Seamless and Secure VR

Adapting and Evaluating Established Authentication Systems for Virtual Reality

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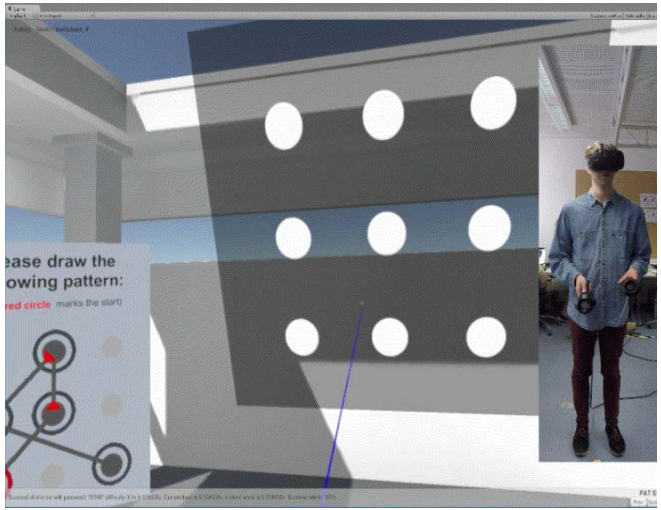
The next 20 min…



Seamless authentication in VR environments can solve practical security problems without reducing usability

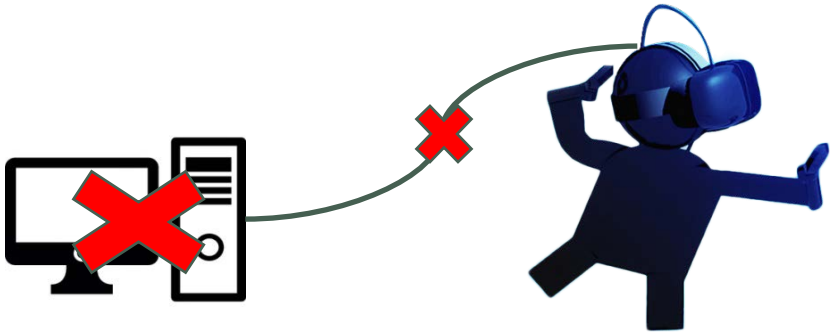
Growing interest in VR consumer products

Use cases for authentication in VR have already been established

Virtual online shopping - Confirming an Order

Social Applications - Signing In

Head mounted displays (HMDs) are ubiquitous devices, striving towards being wireless

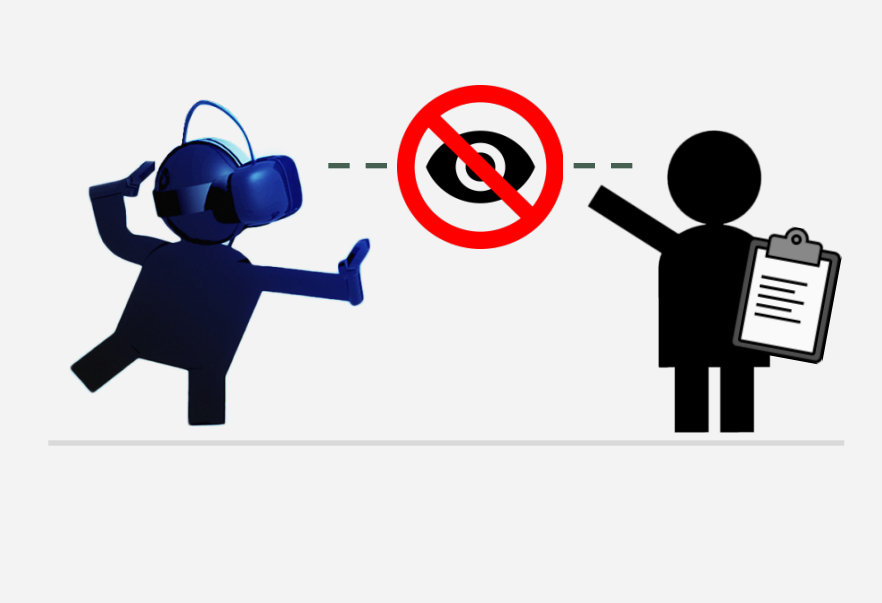


Device becomes self contained

No external display or keyboard

Need for seamless authentication, without taking the headset off

VR experiences differ from previous research on observation-resistant authentication

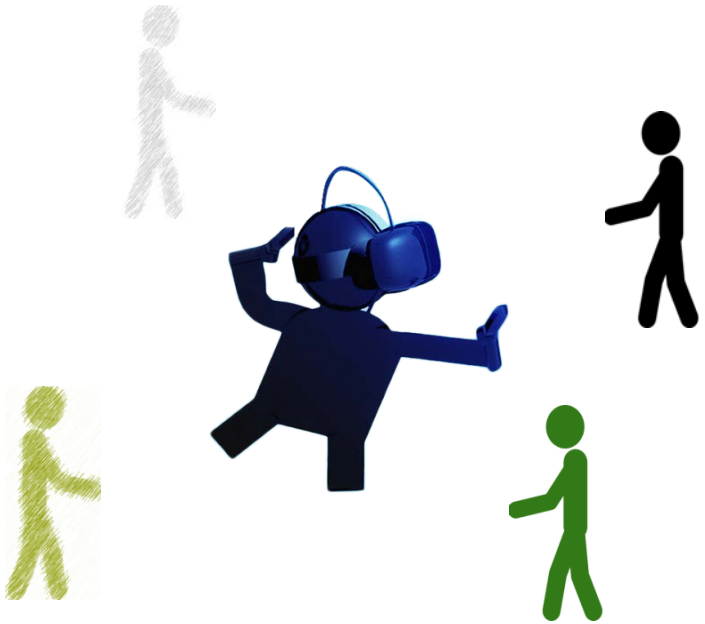


No visual cues of the input interface for real world observers

Mid-air interactions are observable from the real world

Fully immersed users do not notice observers

Threat Model

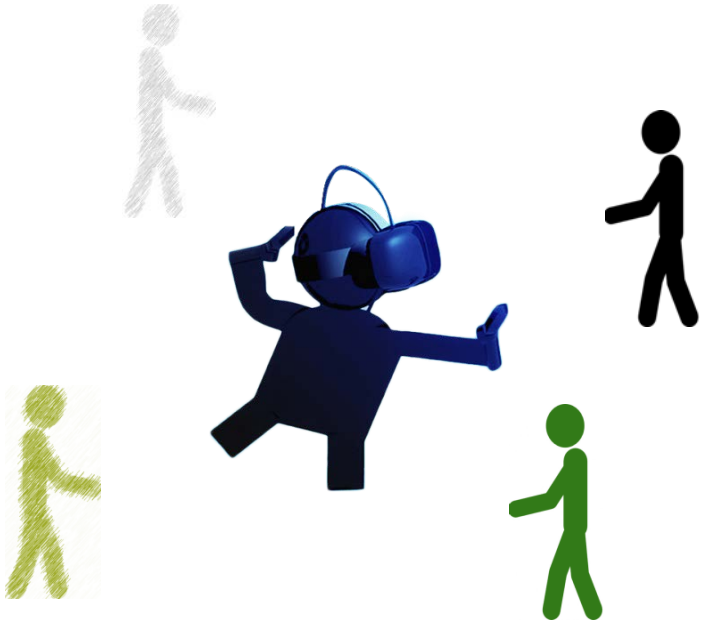


The victim is using VR with friends and family around

Attackers have perfect sight on victims‘ hand movements

Attacker cannot see what the user sees in the HMD

Threat Model



Unlike shoulder surfing in the real world, the attacker in our threat model cannot be seen by the user

The victim authenticates with PIN and pattern in order to complete an in-app purchase

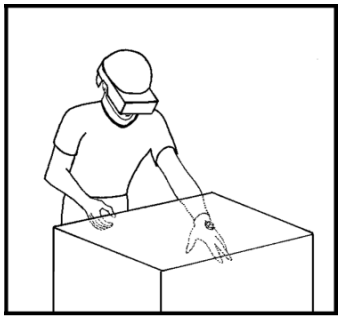
Immediately after authenticating, she takes off the headset in order to step out for a break

The attacker picks up the headset, continues playing the game and when prompted authenticates for another in-app purchase with the victim's password.

Two main metaphors influence VR interaction

Virtual Hand

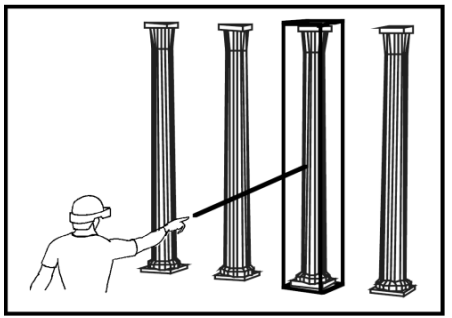
‘Tapping’ Objects to interact



1

Virtual Pointer

Using a ‘Laser Pointer’ to interact

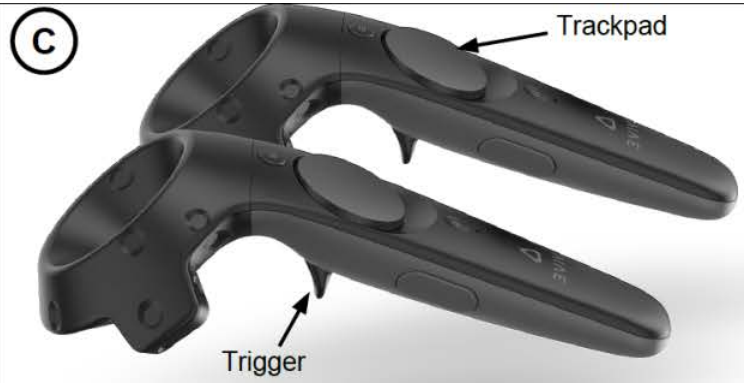


2

HTC Vive Controllers have the same look and feel in the virtual and real world

Real world

Virtual representation



Controller buttons used for interaction

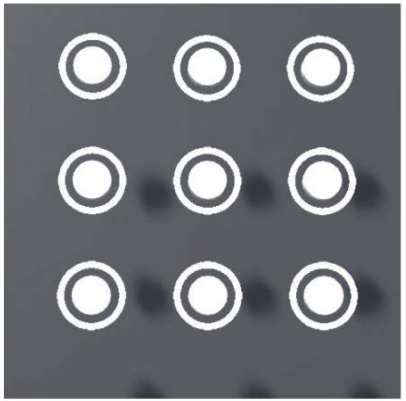
Transferring well established methods from the real world into virtual reality

Personal Identification Number

A

Android Unlock Patterns

B



We built upon the existing usable security research to create a design space for VR

Large + Medium surface

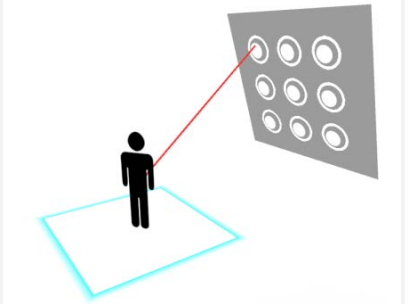
Public Display

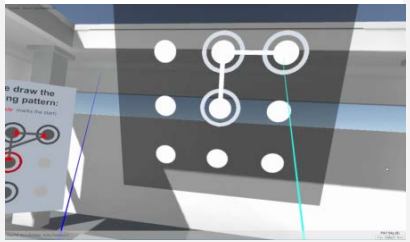
Small surface

Mobile Phone

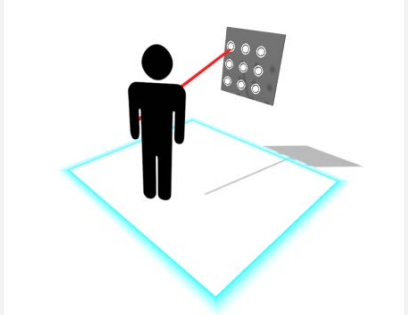
Our design space included four Input Modalities

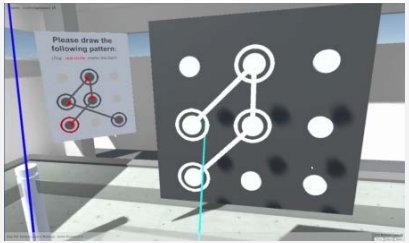
1 Large/Pointer



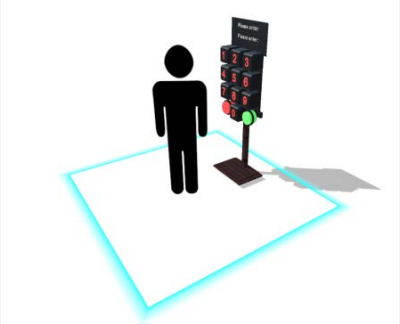


2 Medium/Pointer





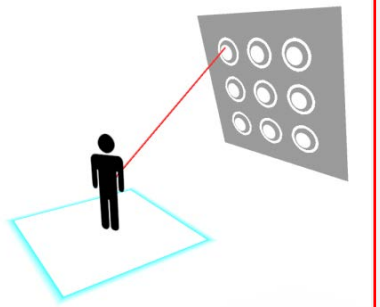
3 Medium/Tap

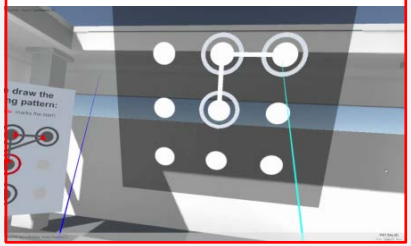


4 Small Stylus/Tap

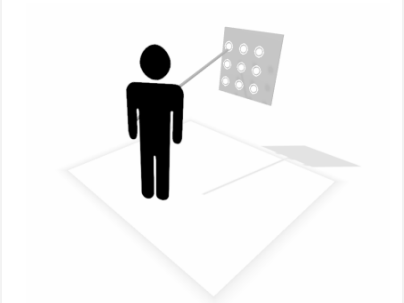
Four Input Modalities

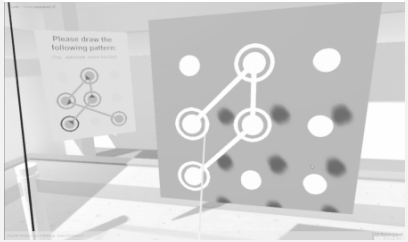
Large/Pointer



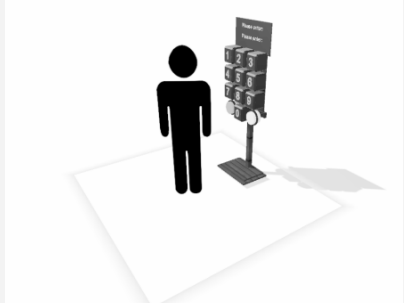


Medium/Pointer



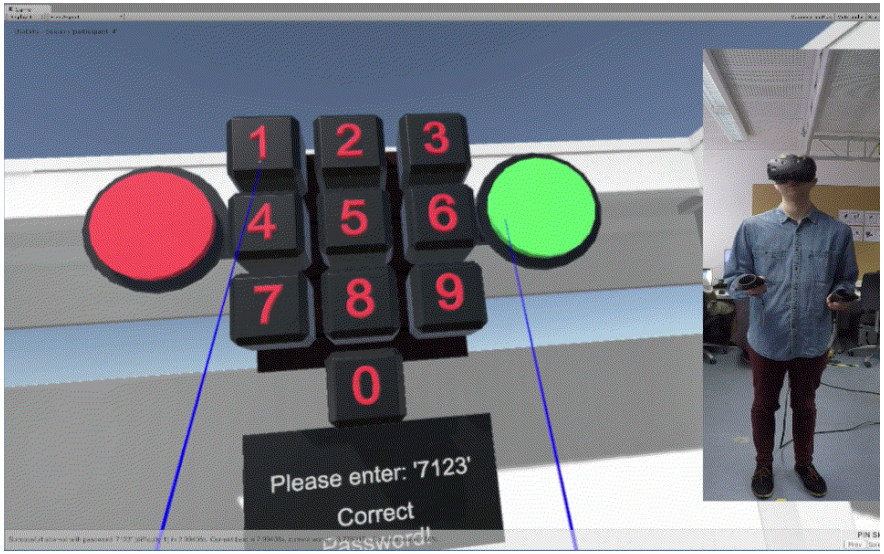


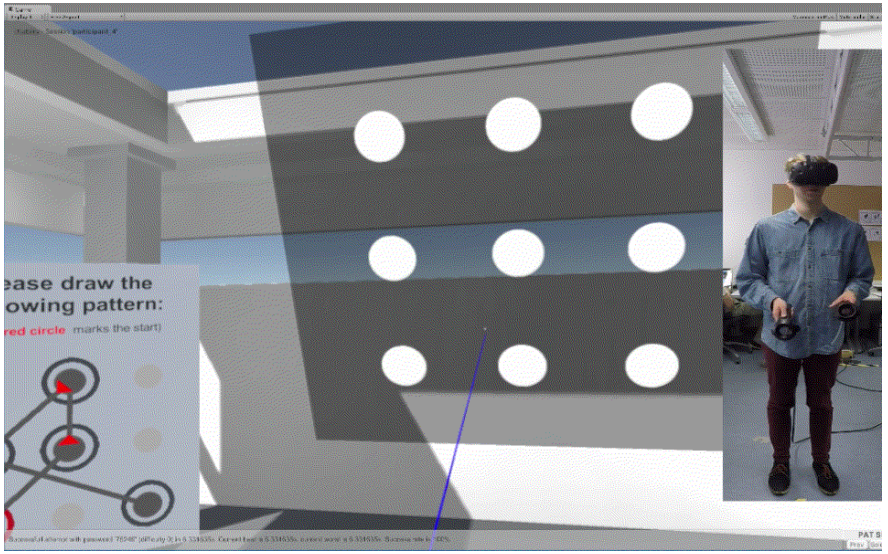
Medium/Tap



Small Stylus/Hybrid

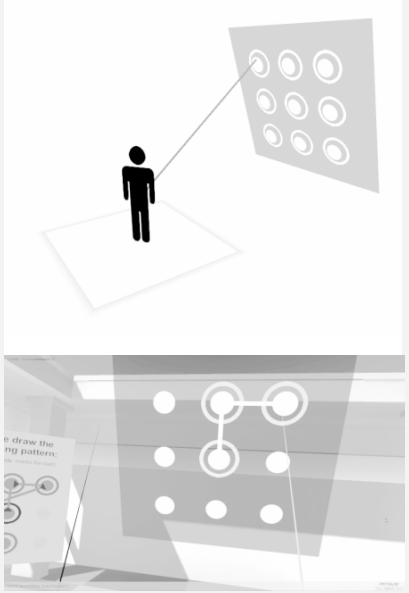
1 “Large/Pointer”



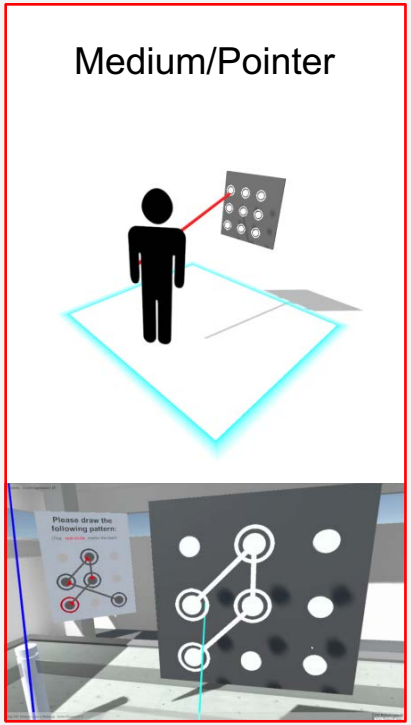


Four Input Modalities

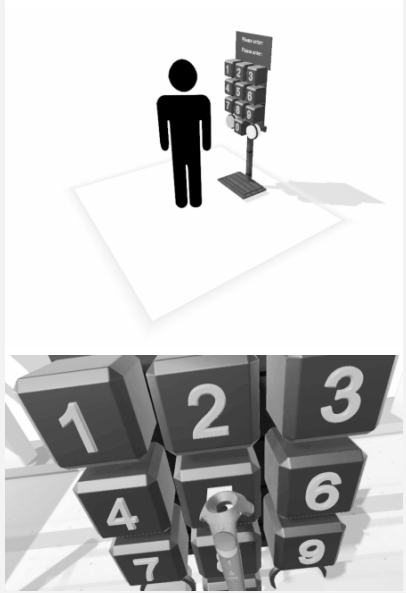
Large/Pointer



Medium/Pointer



Medium/Tap



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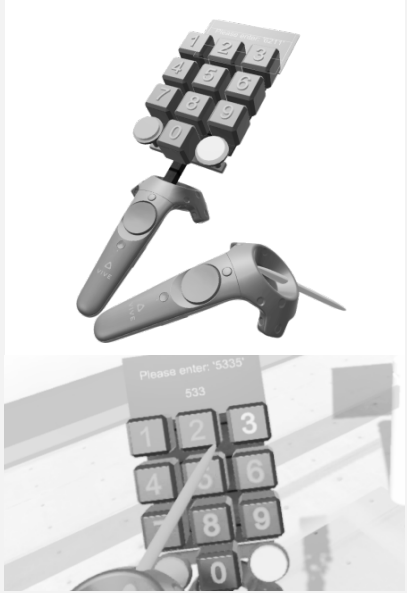

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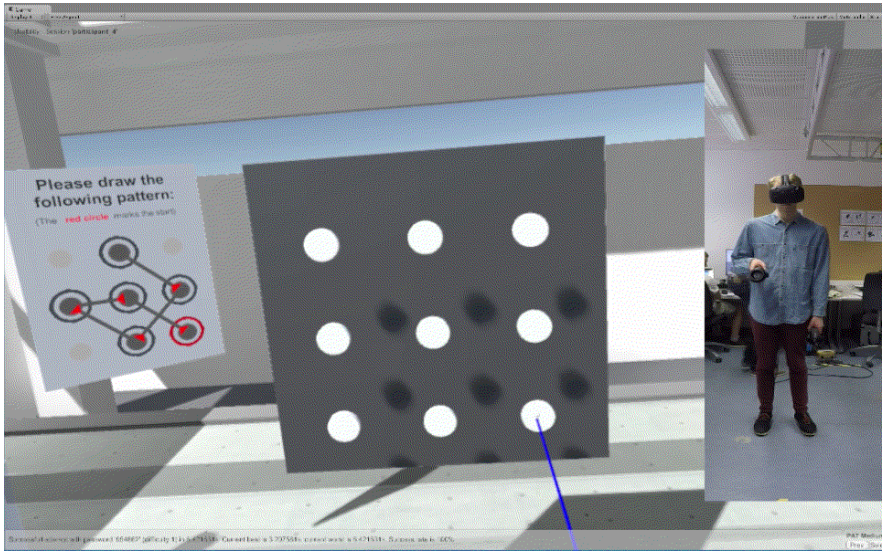
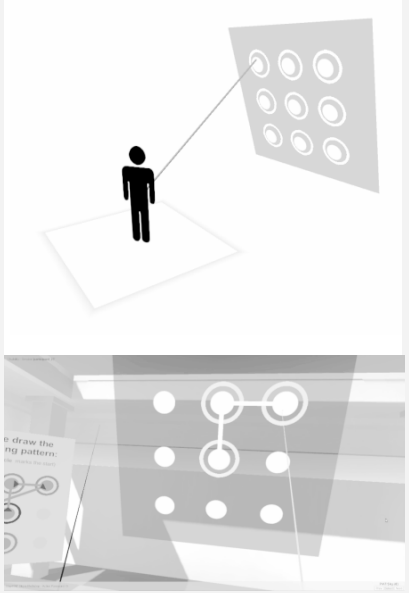
“Medium/Pointer”



Four Input Modalities

Large/Pointer



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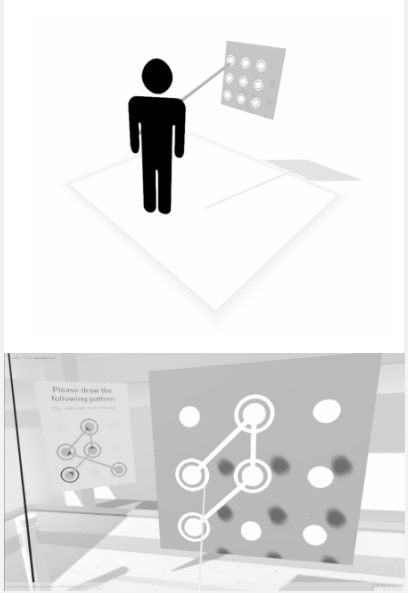
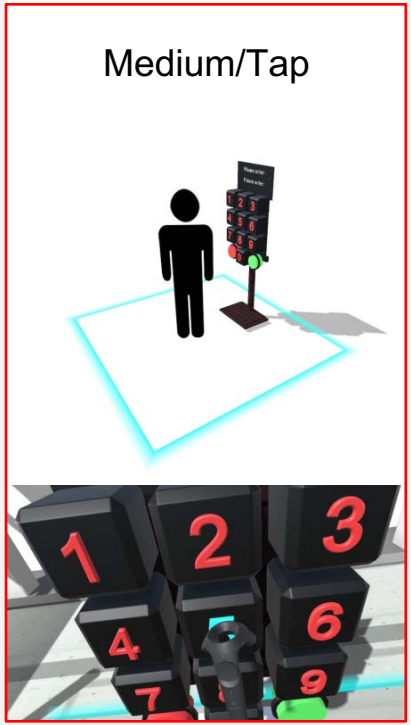


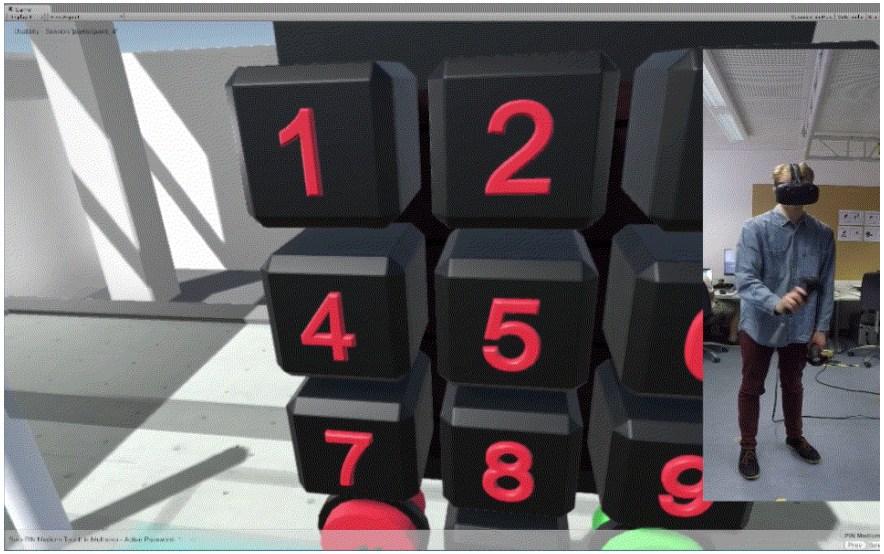
Medium/Tap

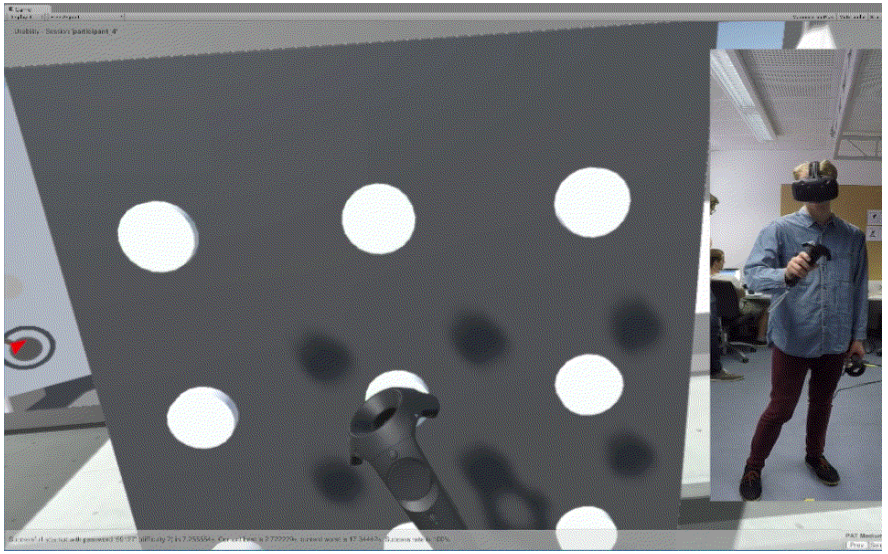


Small Stylus/Hybrid

3

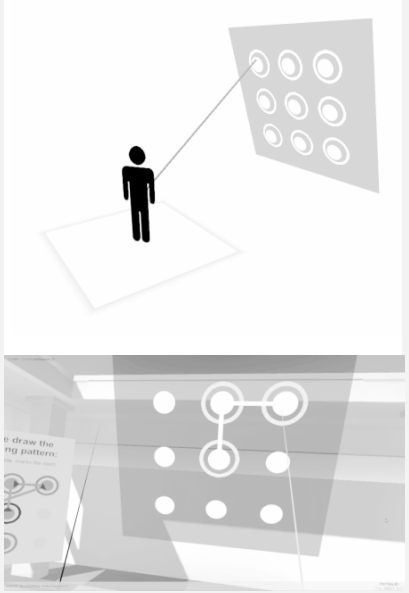
“Medium/Tap”





Four Input Modalities

Large/Pointer



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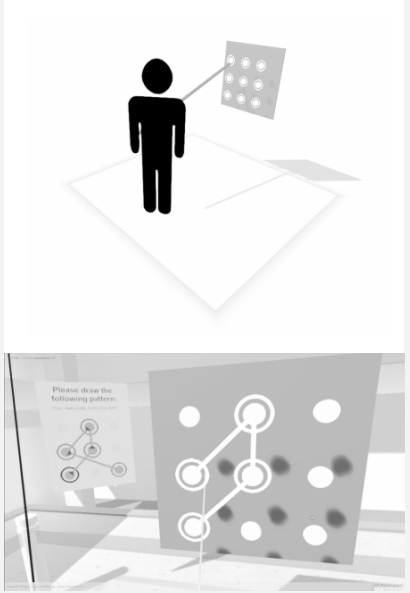
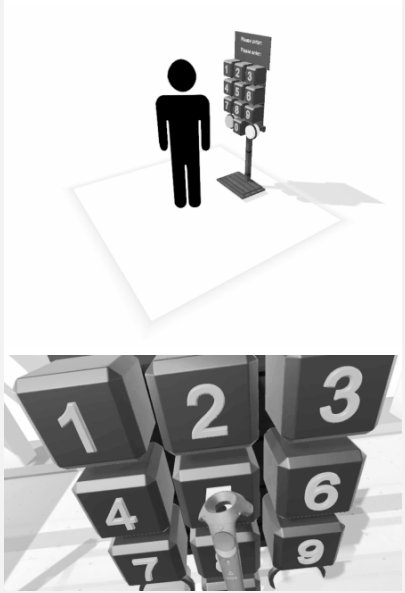


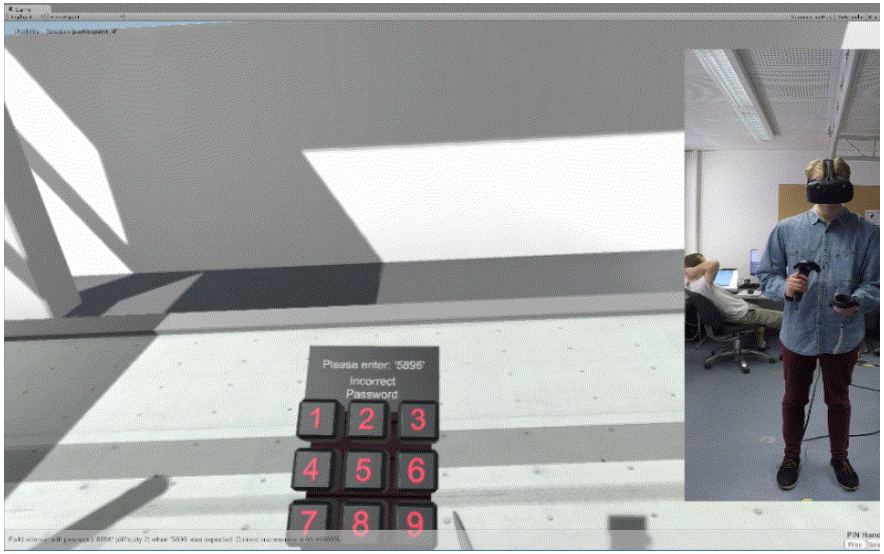
Medium/Tap

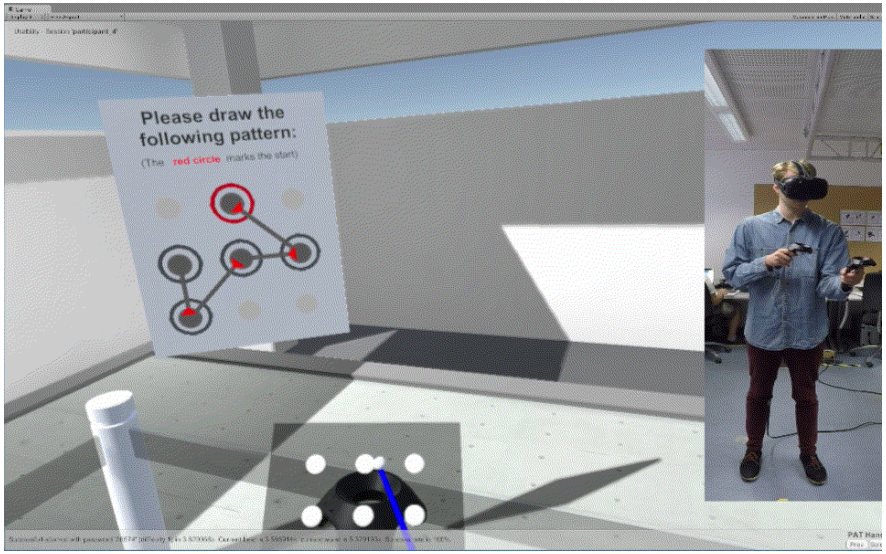


Small Stylus/Hybrid

4

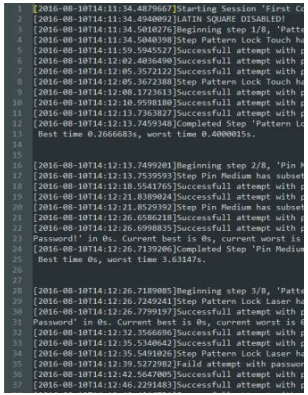
“Small Stylus/Tap”





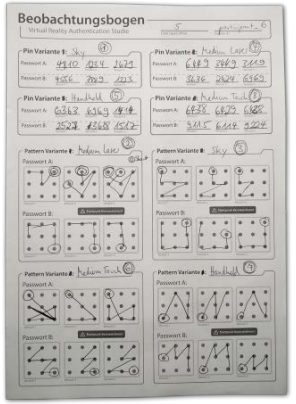
Main study was completed in two parts

1 Usability



Participants use the system to enter passwords. We log how fast they enter the passwords and how many mistakes they make.

2 Security



Participants observe the experimenter using the system. Can they replicate the passwords entered?

Usability Study - Variables

Independent Variables

- Password Type
- Input Modality

Dependent Variables

- Authentication Time
- Errors
- Perceived Ease of Use

Security Study - Variables

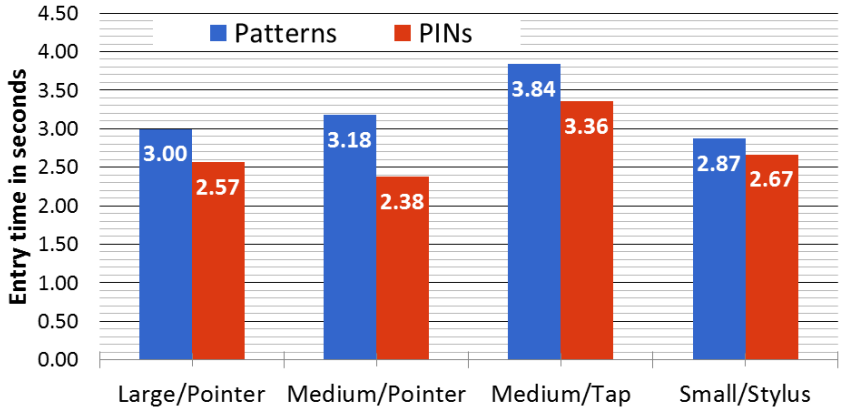
Independet Variables

- Password Type
- Input Modality

Dependent Variables

- Binary Success Rate
- Relative Success Rate
- Perceived Security

Usability – Entry time results



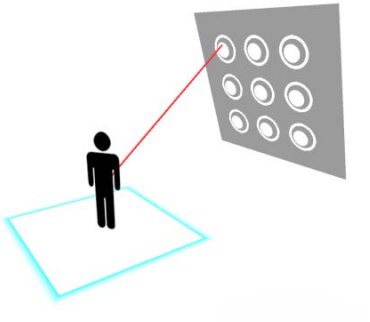
Overall averages across all input modalities:

Pin	2.7s
Pattern	3.2s

→ **significant difference (p<0.001)**

Medium/Tap performed **signficantly (p<0.001)** worse than all other input modalities

Security - Results



18% out of 400 entered passwords were guessed correctly

Pointer conditions performed **significantly** better than tapping

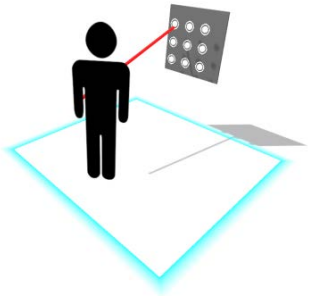
Large/Pointer

Medium/Tap showed **significantly ($p<0.05$)** worse shoulder surfing resistance compared to all other conditions

The most secure modality for both PIN and Pattern input was Large/Pointer

Usability and Security – Perception results

Medium/Pointer was perceived to be **significantly (p<0.001)** more secure and usable than Medium/Tap (before and after study completion)



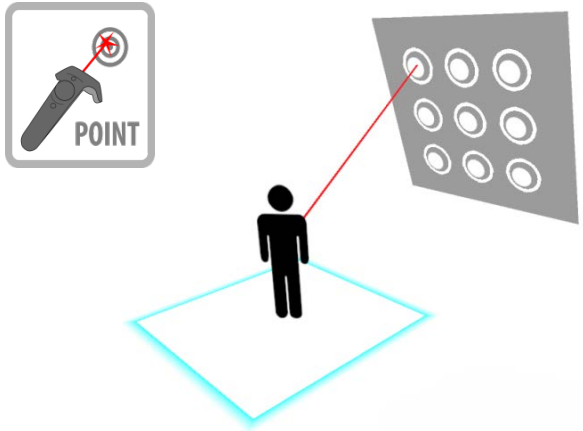
Medium/Pointer

Conclusion

PIN and Pattern capable for VR application

Virtual pointer outperforms virtual tap for authentication purposes

Possibly more secure than mobile device authentication as attacker has no visual feedback of input surface



Seamless authentication in VR environments can solve practical security problems without reducing usability

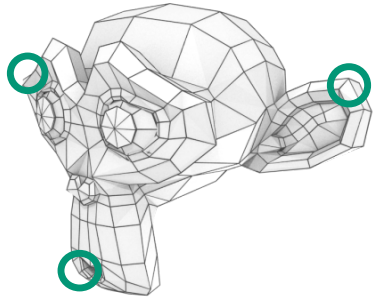
Future Work

Next step would be

Combining our insights on interaction styles to create a [graphical] password space for VR

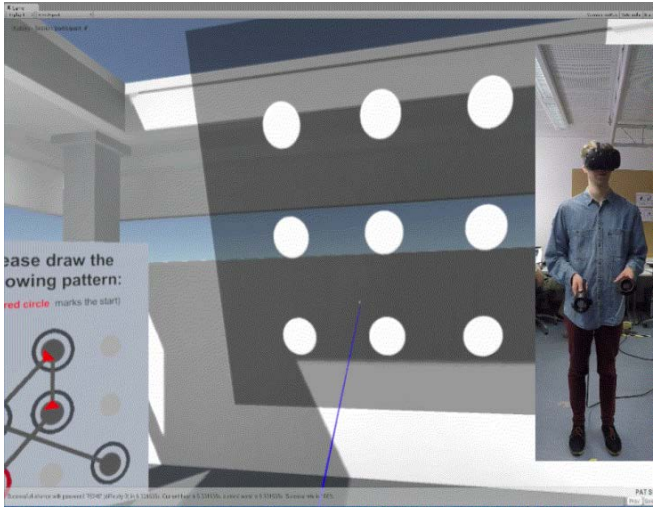
Combining the secret channel provided by HMDs and the new password space to generate VR specific password schemes

VR authentication option I



VR authentication option II

Thank you



Seamless authentication in VR environments can solve practical security problems without reducing usability

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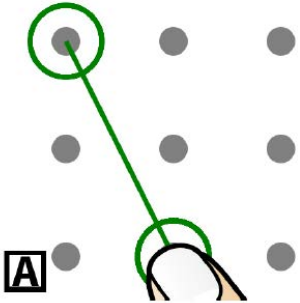
Password Properties: PIN

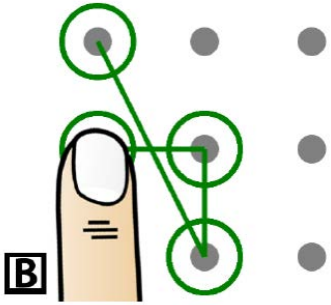
Transformability

- Two types of password sets were used in Security Study:
  - Transformable and non-transformable PINs
- Transformability was originally intended for classification of easy/hard-to-guess PINs
- Transformability often comes along with
  - consecutive
  - repeated
  - neighboring digits

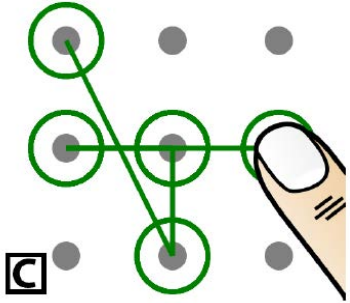
Password Properties: Pattern



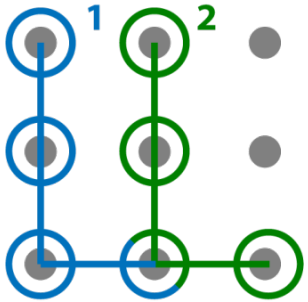
[A] Knight move: A connection between two points that are not immediate neighbors



[B] Intersection: The crossing of one or more lines.



[C] Overlap: A line that crosses a point that has already been activated as part of another line

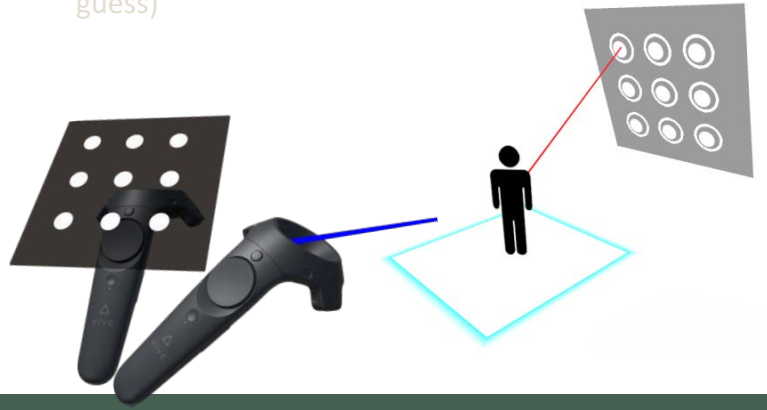


[D] Transformability: The pattern can be drawn in multiple positions on the grid

Conclusions Pattern

- Only **Touch** input has significant drawbacks (30% slower, ~half as secure)
  - **Large Pointer** and **Handheld** lead in popularity (Combining 13 / 15 Votes)
  - **Large Pointer** is most secure (6% attack success vs. 15% hand)
  - **Large Pointer** generates fewer errors (0.083 Errors / Entry vs. 0.153)

- Entry times comparable to smartphone (3.2 excl. Touch vs. Harbach et al. 3.0s , von Zezschwitz et al. 3.1s)
- Security is potentially improved (overall binary success-rate of 14.58%, given 3 guesses compared to ie. Zakaria et al, 19% with shielding, one guess)



References

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“Bendy” - Figure © by Valve, https://support.steampowered.com/steamvr/HTC_Vive/

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SuperDataThere are several other news site reporting or projecting similar numbers (werables.com, forbes.com, businessinsider.com).

P. Lee, D

J. Maida,

https://www.vive.com/us/pr/newsroom-gallery/