

# Cross-Device Transfer in a Collaborative Multi-Surface Environment without User Identification

**Stacey D. Scott, Guillaume Besacier, Phillip J. McClelland**

Systems Design Engineering and Games Institute  
University of Waterloo, Waterloo, Canada



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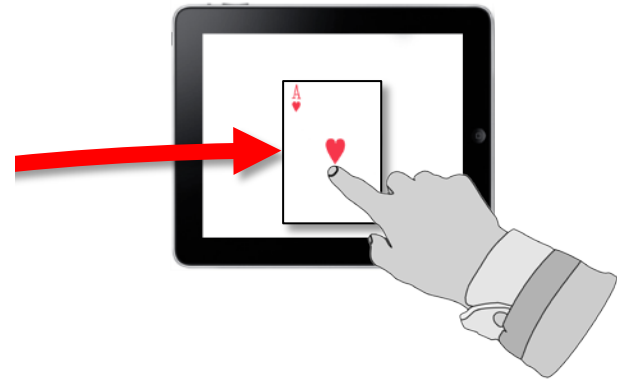


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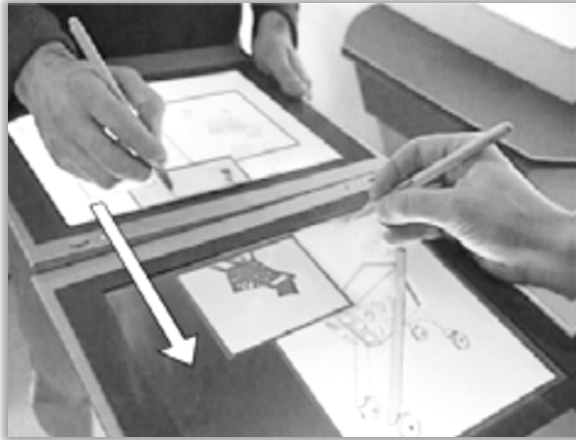
# Utilizing Private Data at a Shared Tabletop

- Need for effective mechanisms to move content across devices (cross-device transfer)



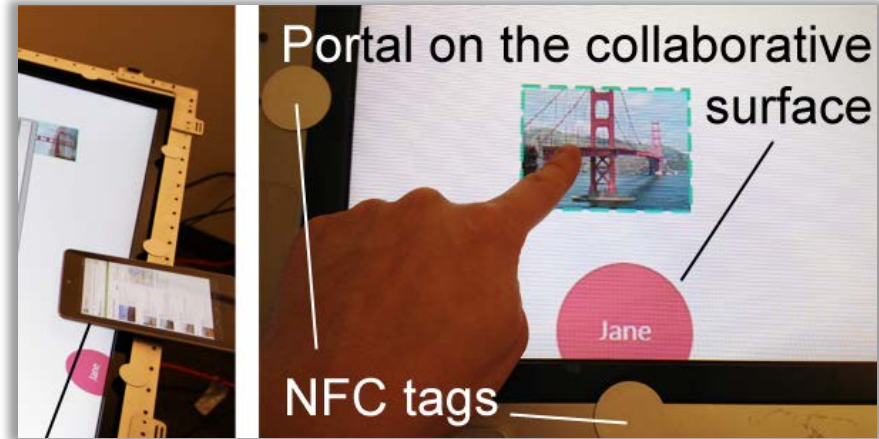
# Existing Cross-Device Transfer Techniques

## contiguous virtual workspace



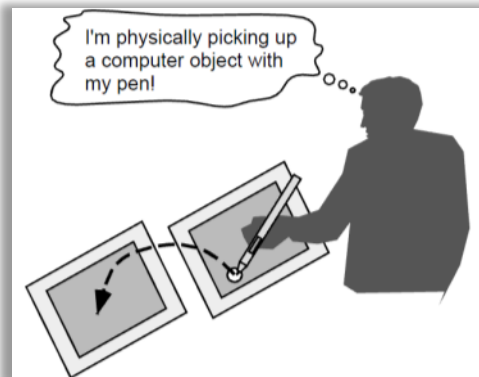
ConnecTables [Tandler et al. 2001]

## virtual portals



Surface Portals [Fei et al. 2013]

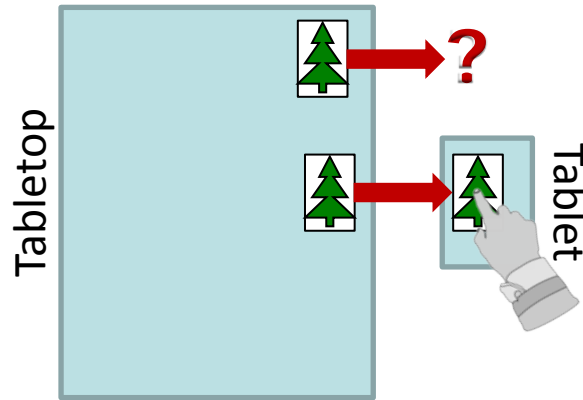
## physical proxy



Pick-and-Drop [Rekimoto 1997]

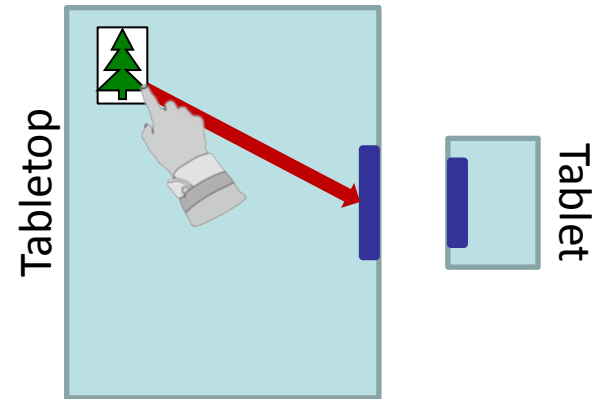
# Limitations for Multi-touch Tabletop and Tablets

## contiguous virtual workspace



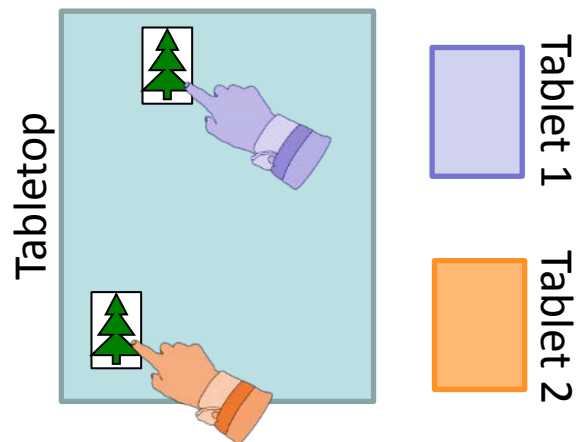
Display size discrepancy

## virtual portal



Physical fatigue over long distances

## physical proxy

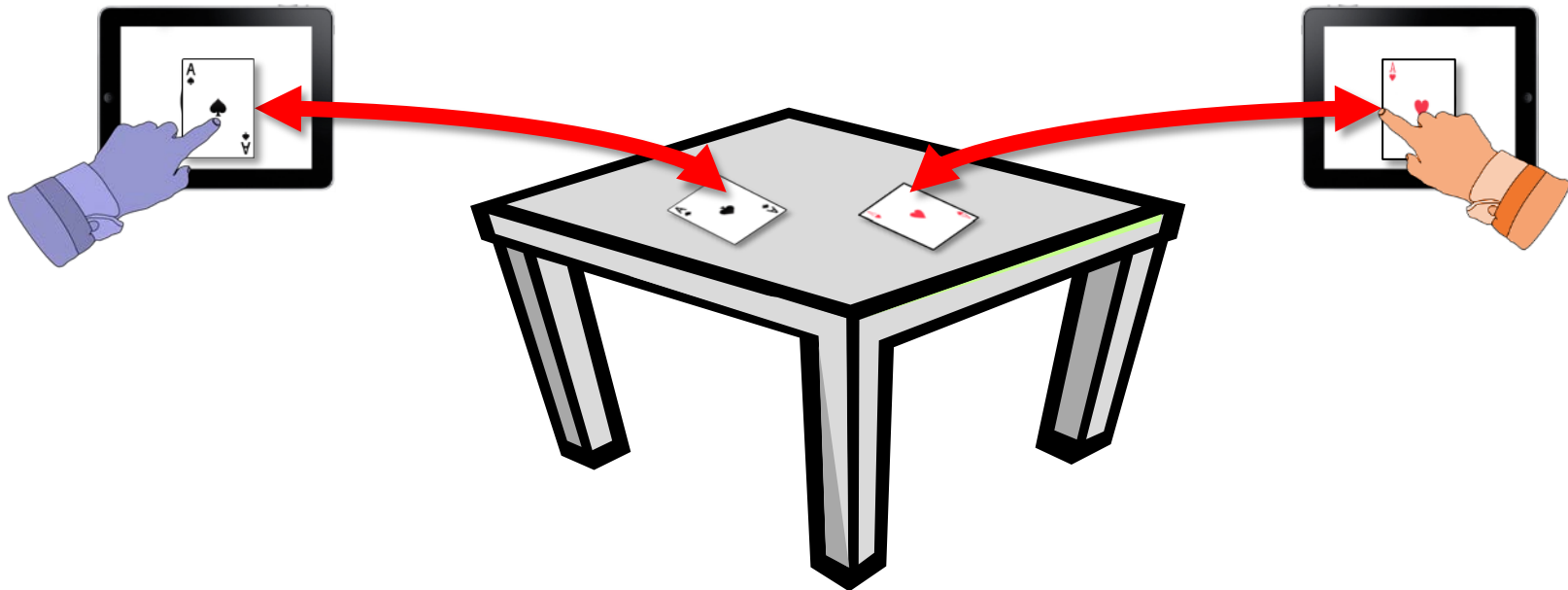


1. No physical proxy (e.g. pen) readily available for many multi-touch devices
2. No user identification on shared tabletop creates confusion during multi-user transfers

# Investigating Existing Techniques on Multi-touch Surfaces

## Research question:

How effective are existing cross-device transfer techniques for **multi-user cross-device transfer** on a digital tabletop **without user identification**?



# Study of Cross-Device Transfer in Digital Tabletop Game

- Popular commercial card game, ***Dominion***, was converted to digital tabletop and tablet application
- Requires frequent transfer of cards between **shared resources** (on tabletop) and **hand-of-cards** (on tablet)



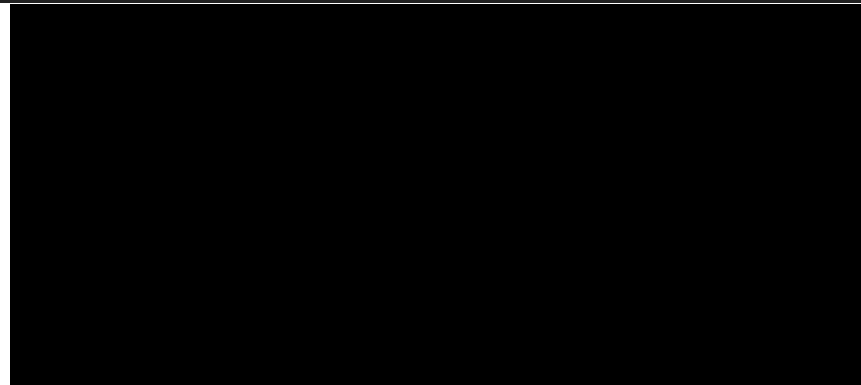
Digital tabletop **Dominion**<sup>1</sup> game



# Studied Transfer Techniques I

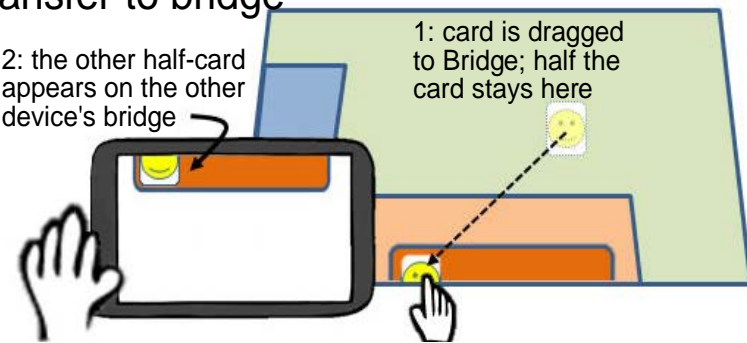
## Bridges

(virtual portals technique)



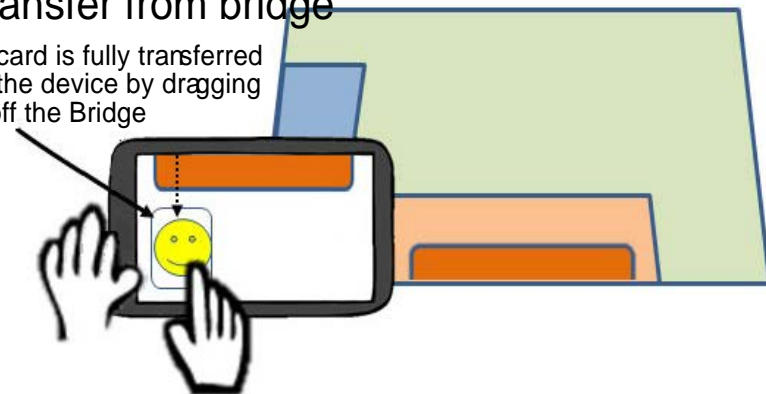
### Transfer to bridge

2: the other half-card appears on the other device's bridge



### Transfer from bridge

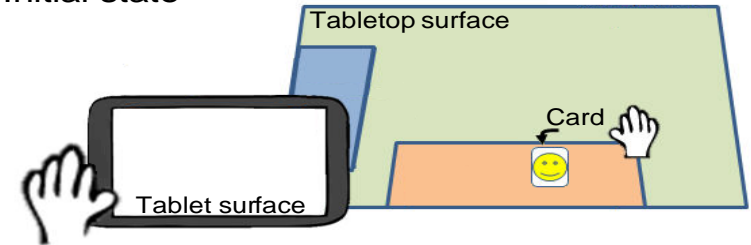
3: card is fully transferred to the device by dragging it off the Bridge



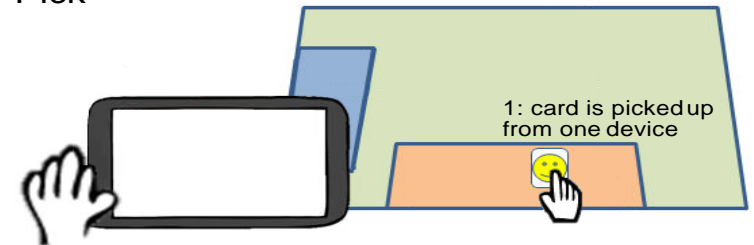
# Studied Transfer Techniques II

## Adapted Pick-and-Drop (A-PND) (physical proxy technique)

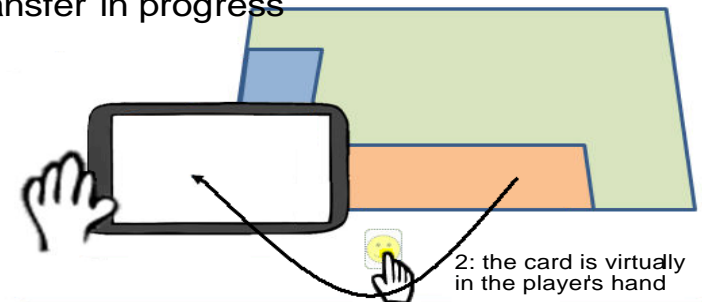
Initial state



Pick

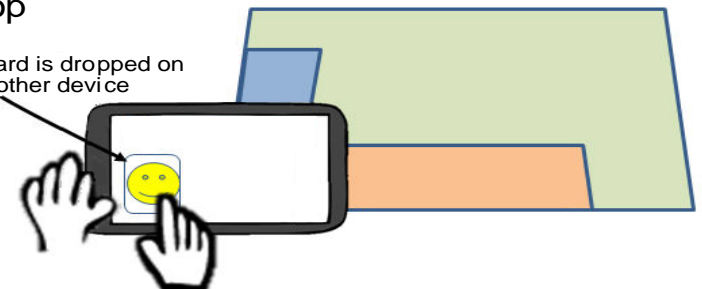


Transfer in progress



Drop

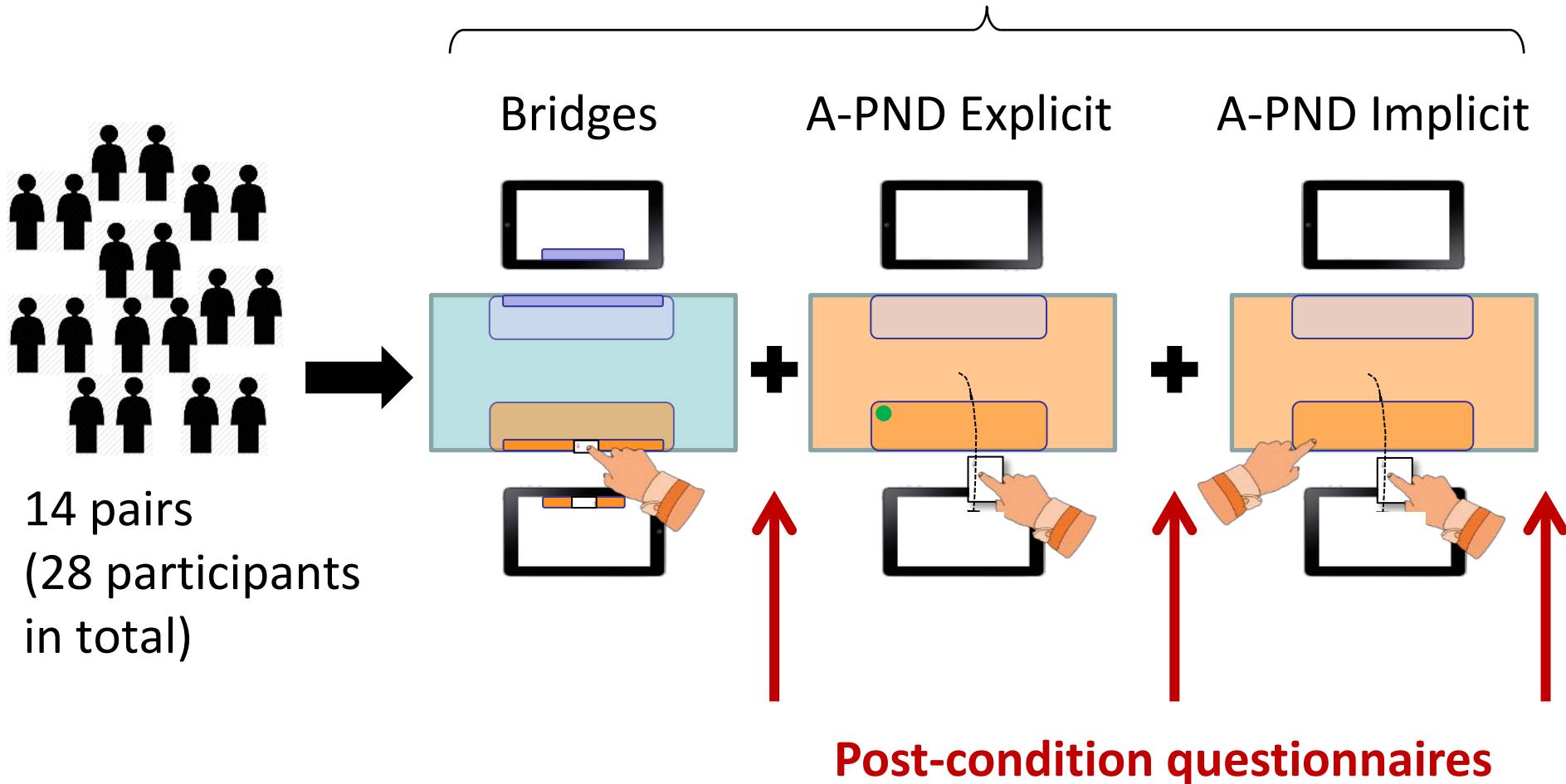
3: card is dropped on the other device





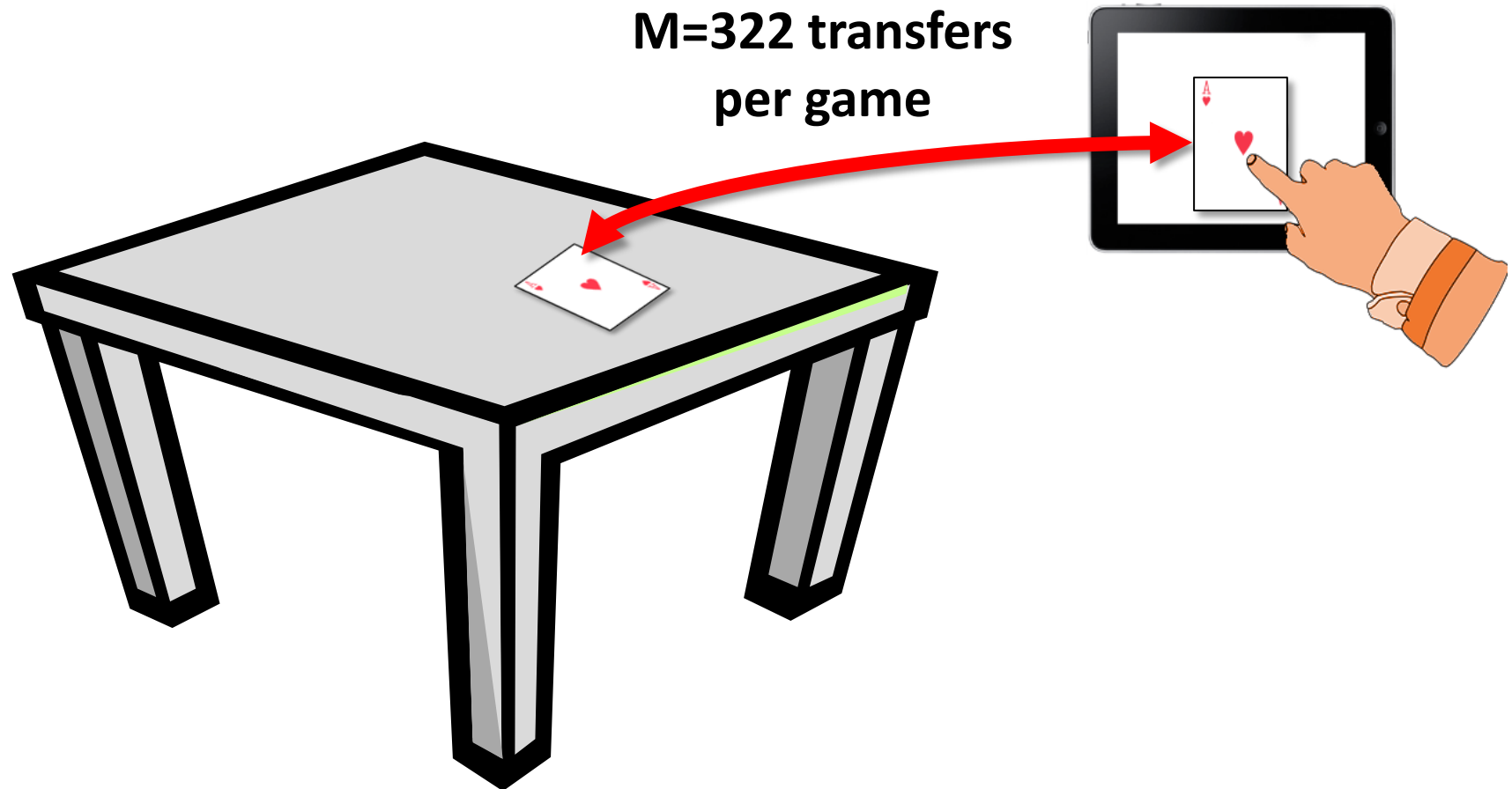
# Comparative User Study: Study Design

within subjects / counter-balanced  
(~30mins per condition)



# Results and Discussion

# Frequent Card Transfers in All Conditions



# Player Preferences Split Across Transfer Techniques

- Statistical analysis revealed:
  - **No significant difference in preference ratings** across transfer techniques
  - **No significant difference in subjective study measures** (game enjoyment, awareness, and level of effort) across transfer techniques
- Participants equally divided in their preferences between Bridges and A-PND transfer techniques

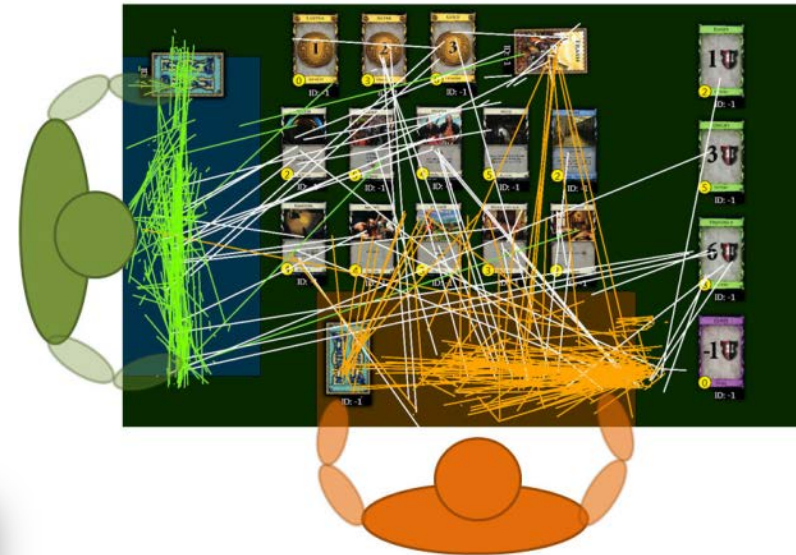


# Qualitative Analysis Comparing Bridges and A-PND

- In-depth qualitative analysis of video data, observer notes, participant comments, and computer log data



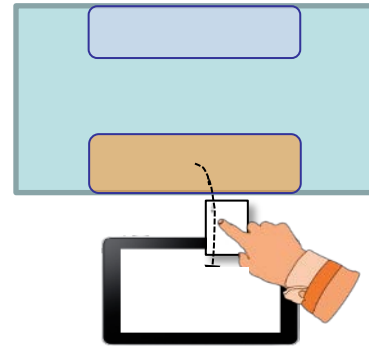
Video data



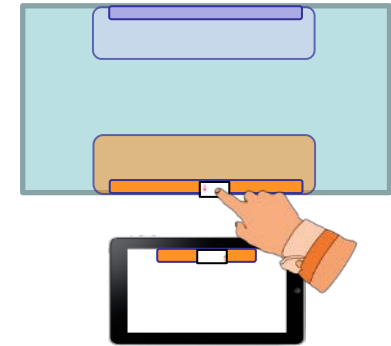
Sample activity plot from  
computer log data  
(A-PND Implicit session)

# Bridges vs. A-PND: Key Themes (More in Paper)

- Cognitive Effort
- Physical Effort
- Privacy & secrecy



A-PND



Bridges

✗ Cognitive demanding to track cards during transfer:

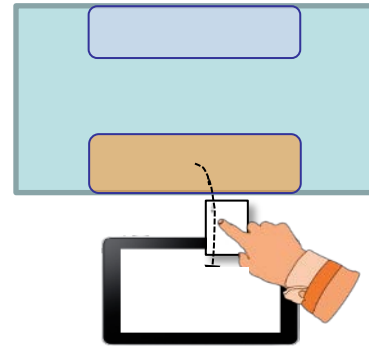
*“Not seeing the cards that are ‘in the ether’ while picking up confused me a couple of times”*

✓ State of cards always visible:

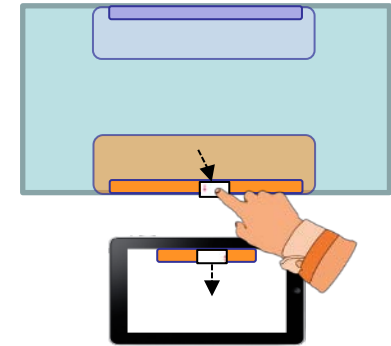
*“Easier to keep track of cards” ; “More intuitive”*

# Bridges vs. A-PND: Key Themes

- Cognitive Effort
- Physical Effort
- Privacy & secrecy



A-PND



Bridges

- ✓ More direct, efficient transfer
- ✓ Multi-card transfer also improved efficiency

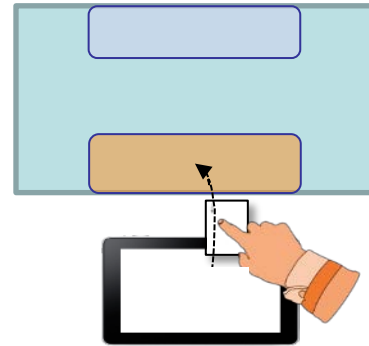
- ✗ Dragging cards to/from Bridge on each device created interaction bottleneck:

*"[Bridges] was super annoying... It just added more clicks to the game."*

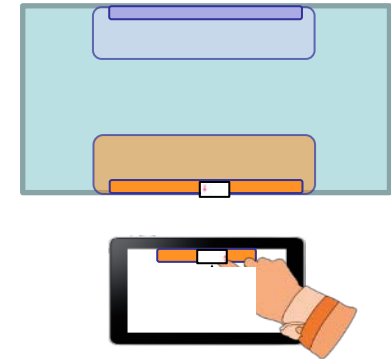


# Bridges vs. A-PND: Key Themes

- Cognitive Effort
- Physical Effort
- Privacy & secrecy



A-PND



Bridges

✓ Drops on table were **context-aware**:

- ✓ Cards dropped on deck took **face-up/face-down value of deck**
- ✓ Enabled competitive players to keep **discarded cards secret**



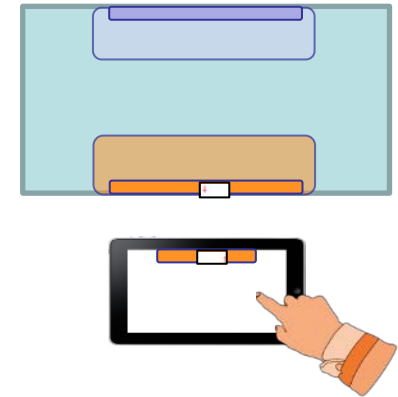
- ✗ All cards transferred to table were **displayed face-up** on table Bridge
- ✓ Non-competitive players appreciated this openness:

*"[Bridges] allowed you to show what you were doing more easily."*

# Emergent Strategy: Bridges Partial-Transfer

- To address limitations of Bridges some players adopted “**partial-transfer**” strategy:

Cards half on table Bridge,  
half on tablet Bridge



- ✓ Reduces physical effort
- ✓ Resolves “disclosure issue”
- ✗ Hard to see card details

# Summary

**No “clear winner”**, each technique had pros and cons, varying across different player play styles

- Bridges was **easier** to use, but A-PND was more **efficient**
- Lack of feedback during A-PND transfer introduced **confusion**
- A-PND preserved **private information** better than Bridges
  - Bridges “**partial-transfer**” strategy resolved this issue

# Conclusion

- Study successfully applied existing transfer techniques to multi-user tabletop without user identification
  - Dedicated Personal Play Areas enabled multi-user ***physical proxy transfer (A-PND)***
  - Dedicated Bridges on tabletop and tablets enabled multi-user ***virtual portals transfer***
- Study revealed Bridges and A-PND technique **each provided unique advantages**, which aligned better or worse with different participants personal tasks goals



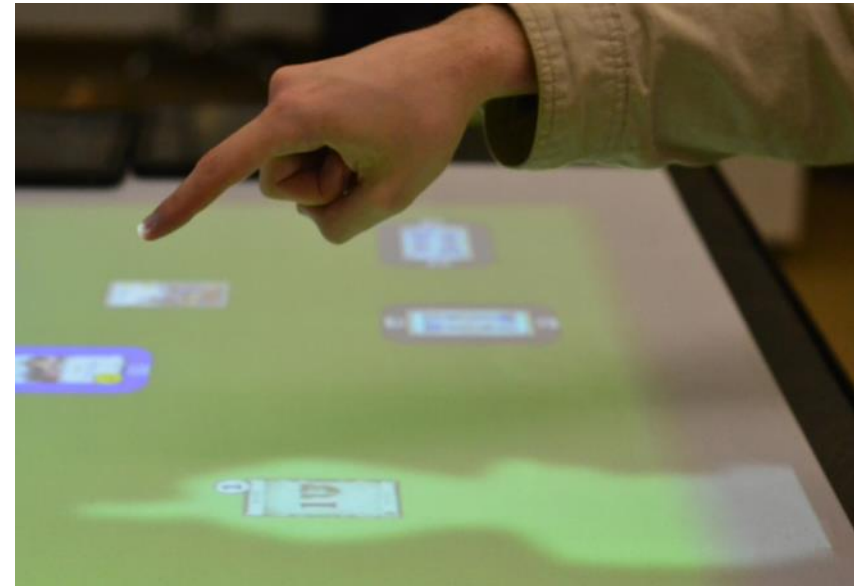
# Ongoing / Future Work

- Address lack of feedback during A-PND transfer

## Object-plus-Arm Shadow Design Concept



## Object-plus-Arm Shadow Implementation



(Presented as a Interactivity Demo at ACM CHI 2014)

[Besacier et al. (2014). Object and Arm Shadows: Visual Feedback for Cross-Device Transfer. CHI 2014]

# Thank You!

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**Dr. Stacey D. Scott**

Collaborative Systems Laboratory

Systems Design Engineering, University of Waterloo

Waterloo, Ontario, Canada

Email: [stacey.scott@uwaterloo.ca](mailto:stacey.scott@uwaterloo.ca)

Website: <http://csl.uwaterloo.ca>

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