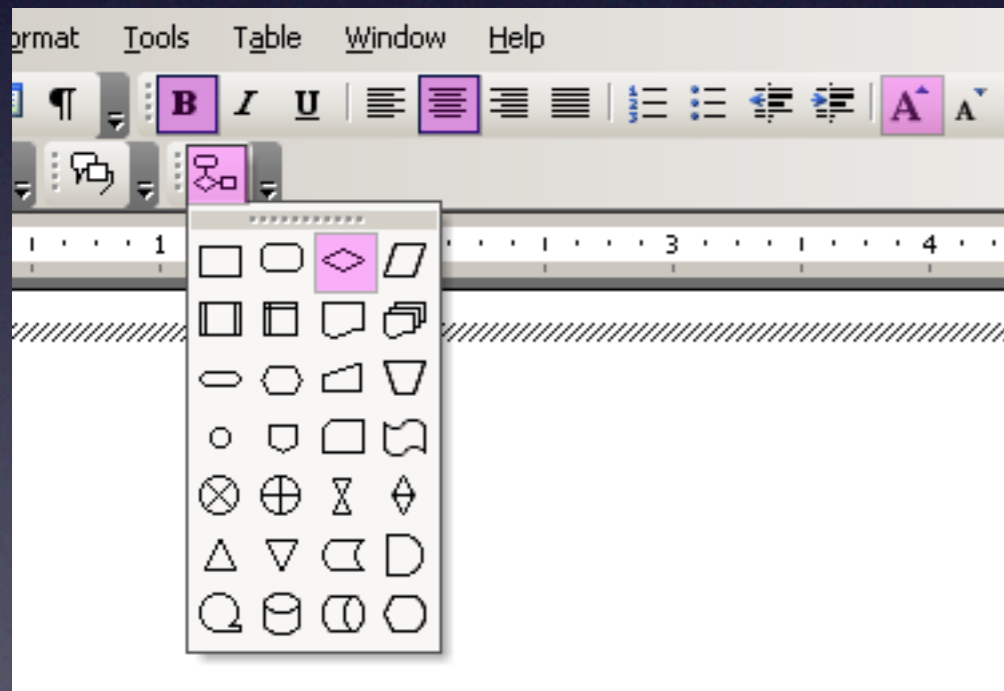


# Exploring the Design Space for Adaptive Graphical User Interfaces



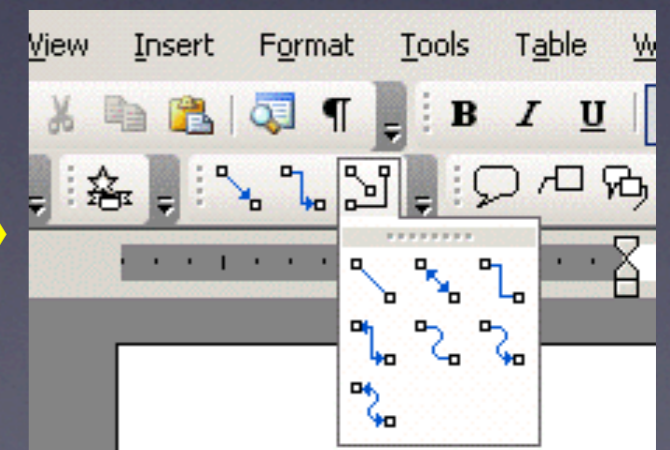
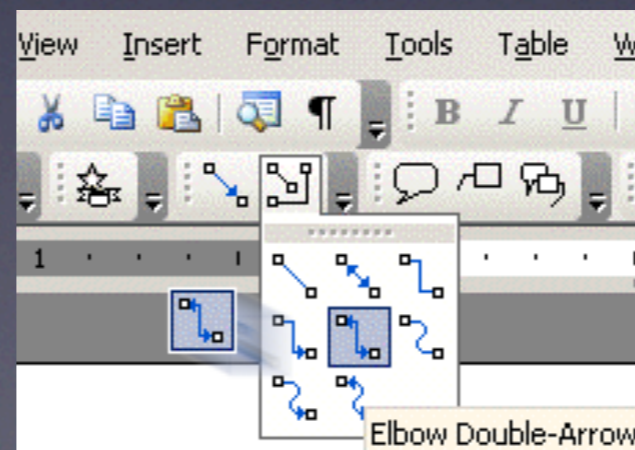
Krzysztof Gajos  
Mary Czerwinski  
Desney Tan  
Daniel S. Weld

(University of Washington)

(Microsoft Research)

(Microsoft Research)

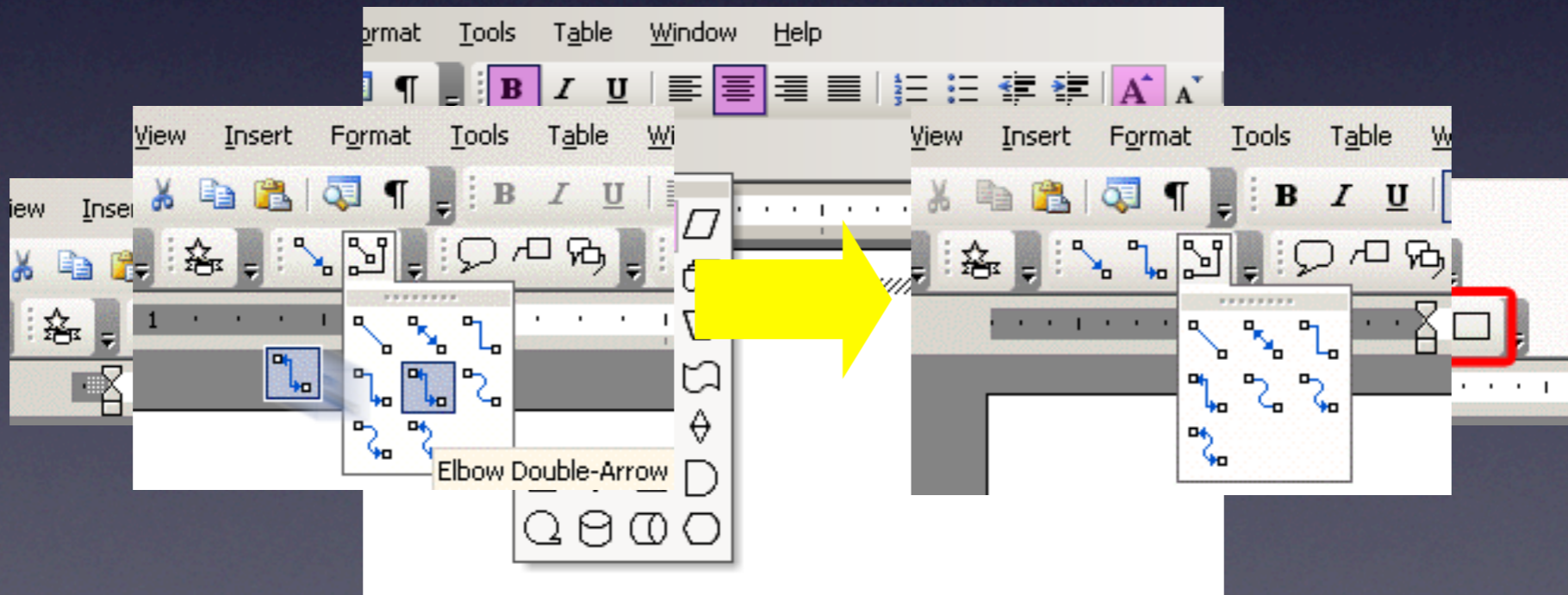
(University of Washington)





# Scope

Graphical User Interfaces where the system automatically adapts the presentation of the functionality



The ~~Visual Basic~~ ~~Microsoft~~ ~~Word~~ ~~2003~~ ~~graphical~~ ~~user~~ ~~interface~~



# Motivation

They optimize  
the UI for the  
individual!

They  
disorient  
the user!





# Prior Work

- ↑ Greenberg and Witten [1985]
- ↕ Trevellyan and Browne [1987]
- ↓ Mitchell and Shneiderman [1989]
- ↑ Sears and Shneiderman [1994]
- ? McGrenere, Baecker and Booth [2002]
- ↓ Findlater and McGrenere [2004]
- ↔ Tsandilas and shraefel [2005]

# Commercial Deployments

Palatino Linotype 12 B I U

Palatino Linotype  
MV Boli  
Monotype Corsiva  
Arial  
Arial Black

**Symbol**

Symbols Special Characters

Font: (normal text) Subset: Currency

□	□	□	n	₣	£	₪	₹	₺	€	%	ℓ	₪
1/3	2/3	1/8	3/8	5/8	7/8	←	↑	→	↓	↔	↕	
∑	-	/	·	√	∞	∩	∪	∫	≈	≠	≡	:
∫	∫	-		∟	∟	∟	∟	∟	∟	∟	∟	∟

Recently used symbols:

€	£	¥	©	®	™	±	≠	≤	≥	÷	×	∞	μ	α	β
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EURO SIGN Character code: 20AC from: Unicode (hex)

AutoCorrect... Shortcut Key... Shortcut key: Alt+Ctrl+E

Insert Cancel

Format Tools Data Window Help

Spelling... F7  
AutoCorrect...  
Share Workbook...  
Track Changes  
Merge Workbooks...  
Protection  
Online Collaboration  
Goal Seek...  
Scenarios...  
Auditing  
Macro  
Add-Ins...  
Customize...  
Options...

kgajos

Internet Mozilla Firefox  
E-mail Mozilla Thunderbird  
Presenter 2.0  
DeckBuilder 2.0  
Microsoft Office Word 2003  
iTunes  
Adobe Reader 7.0  
Microsoft Office PowerPoint 2003

My Documents  
My Recent Documents  
My Pictures  
My Music  
My Computer  
My Network Places  
Control Panel  
Set Program Access and Defaults  
Connect To  
Printers and Faxes  
Help and Support  
Search  
Run...  
Buy at ToshibaDirect

All Programs

Log Off Turn Off Computer

start

Inbox for kgajos



# Our Goal

Uncover the **factors** and **relationships** that influence users' **satisfaction** and actual **performance** when using adaptive UIs



# Road Map

- ✓ Introduce and motivate the problem
- Video**
- Experiment 1: qualitative results
- Experiment 2: quantitative results
- Synthesis
- Conclusions

# **Mapping the Design Space for Adaptive User Interfaces: The Good, the Bad, and the Ugly**



Potential Benefit

Potential Disorientation

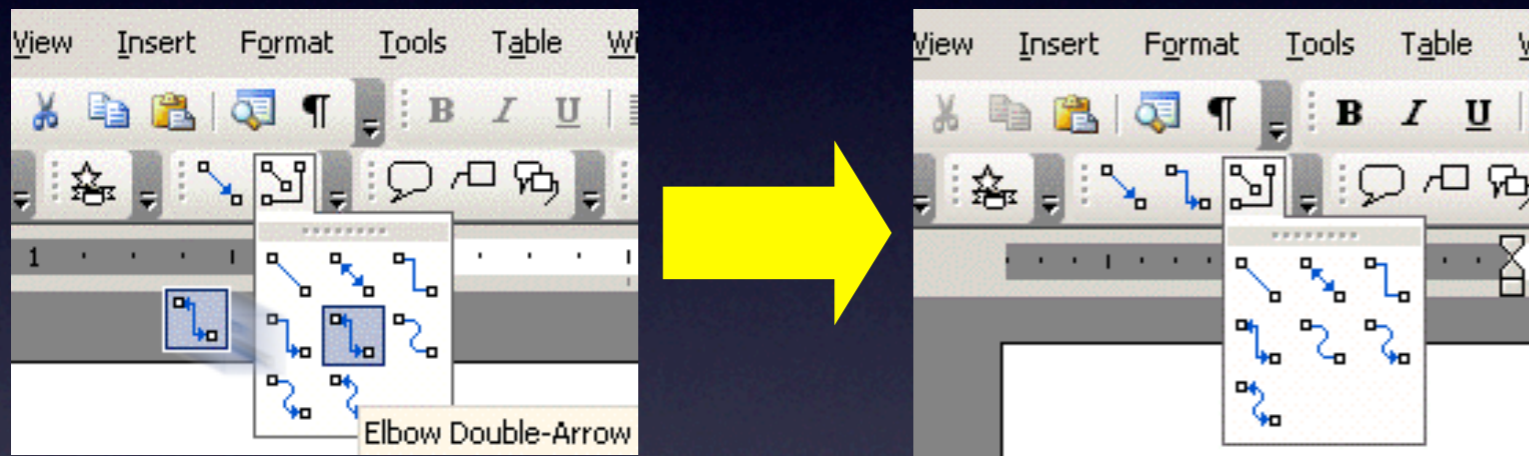
## The Split Interface



Medium

Low

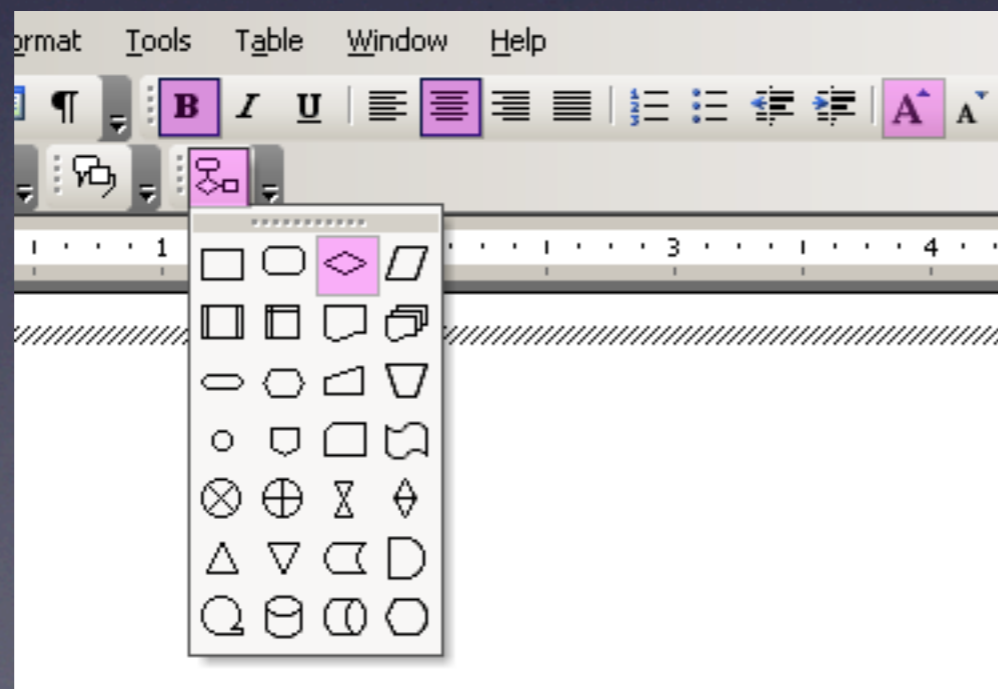
## The Moving Interface



High

Medium

## The Visual Popout Interface



Low

Low



# Experiment 1

**Goal:** collect informative **subjective** data



# Participants

- 26 volunteers (10 female)
- aged 25 to 55 (mean=46)
- moderate to high experience using computers (as indicated by a validated screener)
- intermediate to expert users of MS Office (as indicated by a validated screener)
- participants received software gratuity

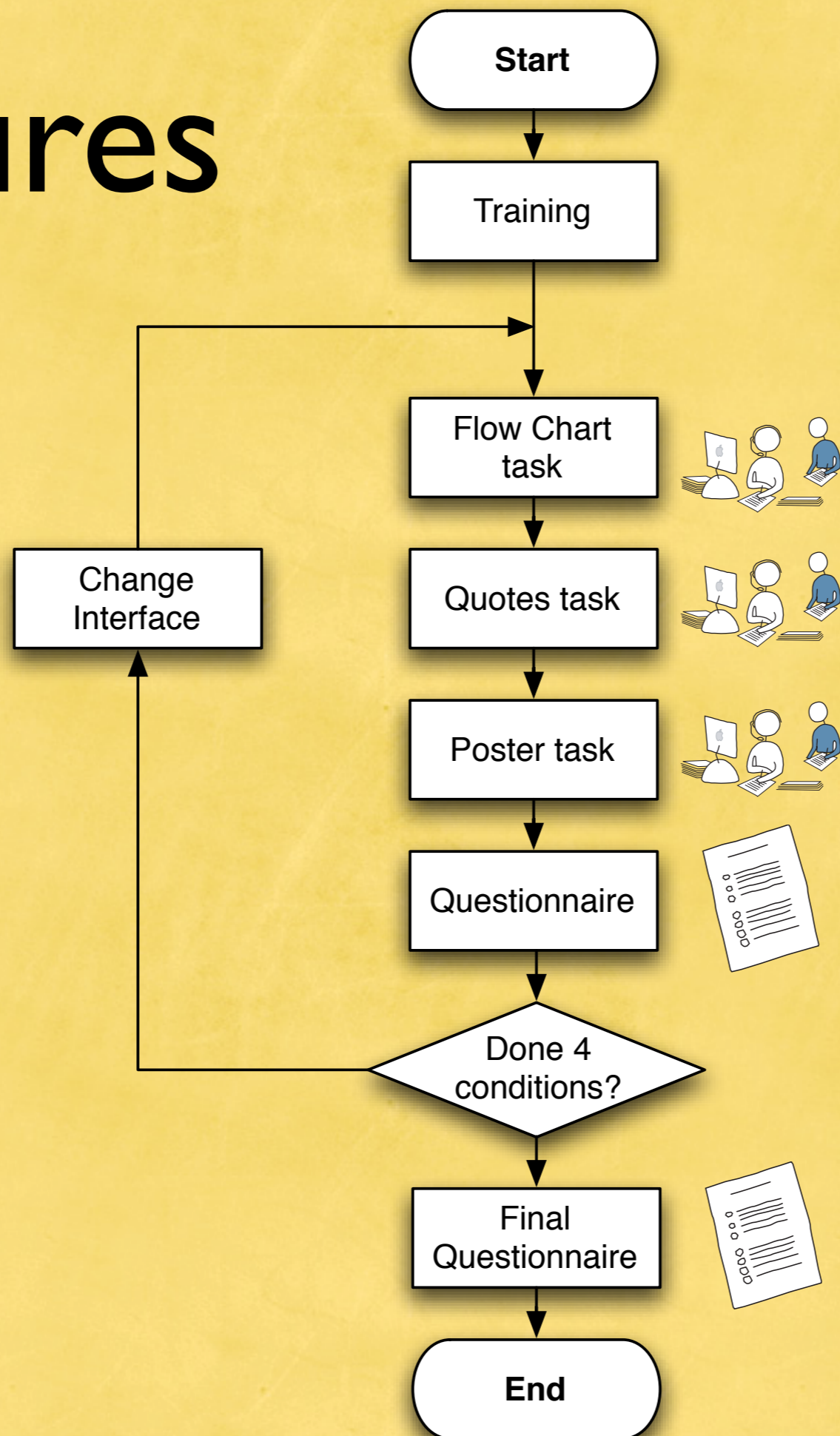


# Tasks

- Three classes of editing tasks:
  - Flow chart edits
  - Text edits
  - Combined text and graphical edits



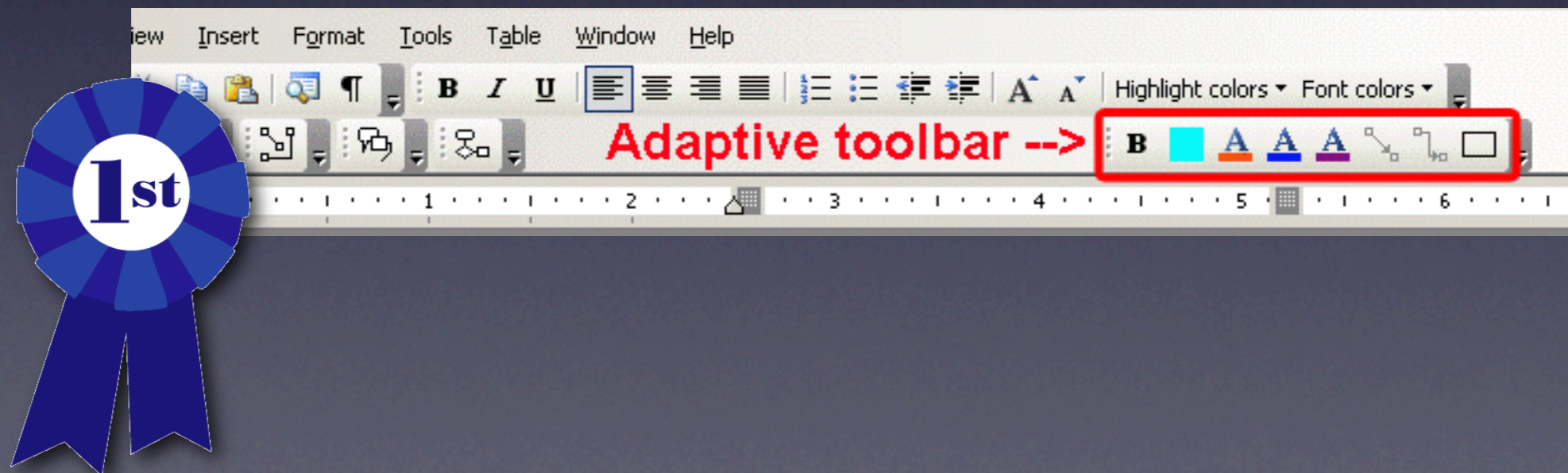
# Procedures





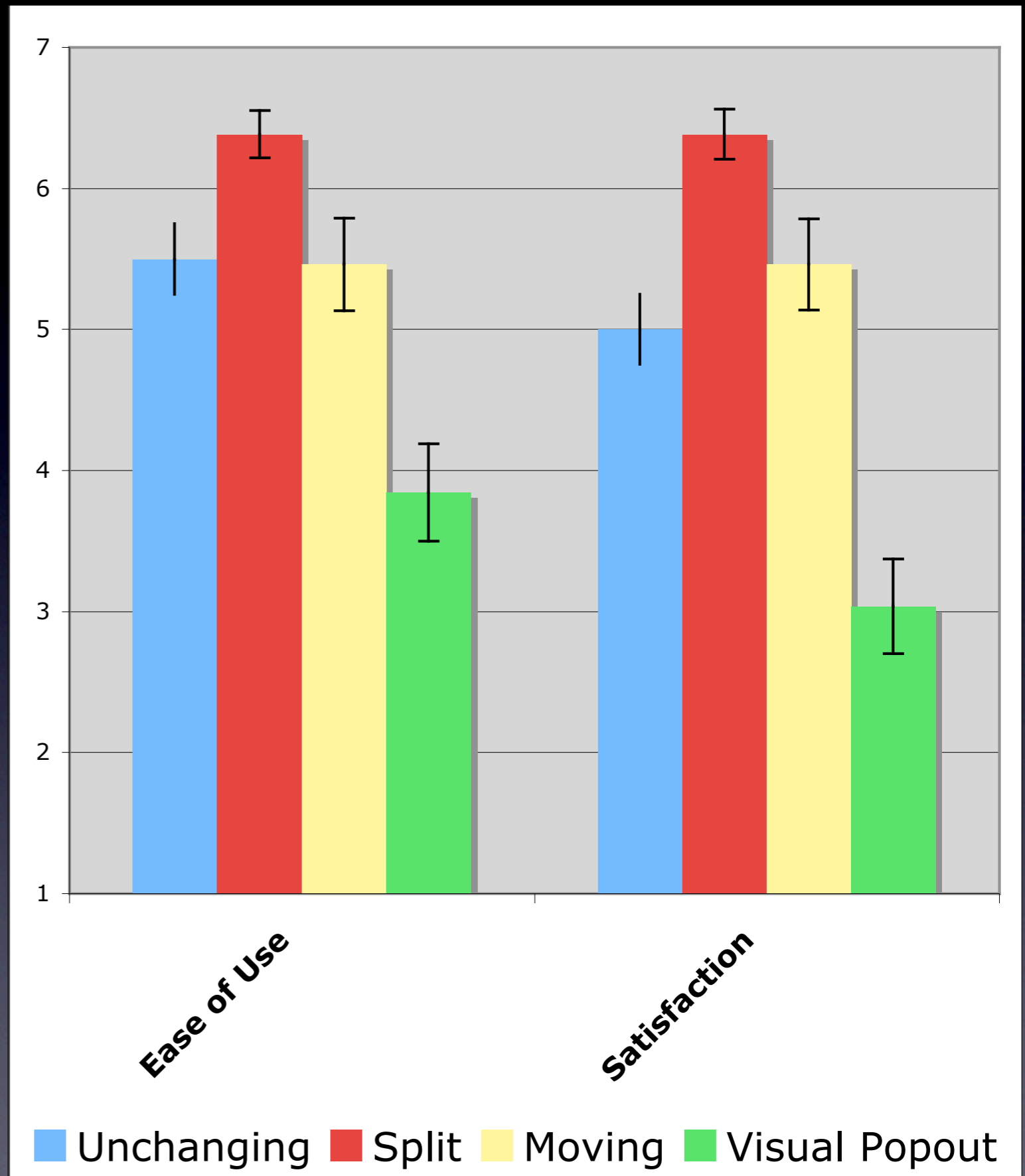
# Results: Ranking

Users ranked the **Split Interface** the highest ( $p < 0.001$ )



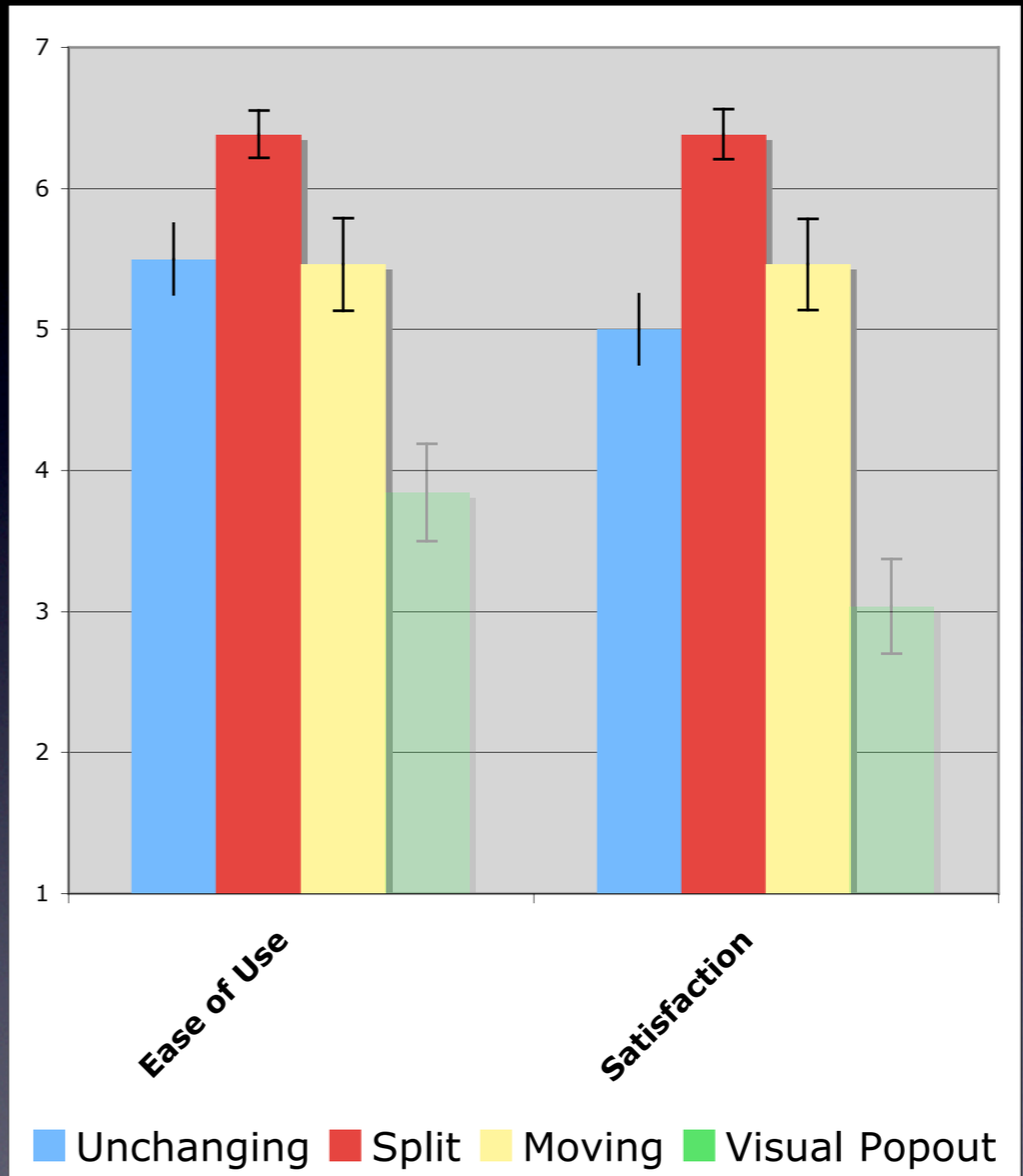


# General Satisfaction



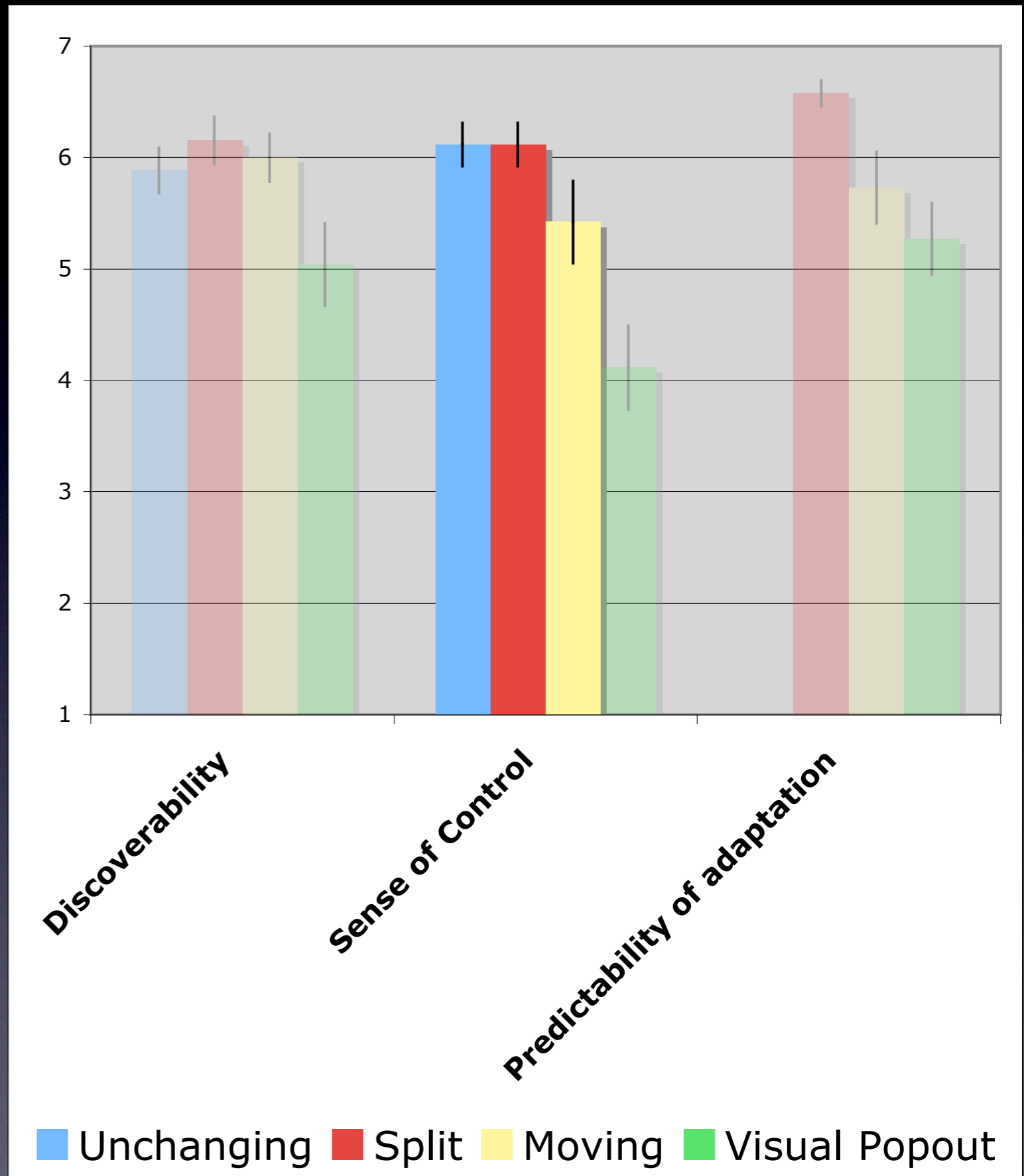


# General Satisfaction





# Usability





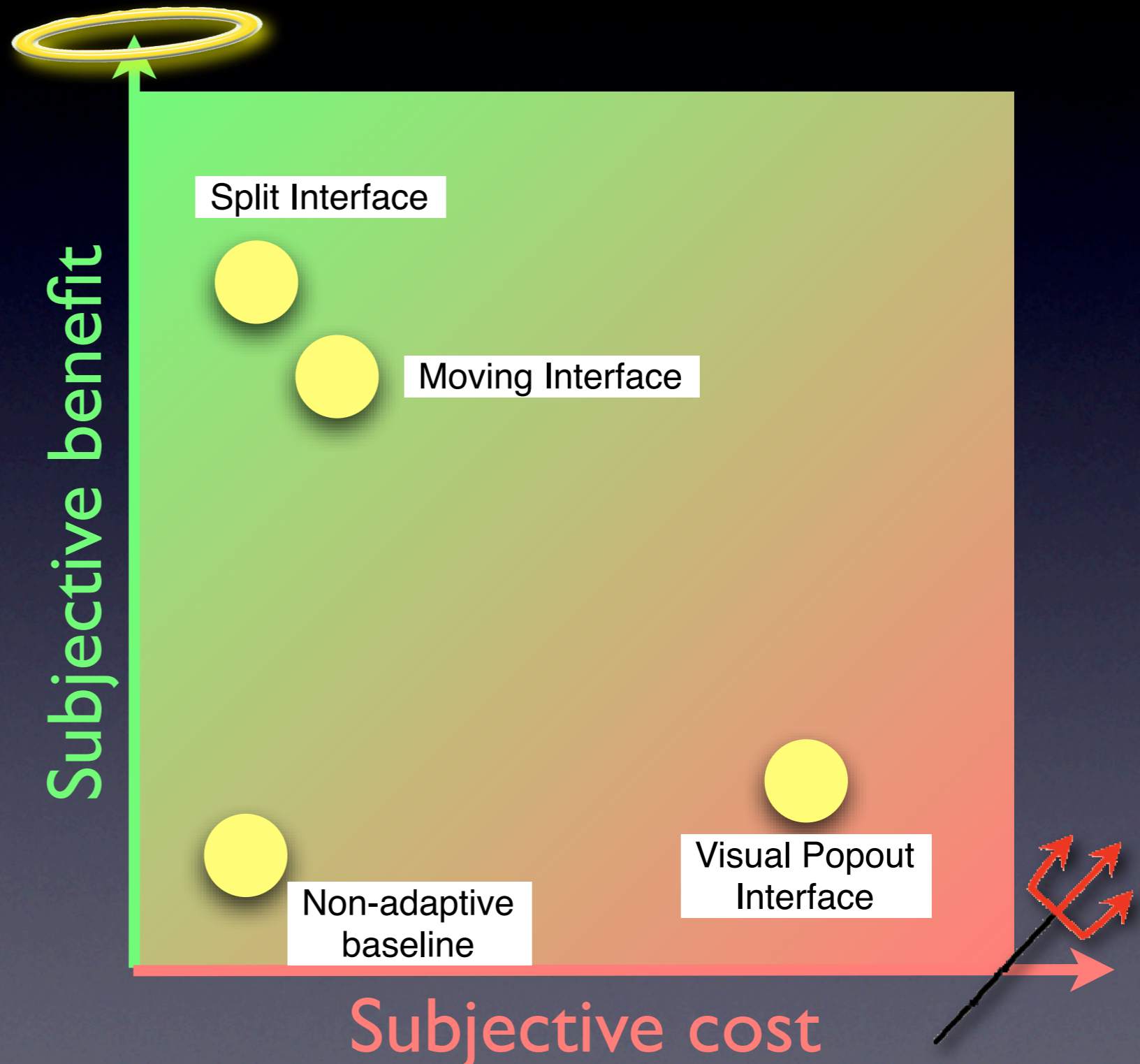
# Subjective Cost and Benefit

- **Subjective cost**  
based on:
  - Mental demand
  - Physical Demand
  - Frustration
  - Confusion due to adaptation
- **Subjective benefit**  
based on:
  - Performance
  - Efficiency due to adaptation



# Subjective Cost and Benefit

- **Subjective cost** based on:
  - Mental demand
  - Physical Demand
  - Frustration
  - Confusion due to adaptation
- **Subjective benefit** based on:
  - Performance
  - Efficiency due to adaptation





# User Comments

Split Interface

Moving Interface

Visual Popout  
Interface

- stability
- semantic  
grouping

- discoverability

- poor  
discoverability

- instability

- anti-saliience



# Road Map

- ✓ Introduce and motivate the problem
- ✓ Video
- ✓ Experiment 1: qualitative results
- Experiment 2: quantitative results**
- Synthesis
- Conclusions



# Experiment 2

## Goals:

Collect accurate **performance** data

Investigate how the **accuracy** of the adaptive algorithm affects how adaptation is used



# Participants

- 8 research colleagues (2 female)
- aged 25 to 58 (mean=36)
- high experience using computers
- expert users of MS Office
- participants received two meal vouchers as gratuity



# Tasks

The image shows a screenshot of the Microsoft Word interface. The window title is "Please find and click this button - Microsoft Word". The menu bar includes File, Edit, View, Insert, Format, Tools, Table, Window, and Help. The ribbon shows the Insert tab, with the Shapes gallery expanded to show various shapes like stars, banners, and callouts. A red box highlights this gallery. In the main document area, there are two text boxes with arrows pointing to buttons. The first box contains the text "Please find and click this button" and points to a button labeled "De" with a green square icon. The second box contains the text "And then click here" and points to a button labeled "Experim" with a yellow smiley face icon and the text "Next Button".

Please find and click this button →

And then click here →

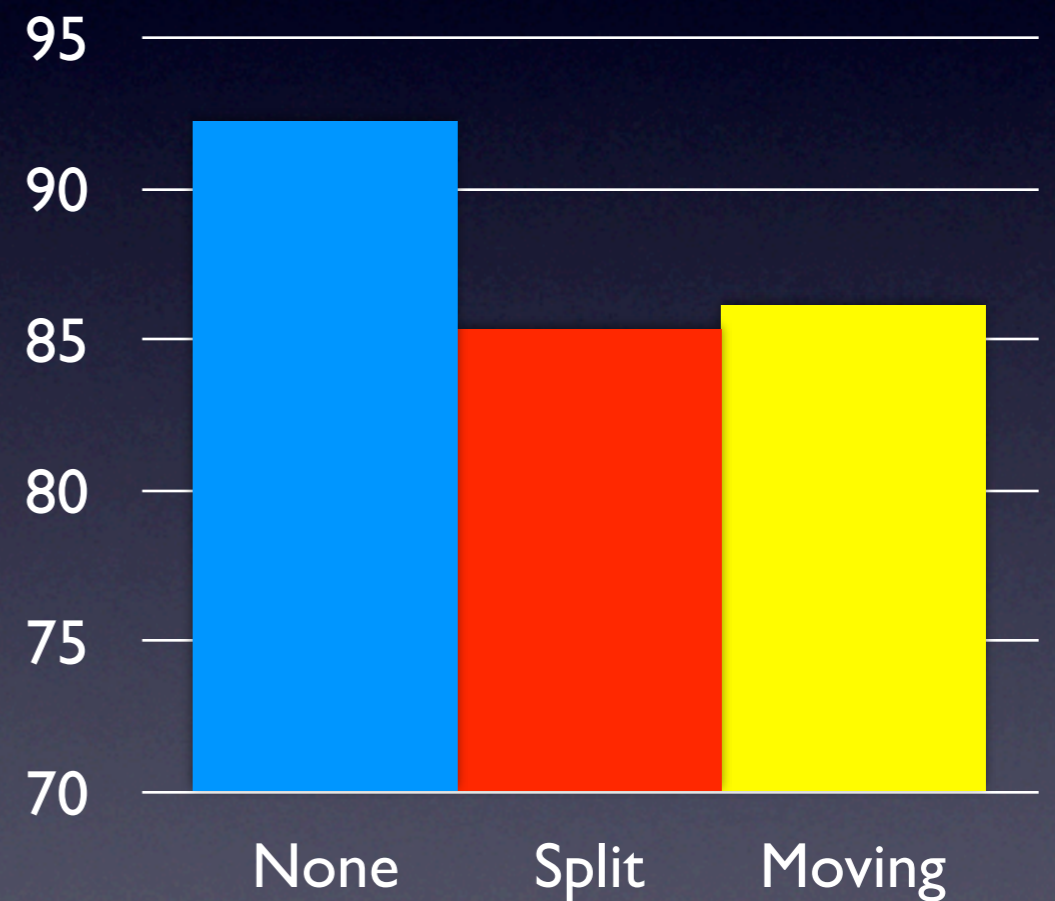
# Procedures

- Introduction and a brief training on a non-adaptive version of the interface
- Each participant used each of the three interfaces (Unchanging, Split and Moving) at two different accuracy levels (30% and 70%)



# Performance Vs. Adaptation Type

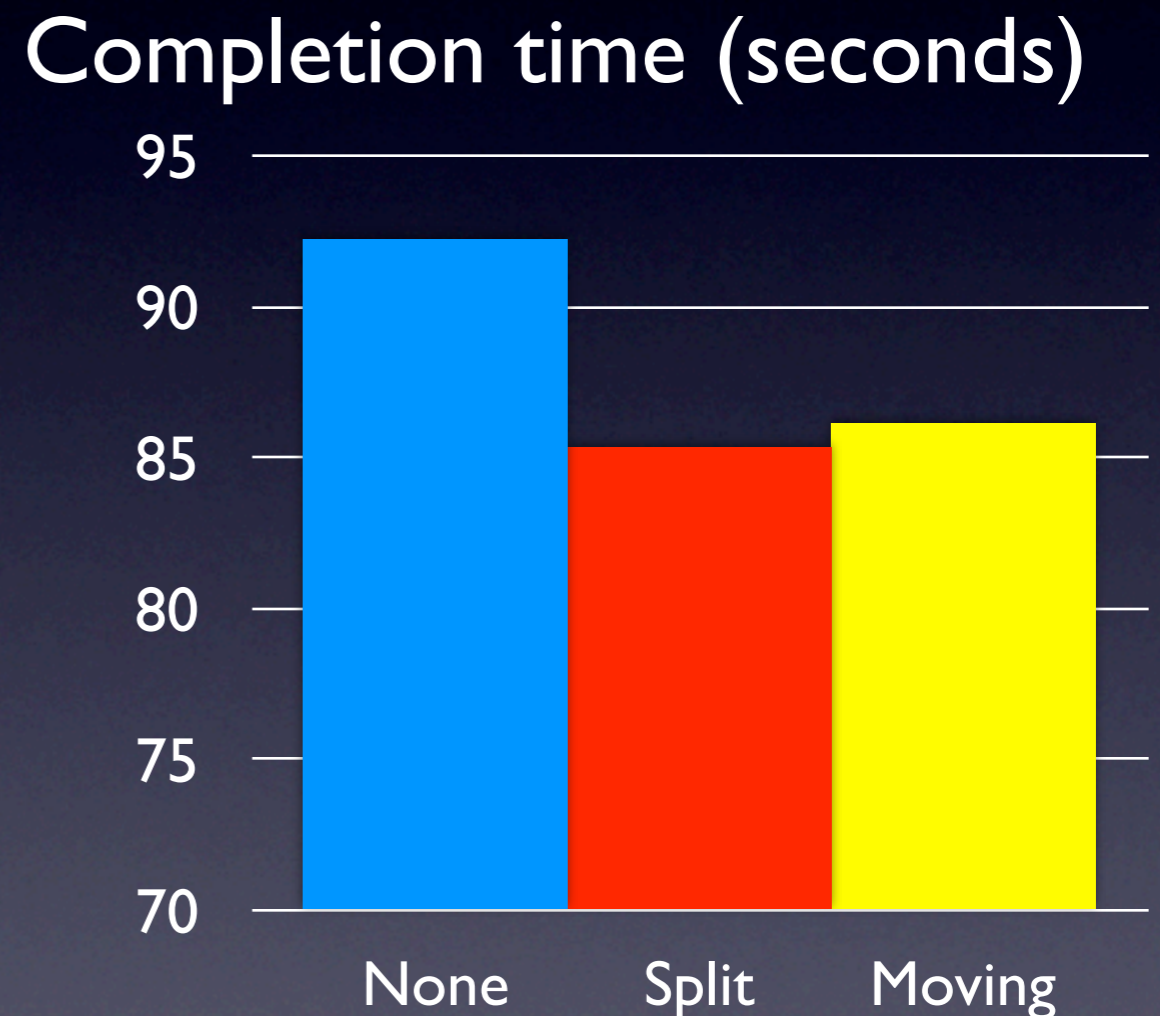
Completion time (seconds)





# Performance Vs. Adaptation Type

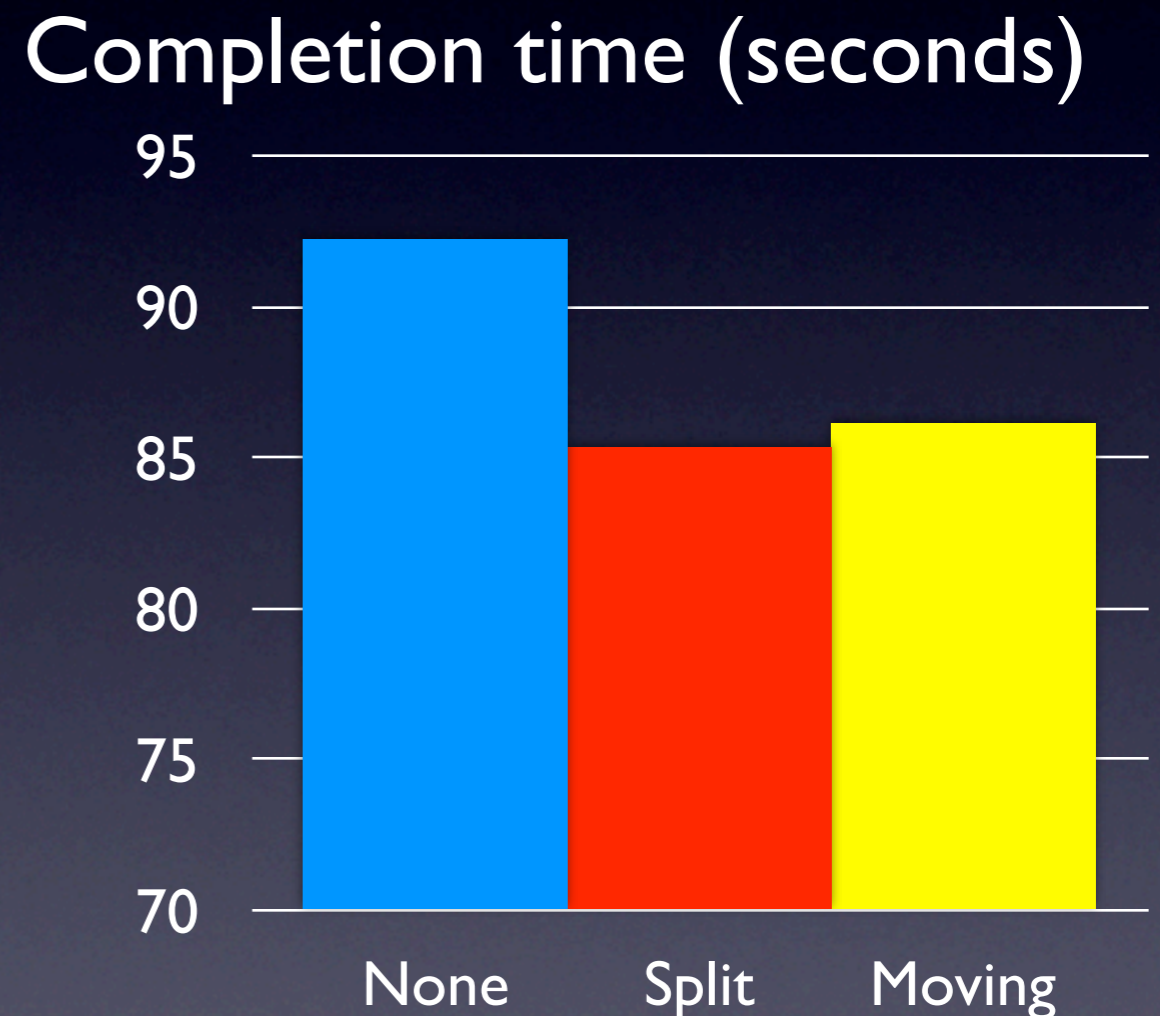
- Participants were significantly **faster** using Split Interface than Non-adaptive baseline ( $p < 0.003$ )





# Performance Vs. Adaptation Type

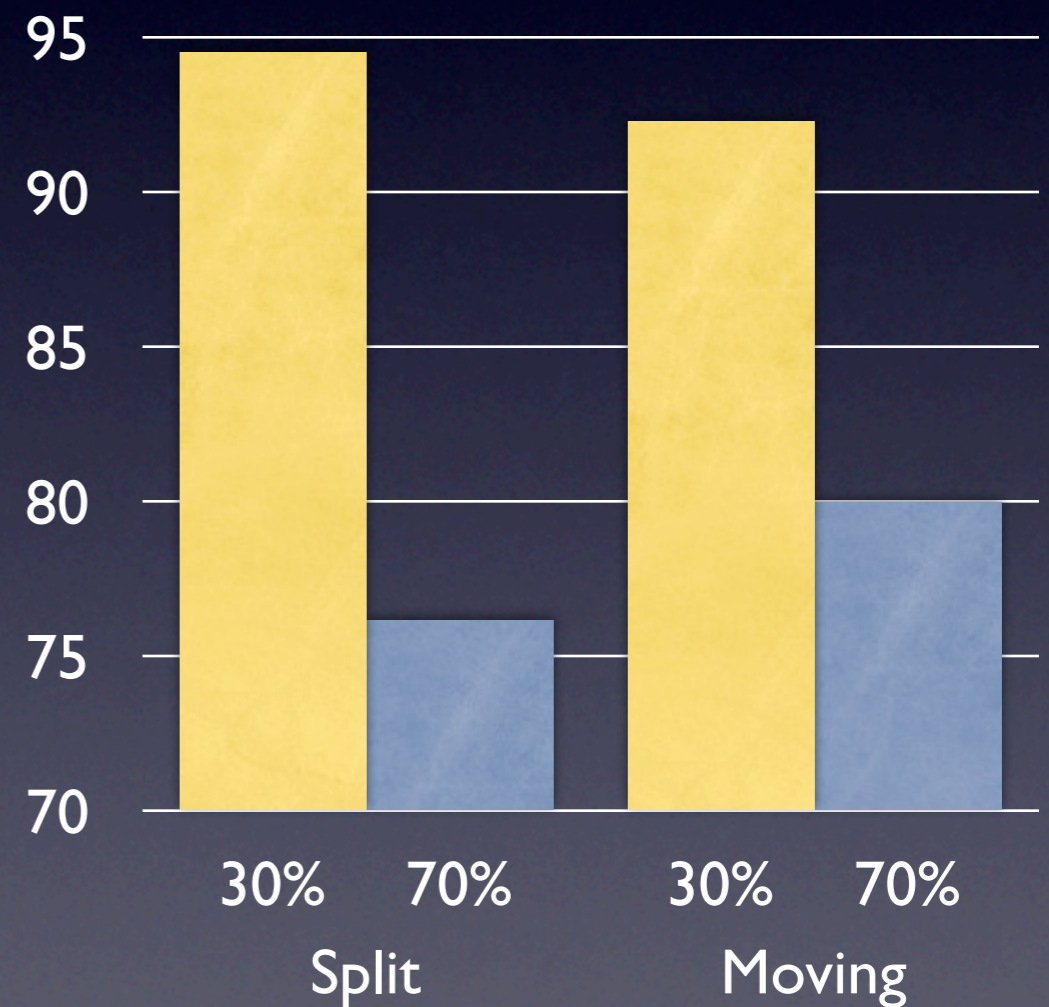
- Participants were significantly **faster** using Split Interface than Non-adaptive baseline ( $p < 0.003$ )
- Participants were **marginally faster** using Moving Interface than Non-adaptive baseline ( $p < 0.073$ )





# Performance Vs. Accuracy

- Both adaptive interfaces resulted in faster performance at the higher (70%) accuracy level than at the lower (30%) level ( $p < 0.001$ )





# Frequency of Use Vs. Accuracy

Please find and click this button →

And then click here →

7%

19%

93%

81%

70% accuracy

30% accuracy

Button	Frequency of Use	Accuracy
Square Button	7%	70%
Next Button (Smiley Face)	93%	30%

# User Comments

Split Interface

Moving Interface

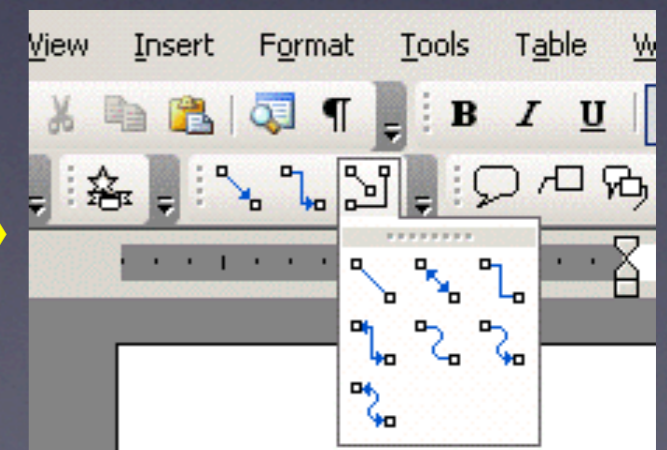
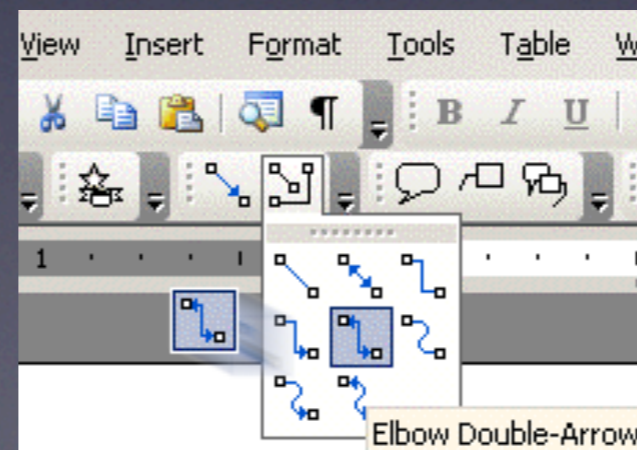
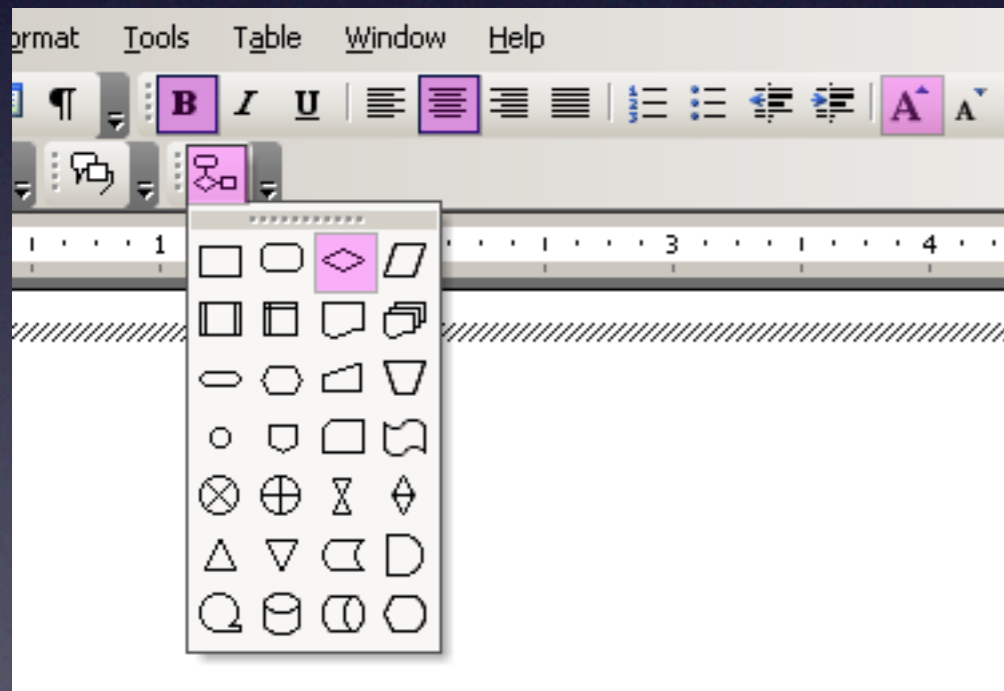
- poor discoverability

- discoverability

- instability

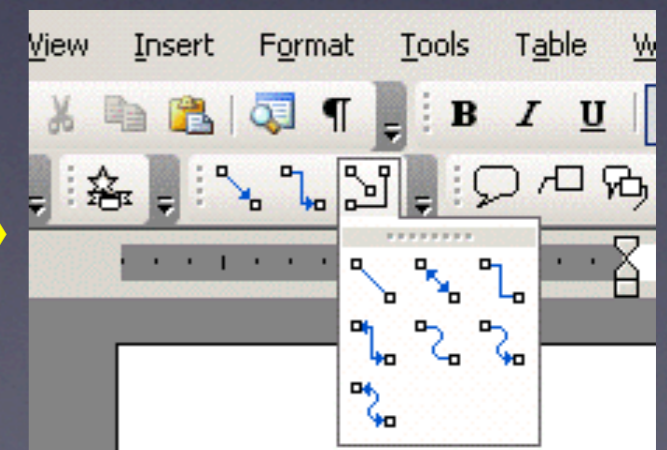
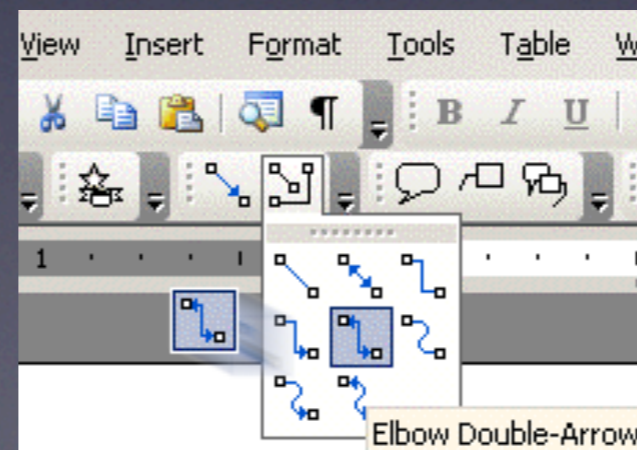
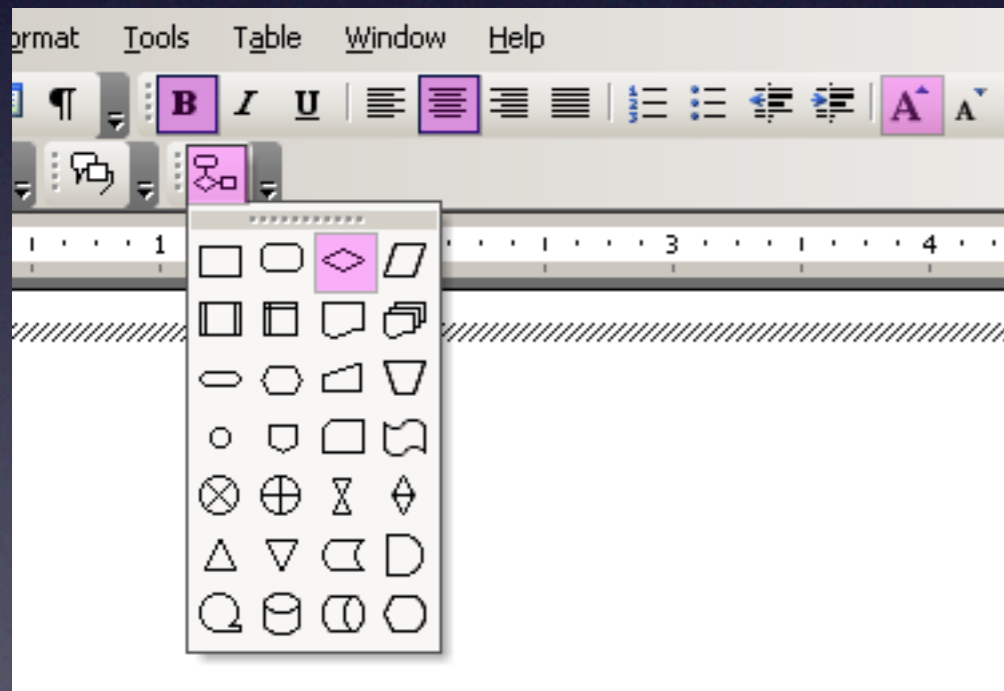


# Exploring the Design Space for Adaptive Graphical User Interfaces





# Exploring the Design Space for Adaptive Graphical User Interfaces





# Putting It All Together

## Interaction Mechanics

stability

locality

## Algorithm Behavior

frequency of adaptation

accuracy

predictability

## Context

interaction frequency

task complexity

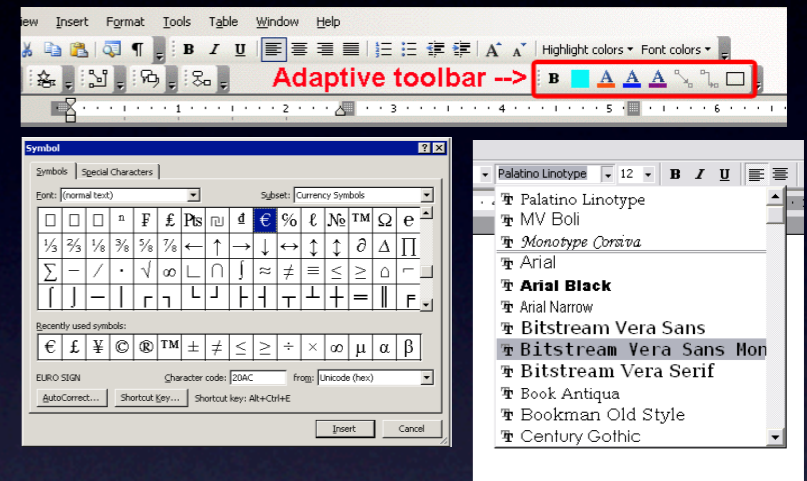


# Stability

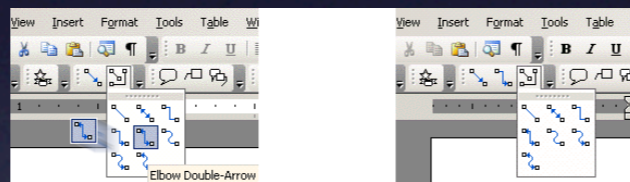
Interaction Mechanics	Algorithm Behavior	Context
stability	frequency of adaptation	interaction frequency
locality	accuracy	task complexity
	predictability	

User satisfaction

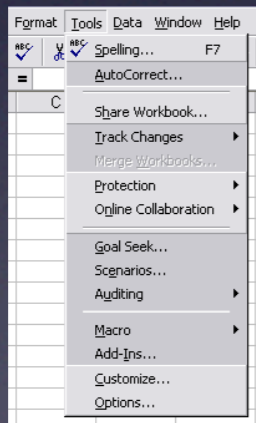
## Split Interfaces



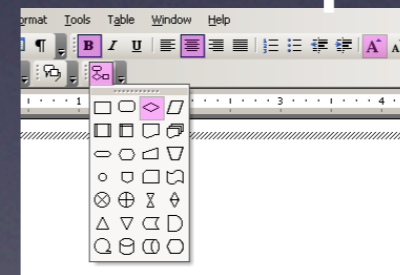
## Moving Interface



## MS Smart Menus



## Visual Popout



Low stability

High stability



# Locality

Interaction Mechanics	Algorithm Behavior	Context
stability	frequency of adaptation	interaction frequency
locality	accuracy	task complexity
	predictability	

- User comments indicate that, especially for manual tasks, high locality improves discoverability of adaptation.



# Adaptation Frequency

Interaction Mechanics
stability
locality

Algorithm Behavior
frequency of adaptation
accuracy
predictability

Context
interaction frequency
task complexity

Two studies of Split Menus:

- ↑ Sears and Shneiderman [1994]  
adaptation once per user/session
- ↓ Findlater and McGrenere [2004]  
adaptation once per interaction



# Accuracy

Interaction Mechanics
stability
locality

Algorithm Behavior
frequency of adaptation
accuracy
predictability

Context
interaction frequency
task complexity

- Participants performed faster at higher accuracy levels  
(also in [Tsandilas and schraefel CHI'05])
- Participants were more likely to take advantage of adaptation at higher accuracy levels



# Predictability

Interaction Mechanics
stability
locality

Algorithm Behavior
frequency of adaptation
accuracy
<b>predictability</b>

Context
interaction frequency
task complexity

A study in progress!



# Interaction Frequency

Interaction Mechanics
stability
locality

Algorithm Behavior
frequency of adaptation
accuracy
predictability

Context
interaction frequency
task complexity

Two studies of adaptive deep hierarchical menus:

↑ Greenberg and Witten [1985]  
30 interactions per trial

↕ Trevellyan and Browne [1987]  
100 interactions per trial:  
-- first 30 positive  
-- last 30 neutral or negative



# Task Complexity

Interaction Mechanics
stability
locality

Algorithm Behavior
frequency of adaptation
accuracy
predictability

Context
interaction frequency
task complexity

## Experiment 1

Split Interface	Moving Interface
<ul style="list-style-type: none"><li>- stability</li><li>- semantic grouping</li></ul>	<ul style="list-style-type: none"><li>- discoverability</li></ul>
<ul style="list-style-type: none"><li>- poor discoverability</li></ul>	<ul style="list-style-type: none"><li>- instability</li></ul>

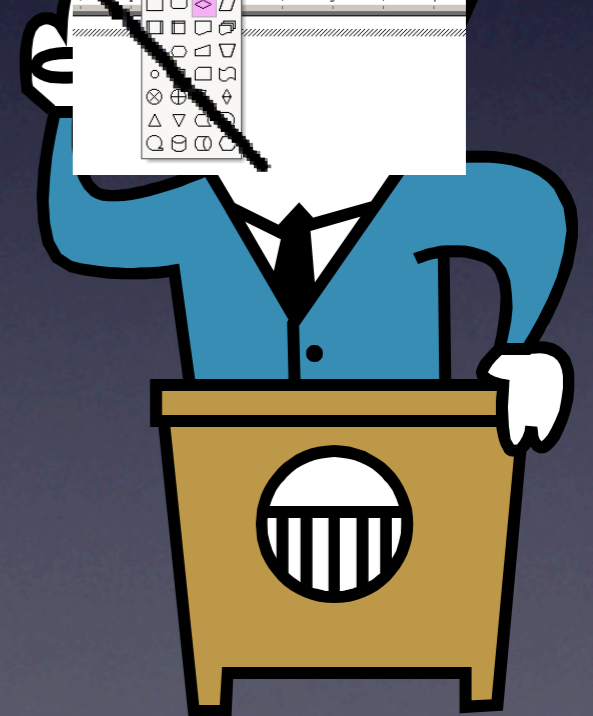
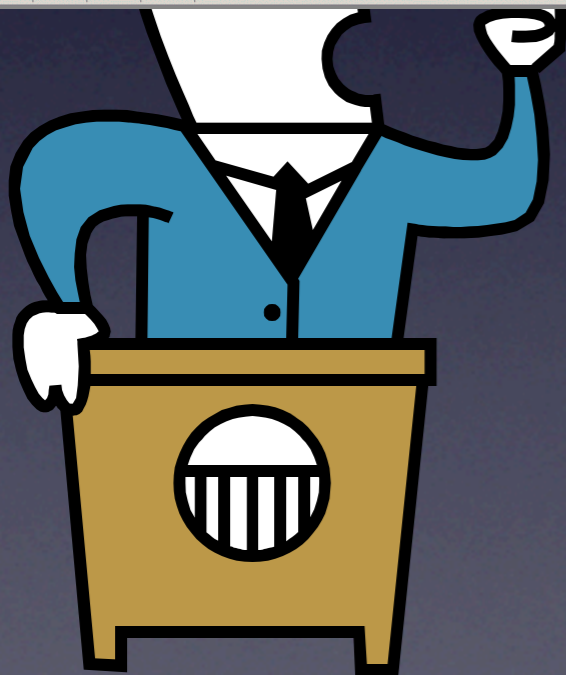
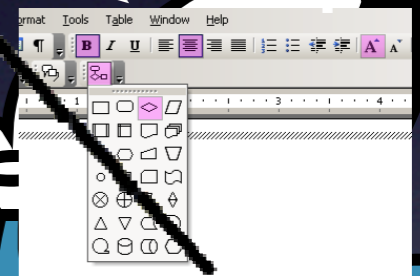
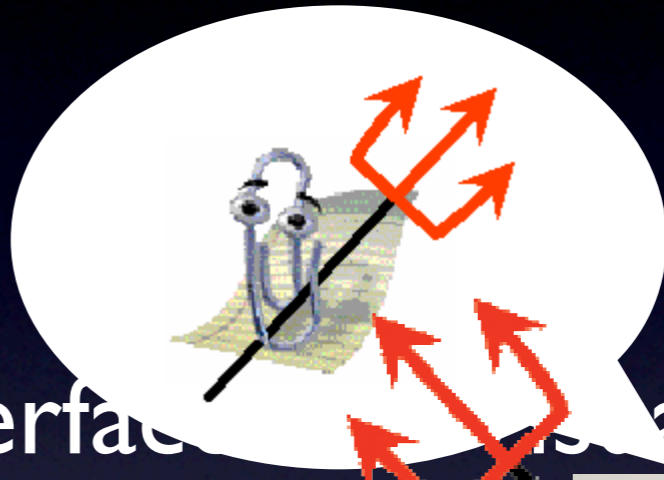
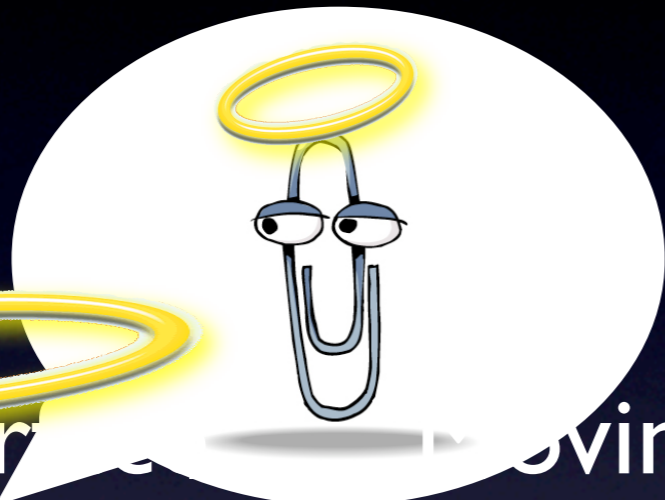
## Experiment 2

Split Interface	Moving Interface
	<ul style="list-style-type: none"><li>- discoverability</li></ul>
<ul style="list-style-type: none"><li>- poor discoverability</li></ul>	<ul style="list-style-type: none"><li>- instability</li></ul>



# Conclusions

Split interface      Moving Interface      Visual Popout






# Conclusions

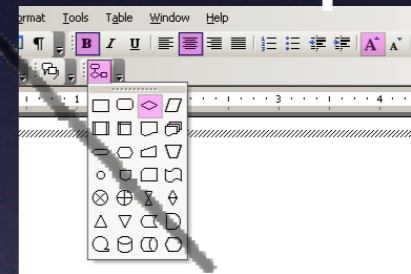
  
Split Interface



Moving Interface



  
Visual Popout



← Preferred

[Experiment I]

Disliked →



# Conclusions

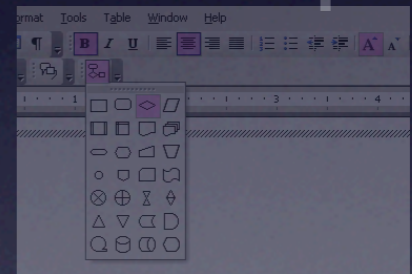
  
Split Interface



Moving Interface



Visual Popout



← Preferred

Faster

[Experiment 2]

→ Disliked



# Conclusions

## Interaction Mechanics

stability

locality

## Algorithm Behavior

frequency of adaptation

accuracy

predictability

## Context

interaction frequency

task complexity



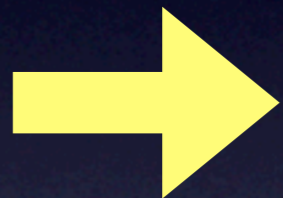
# Acknowledgments

- Andrea Bunt, Leah Findlater and Joanna McGrenere at UBC
- Members of the VIBE Group at MSR
- DUB group at University of Washington



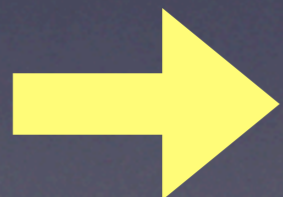
# Contact Information

- **Krzysztof Gajos:**  
[kgajos@cs.washington.edu](mailto:kgajos@cs.washington.edu)



- **Mary Czerwinski:**  
[marycz@microsoft.com](mailto:marycz@microsoft.com)

- **Desney Tan:**  
[desney@microsoft.com](mailto:desney@microsoft.com)



- **Daniel Weld:**  
[weld@cs.washington.edu](mailto:weld@cs.washington.edu)