Section 1 Survey and VR preparation (5min)

- The participant is asked to fill up the online background survey: https://docs.google.com/forms/d/e/1FAIpQLSfAPc9BmYaPxyhfJ8qmjnrS4qGiemdLyHpDZuRuPS-QRCelQg/viewform
- The facilitator helps the participant prepare the VR headset:
  - Wipe the glasses of the VR headset
  - Fit and adjust the VR headset on the participant's head
  - Tune focus of the VR headset using the basic tutorial scene

Section 2 Two mini lectures (5min)

- The participant is invited to watch the video lecture on Lorentz transformation (4min): https://www.youtube.com/watch?v=p63NJpkNtjY
- The participant is invited skim through the video recording of Stanford physics class (1min): https://www.youtube.com/watch?v=toGH5BdgRZ4

Section 3 Interview (5min, recorded)

- Q1: Do you like the lectures or not? Can you explain why?
- Q2: What is your impression about the theory of special relativity?
- Q2: Do you want to spend two hours to finish the lecture in Stanford physics class?

Section 4 Play the VR game (15min)

- The facilitator prepares the game scene
  - Open EPVR (Bern scene)
  - Switch to flat camera mode using “z” in the keyboard
  - Skip the instruction slides in the game using “0” in the keyboard
  - Tuns off Doppler effect using “v” in the keyboard
  - Turns off birds using “1” in the keyboard
  - Turns off trams using “2” in the keyboard
  - Confirms that the max speed is 5
  - Confirms that the acceleration is 2
- The facilitator explains to the participant how to control the movement in VR
  - The moving direction aligns with that of the headset
  - The movement is controlled by the left thumbstick (left, right, forward, backward)
  - The speed of light can be changed by pressing X or Y button
  - The speed of light is indicated by the number of luminous street lights
- Task-1: the participant moves around in the city and gets familiar with the VR control and environment
- Task-2a: the participant moves left, right, forward, backward on the streets and observes the buildings with the speed of light equal to 1000
- Task-2b: the participant moves left, right, forward, backward on the streets and observes the buildings with the speed of light equal to 5.1
- The facilitator activates the trams using “2” in the keyboard
- Task-3a: the participant stands in the square of clock tower and observes the trams move from left to right with the speed of light equal to 1000
- Task-3b: the participant stands in the square of clock tower and observes the trams move from left to right with the speed of light equal to 5.1
- The facilitator activates Doppler effect using “v” in the keyboard
- Task-4: the participant stands or moves around, changes the speed of light, and observes how optical effects are superposed on the previous observations

Section 5 Interview (5min, recorded)

- Q1: What did you notice in the game? Which observation impressed you most?
- Q2: What can you explain and what you cannot explain about your observations?
- Q3: Do you want to learn more about the theory to interpret what you have seen in the game?

Section 6 Play the VD game (15min)

- The facilitator prepares the game scene

- Open EPVD (Bern scene)
  - Switch to flat camera mode using “z” in the keyboard
  - Skip the instruction slides in the game using “0” in the keyboard
  - Tuns off Doppler effect using “v” in the keyboard
  - Turns off birds using “1” in the keyboard
  - Turns off trams using “2” in the keyboard
  - Confirms that the max speed is 5
  - Confirms that the acceleration is 2
- The facilitator explains to the participant how to control the movement in VD
  - The moving direction is controlled by the right thumbstick (turn left, turn right, raise head, bow head)
  - The movement is controlled by the left thumbstick (left, right, forward, backward)
  - The speed of light can be changed by the cross bar
  - The speed of light is indicated by the number of luminous street lights
- Task-1: the participant moves around in the city and gets familiar with the VR control and environment
- Task-2a: the participant moves left, right, forward, backward on the streets and observes the buildings with the speed of light equal to 1000
- Task-2b: the participant moves left, right, forward, backward on the streets and observes the buildings with the speed of light equal to 5.1
- The facilitator activates the trams using “2” in the keyboard
- Task-3a: the participant stands in the square of clock tower and observes the trams move from left to right with the speed of light equal to 1000
- Task-3b: the participant stands in the square of clock tower and observes the trams move from left to right with the speed of light equal to 5.1
- The facilitator activates Doppler effect using “v” in the keyboard
- Task-4: the participant stands or moves around, changes the speed of light, and observes how optical effects are superposed on the previous observations

Section 7 Interview (5min, recorded)

- Q1: Which version of the game do you feel more comfortable to play with? Why?
- Q2: Can you identify a few differences between the VR and VD version of the game?
- Q3: Do you think if playing games in addition to having lectures would help motivate you to study the theory of special relativity?
- Q4: Do you think if gaming experiences would help improve learning in other educational context?
- Q5: Do you have any other comments or questions?

Comment: Section 4 and 6 are interchangeable which helps to eliminate the order effect on the experiment outcome.

Results

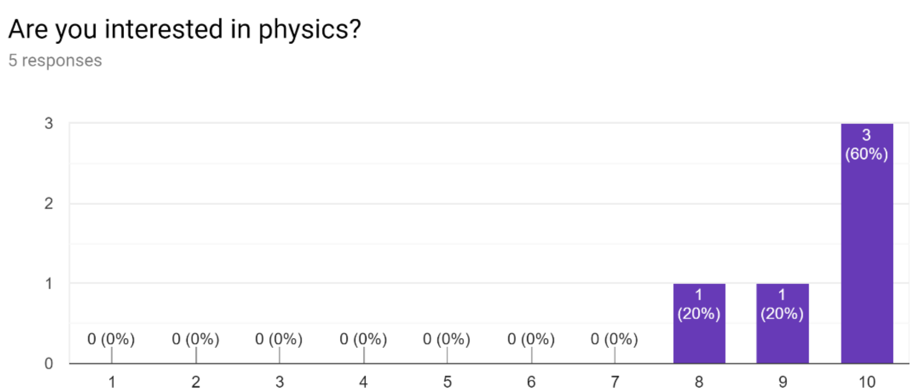
The experiments were carried out in the MIT game lab with five participants between 18 and 35 who agreed to play VR and VD games and take interviews. Although the sample size was too small to do a statistical analysis, we had a chance to perform in-depth interviews with each of them to have their reflections on the VR game as well as its pedagogical effectiveness. The results are summarized in the following four topics. For the sake of privacy protection, participant's names have been replaced by numbers.

Learner's Variation

The pre-test survey indicates that the five participants vary significantly in their background in physics and prior experiences with 3d game or VR. We have observed that the learner's variation may have enormous impacts on their behaviors in the experiment. For example, a novice VR tester would be overwhelmed by the technology whereas an experienced VR tester would pay more attention to the content of the game. Moreover, experts of the theory of special relativity would be more critical about the mini lectures than laypersons. Such person-to-person variation should also exist in real teaching practice and need to be considered when using VR in the classroom.

Tester	Gender	Concentration	Education	Order
1	Male	Chemistry	PhD student	VR/VD
2	Female	Law	Master student	VD/VR
3	Male	Chemistry	PhD student	VR/VD
4	Male	General	High school student	VD/VR
5	Male	Engineering, Education	Master student	VD/VR

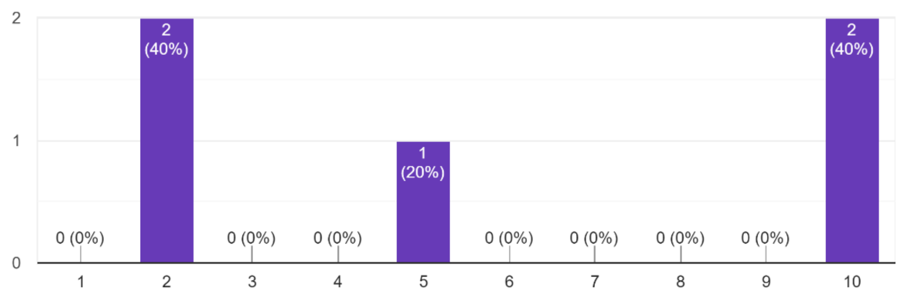
Q1



Q2

Are you familiar with the theory of special relativity?

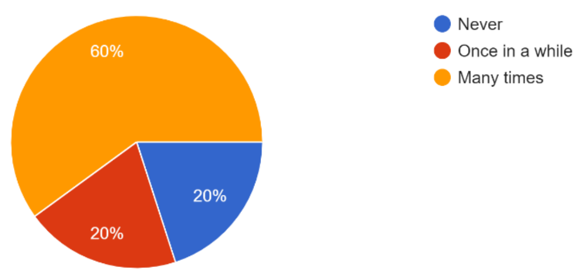
5 responses



Q3

Do you have prior experience in first-person 3d games?

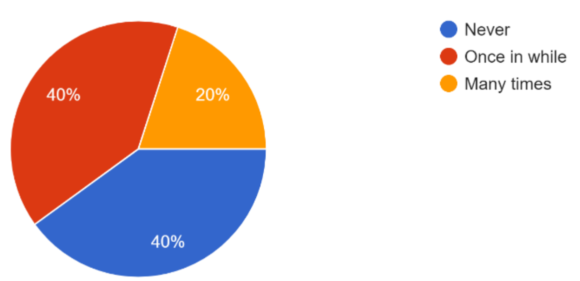
5 responses



Q4

Do you have prior experience in VR games?

5 responses



Concerning the representative of the sampling, we would like to point out that there is a potential bias: All participants are strongly interested in physics evidenced by the fact that the average rating is 9.4/10.0 in Q1. They are interested in participating in the experiment partially because they are passionate about science or computer games. It is unclear if the results obtained from this group of testers would apply to those who have little interest in either science or computer games. Furthermore, four of five participants are from Harvard University who are highly motivated to learn and hence are not representative of average students. In addition, four of five participants are male, implying a serious gender imbalance. Therefore, the observations cannot be trivially generalized to all learners.

Pedagogical Effectiveness

All participants were actively engaged in playing both VR and VD games. They intended to ask more questions when playing the games as compared to watching the video lectures. For example, tester-1 asked why the color shift due to relativistic Doppler effect produced a "double rainbow" rather than a monotonic spectrum; tester-4 asked whether an object would be transparent once the light was shifted to the IR or UV regime. More interestingly, tester-4 experimented to follow the trams in order to cancel out the relativistic effect, which was beyond the design of the experiment. In other words, they were not a passive game tester but a proactive agent who was conducting his/her own scientific inquiry.

All participants were motivated to learn deeper about the theory of special relativity, irrespective to their prior knowledge of the theory. Even an expert of the theory could be confounded by unexplained observations in the game. For example, moving objects are described to have a Lorentz contraction in a standard textbook, whereas the visual effects in the game are complicated by Terrell rotation. Another complexity concerns color rendering in human eyes. In a standard textbook, it is asserted that an object moving toward/away the observer would blue/red shifted, whereas human eyes can only detect visible light and IR and UV would appear as black. All these surprising effects would motivate the participants to re-examine their comprehension of the theory.

All participants agreed that integrating hands-on experiences of computer games into traditional lectures would improve learning experiences. They did not agree, however, whether to play the game first or take the lecture first. Those who supported game first think that playing games would prepare learners with physical intuitions so that they would be able to have concrete examples in their minds when learning an abstract theory. Those who supported lecture first think that having a theoretical framework in mind would guide the learners to test their hypothesis and check their understanding of the theory while playing the game. The optimal combination of lectures and hands-on experiments is still an open question, which may depend on learners' background and the preferred way of learning.

Media Comparison: VR Game vs VD Game

The psychological impact of the VR game can be stronger than the VD counterpart. Participants behaved as if they were present in the virtual world while playing the VR version. For example, when doing experiments near the track of trams, most of them kept a safe distance from the track. Even those who were experienced in VR and knew it was absolutely safe would ask what could happen if hit by a tram. Another example is that all participants chose to go through the tunnel of the clock tower and watch the mural as if they were visiting a real city. These behaviors were not consistently observed while they playing the VD game. The emotional impact of VR can be so strong to the first-time player that tester-1 said that she felt "scary" to find the virtual world was so real. This should be a concern to educators when applying VR games to young audience.

The VR game is more natural to control than the VD one if a player has no prior computer game experiences. It is observed that all participants learned to control the direction and movement quickly in the VR game while some participants were less conversant with the X-box controller. The reason is that in VR the direction is controlled directly by head movement which is consistent with life experiences whereas in VD one needs to be trained to use a thumbstick to manipulate the direction. There is an exception, however, that a participant was proficient in playing VD games and hence was more comfortable to play the VD version.

One participant (tester-5) pointed out that the VR game gave him the real scale of objects such as buildings and trams while the VD one did not. It is an interesting point because the images created by the two versions are essentially the same except for the angle and size projected to the player's eyes. The small differences in the size and angle have a large influence on the player's brain which interprets whether the perceived images are real or fake.

The anticipated two-eye problem associated with relativistic effects turns out to be negligible. No participants complained about the interferences between the images of two eyes when the speed of light was slowdown. One possible explanation is that human brain is good at extracting meaningful information out of slightly inconsistent images from two eyes. For example, one has little problem to interpret a 3d visualization through a pair of glasses in which one lens is red and the other is blue.

Similarly, even if the color and shape received by two eyes are distinct due to the time delay, human brain can still successfully reconstruct a 3d profile.

Motion sickness is a serious concern of the current VR version of Einstein's playground. One participant (tester-3) felt nausea and had to go to the bathroom to calm down the sickness. Other participants varied in response to motion sickness, from totally fine to slightly discomfort. It is noticed that the order of doing the VD game and the VR game matters. If a participant played the VD game first, he/she would be better adjusted to the movement control and less likely to be nausea in the VR game. It is noticed by one participant (tester-4) that there exists a comfort zone for speed and acceleration in which players feel less nausea. In general, however, the design of Einstein's playground seems not comply with the principles of VR games which requires minimum player movement. To reduce the motion sickness, one can consider removing the gliding effect after releasing the thumbstick and adding more movement cues such as sound and body avatar.

Conclusion

In this project, we have enabled VR in the video game Einstein's playground and tested both VD and VR version of the game with five volunteers. We have found that hands-on experiences with either VD or VR games would provide learners with vivid intuition of relativistic effects and motivate them to study the theory of special relativity in order to interpret what they have observed in the games. The VR version, compared to the VD version, is more powerful in creating emotional impacts on players and rendering spatial concepts associated with the Lorentz transformation. The current implementation of the VR version, however, suffers more from motion sickness than the VD one. Major improvements such as enabling more movement cues are necessary before using it in teaching practice.

Acknowledgement

I would like to thank Richard Eberhardt for hosting the study in the MIT game lab and providing me with enormous support during the study. I would like to thank Andrew Grant for his invaluable advice on both Unity and Oculus Rift, Philip Tan for stimulating discussions on OpenRelativity library and interpretation of relativistic effects, and Meredith Thompson for a meeting on the design of the VR experiment. I would like to thank Prof. Eric Klopfer for supervising the project and inviting me to join the lunch seminars of the Education Arcade. Finally, I am grateful to my HGSE advisor Prof. Tina Grotzer who supervised the project through regular meetings and encouraged me to carry out the research.

References

[1] Jeremy Bailenson, *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do*, ISBN 9780393253702 (W. W. Norton & Company, 2018).

[2] Zachary W. Sherin, Ryan Cheu, and Philip Tan, *Visualizing relativity: The OpenRelativity project*, American Journal of Physics 84, 369 (2016); https://doi.org/10.1119/1.4938057.

[3] Gerd Kortemeyer, Jordan Fish, Jesse Hacker, Justin Kienle, Alexander Kobylarek et al., *Seeing and Experiencing Relativity — A New Tool for Teaching?* Phys. Teach. 51, 460 (2013); doi: 10.1119/1.4824935.

Appendix-A Procedure to Enable VR in Einstein's Playground

The VR version of Einstein's playground is designed to have the following functionality

- Left hand touch controller
    - Thumbstick rotation: control the movement of the agent
    - Thumbstick button: trigger events
    - A/B button: increase or decrease the speed of light
    - Home button: reset the position of the agent
- Keyboard
    - Same as the VD version

The VR version can be implemented by carrying out the following procedure from the VD version Museum dated Feb 2019:

1. Copy EPVD/Museum to EPVR/Museum

2. Open EPVR/Museum in Unity (2018.3.1f1)

3. Import Oculus Integration

4. Edit Assets/Oculus/LipSync/Editor/

OVRLipSyncTool.cs: line 84

- Old: string newPath = path.Replace(Path.GetExtension(path), "_lipSync.asset");
- New: string newPath = path.Replace(System.IO.Path.GetExtension(path), "_lipSync.asset");

5. Edit Assets/Oculus/SampleFramework/Usage/Stereo180Video/Scripts/

MoviePlayerSample.cs: line 66

- Old: var guids = UnityEditor.AssetDatabase.FindAssets(Path.GetFileNameWithoutExtension(MovieName));
- New: var guids = UnityEditor.AssetDatabase.FindAssets(System.IO.Path.GetFileNameWithoutExtension(MovieName));

6 Modify project settings

- player/XR settings: virtual reality supported [select]

- player/XR settings: stereo rendering mode: single pass [select]
- player/other settings/graphics APIs for windows: OpenGLCore, Vulkan, Direct3D11 [change order]

7. Open the scene Assets/Scenes/bern

- add OVRCameraRig (Assets/Oculus/VR/Prefabs/OVRCameraRig) to PlayerMesh
- OVRCameraRig: unpack prefab completely [right click and select]
- modify the value of the variable *direction*
    - Player/PlaygroundScripts/FlatCamTransform/direction: OVRCameraRig/TrackingSpace/CenterEyeAnchor
    - Player/PlaygroundScripts/CamTransform/direction: OVRCameraRig/TrackingSpace/CenterEyeAnchor
- add LocalAvatar (Assets/Oculus/Avatar/Content/Prefabs/LocalAvatar) to PlayerMesh
- edit LocalAvatar options
    - unpack prefab completely (right click and select)
    - inspector window: Start With Controllers [select]
    - inspector window: Ovr Avatar -> surface shaders PBS -> Ovr Avatar/AvatarSurfaceShaderPBSV2
- modify project settings: Graphics -> Build-in Shader Settings -> Always Included Shaders: size = size (current value) + 3

8. Edit input manager: Assets/Scripts/Input/InputManager.cs

- replace the function *GetKeyDown* by

```
  public static bool GetKeyDown(string action)
  {
      if (DisabledInputs.Contains(action)) return false;
      if (Keybinds.ContainsKey(action))
      {
          bool overrides = KeyOverrides[action];
          KeyOverrides[action] = false;
          bool value = (overrides) || Keybinds[action].AsEnumerable<ButtonInput>().Aggregate(false, (acc, x)
=> acc || x.GetDown());
          if (UnityEngine.XR.XRDevice.isPresent && action.Equals("next slide"))          { value = value ||
OVRInput.GetDown(OVRInput.Button.PrimaryThumbstick); }
```

```
        if (UnityEngine.XR.XRDevice.isPresent && action.Equals("toggle ducks"))         { value = value ||
OVRInput.GetDown(OVRInput.Button.PrimaryThumbstick); }

        if (UnityEngine.XR.XRDevice.isPresent && action.Equals("fire duckboat"))        { value = value ||
OVRInput.GetDown(OVRInput.Button.PrimaryThumbstick); }

        if (UnityEngine.XR.XRDevice.isPresent && action.Equals("fire museum fireworks")) { value = value ||
OVRInput.GetDown(OVRInput.Button.PrimaryThumbstick); }

                    if (UnityEngine.XR.XRDevice.isPresent && action.Equals("reset"))
{ value = value || OVRInput.GetDown(OVRInput.Button.Start); }

        return value;

      }

      return false;

    }
```

- Replace the function GetAxis by

```
    public static float GetAxis(string axis)

    {

      if (DisabledInputs.Contains(axis)) return 0.0f;

      if (AxisMappings.ContainsKey(axis))

      {

        float value = AxisMappings[axis].AsEnumerable<AxisInput>().Aggregate(0.0f, (acc, x) =>
Math.Abs(x.Get()) > Math.Abs(acc) ? x.Get() : acc);

        if (UnityEngine.XR.XRDevice.isPresent && axis.Equals("move x")) { value =
OVRInput.Get(OVRInput.Axis2D.PrimaryThumbstick).x; }

        if (UnityEngine.XR.XRDevice.isPresent && axis.Equals("move z")) { value =
OVRInput.Get(OVRInput.Axis2D.PrimaryThumbstick).y; }

        if (UnityEngine.XR.XRDevice.isPresent && axis.Equals("speed of c") &&

          (OVRInput.GetDown(OVRInput.Button.One) || OVRInput.GetDown(OVRInput.Button.Three)))
{ value = 1.0f; }

        if (UnityEngine.XR.XRDevice.isPresent && axis.Equals("speed of c") &&

          (OVRInput.GetDown(OVRInput.Button.Two) || OVRInput.GetDown(OVRInput.Button.Four)))
{ value = -1.0f; }

        return value;

      }

      return 0.0f;

    }
```

9. Build the executable

- file -> build settings
- scenes in build -> scences/bern [select]
- architecture: x86_64
- build

Appendix-B Miscellaneous Technical Issues

- Relativistic optical effects are more noticeable than the geometric effects. Therefore, it is preferred to first turn off the Doppler effect in order to present Lorentz transformation effect.
- Players with glasses would have the best VR experience by wearing their glasses and adjusting the VR headset to the maximum size.
- Some previous VR tutorial uses outdated library Standard Assets/characters/FirstPersonController/Prefabs/FPSController to implement VR control. The updated one would be Oculus Integration: Oculus/VR/Prefabs/OVRCameraRig.
- To resolve the error due to path confusion, one needs to replace "Path" by "System.IO.Path" in corresponding c# scripts.
- A lot of problems are caused by the API graphics library
  (1) Direct3D is good for a new project but not compatible with Einstein's playground
  (2) Vulkan has the best visual effect but not compatible with VR
  (3) OpenGLCore is a reasonable compromise but may bring new issues such as stereo rendering mode and avatar shader (see procedure for solutions)
- The left and right touch controller cannot be distinguished properly in the current version of Unity and Oculus Integration.
- The input manager needs to be re-implemented in the future VR version. The functionality of touch controller seems to interference with unknown previous implementation (X-box?).

Appendix-C Consent Form

A Virtual Tour in Einstein's Playground

CONSENT TO PARTICIPATE IN

NON-BIOMEDICAL RESEARCH

Consent form

You are asked to participate in a research study conducted by Yu Zhu. You should read the information below, and ask questions about anything you do not understand, before deciding whether or not to participate.

PARTICIPATION AND WITHDRAWAL – Your participation in this study is completely voluntary. If you choose to be in this study, you may subsequently withdraw from it at any time without penalty or consequences of any kind.

PURPOSE OF THE STUDY - This study aims to investigate whether video games and virtual reality games would help learners develop intuitions in relativistic effects and motivate them to study the theory of special relativity.

PROCEDURES - If you volunteer to participate in this study, you will do the following things: (1) have a mini-lecture on the theory of special relativity; (2) play the video game version of Einstein's playground; (3) play the VR version of Einstein's playground; (4) take recorded interviews to provide your feedback. The experiment is anticipated to take about an hour.

POTENTIAL RISKS AND DISCOMFORTS - Some individuals experience dizziness while using a virtual reality headset. We will monitor each you dent while in the headset and end the simulation if you should become dizzy. There are no other potential risks or discomforts associated with this study.

PAYMENT FOR PARTICIPATION - Students will not be compensated for participation in the study.

CONFIDENTIALITY -Any information that is obtained in connection with this study and that can be identified with your child will remain confidential and will be disclosed only with your permission or as required by law. In addition, your information may be reviewed by authorized MIT representatives to ensure compliance with MIT policies and procedures.

Audio recordings may be shared with transcribers, but otherwise will primarily be viewed by project researchers for research purposes.

Participants will be assigned study ID numbers in order to anonymize data everywhere possible. Only anonymized, aggregated data will be reported and shared. All data will be digital or digitized and will be stored on secure password-protected servers accessible only by research staff.

IDENTIFICATION OF INVESTIGATORS If you have any questions or concerns about the research please feel free to contact eric_zhu@gse.harvard.edu

SIGNATURE OF RESEARCH SUBJECT

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

I consent I will participate in the following activities (please check boxes next to activities you will allow):

☐ The general study which includes surveys, interviews, and observations.

☐ Being audio recorded during interviews and observations.

Name of Participant

Signature of Participant Date

SIGNATURE OF PERSON OBTAINING INFORMED CONSENT

In my judgment the subject is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.

Name of Person Obtaining Informed Consent

Signature of Person Obtaining Informed Consent Date