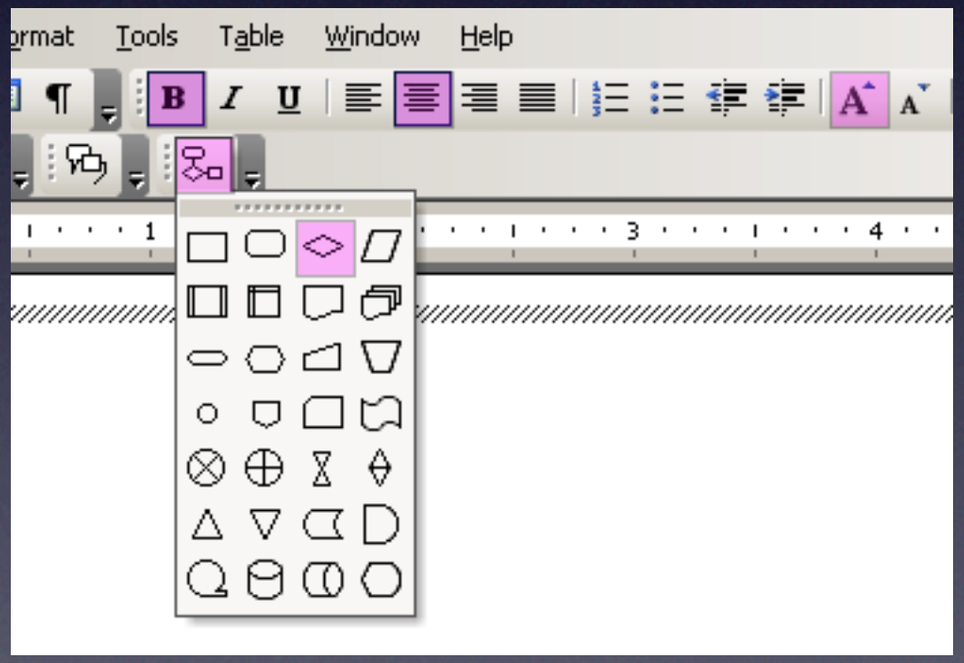
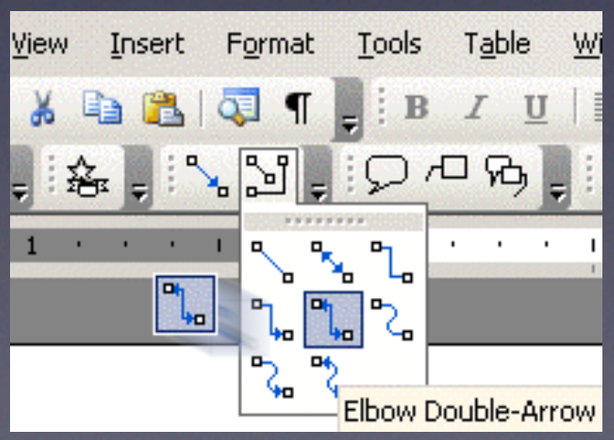
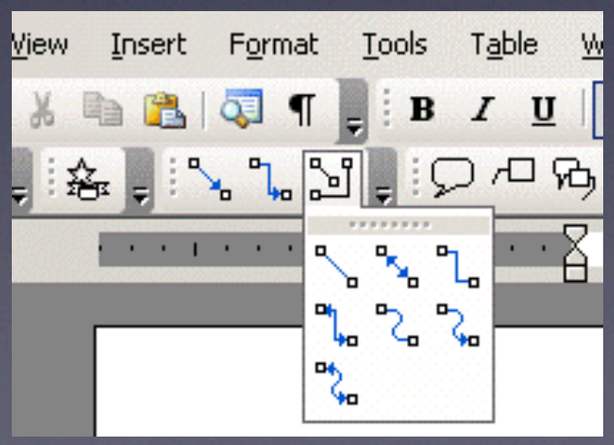
Exploring the Design Space for Adaptive Graphical User Interfaces



Krzysztof Gajos (University of Washington)
Mary Czerwinski (Microsoft Research)
Desney Tan (Microsoft Research)
Daniel S. Weld (University of Washington)





Scope

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

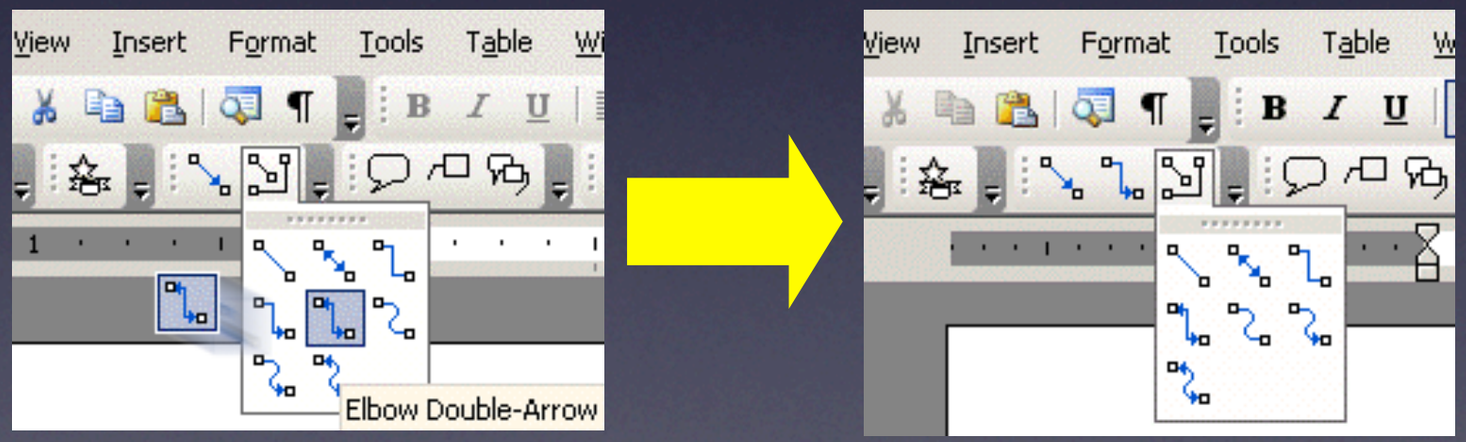
Scope

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

The Split Interface

Scope

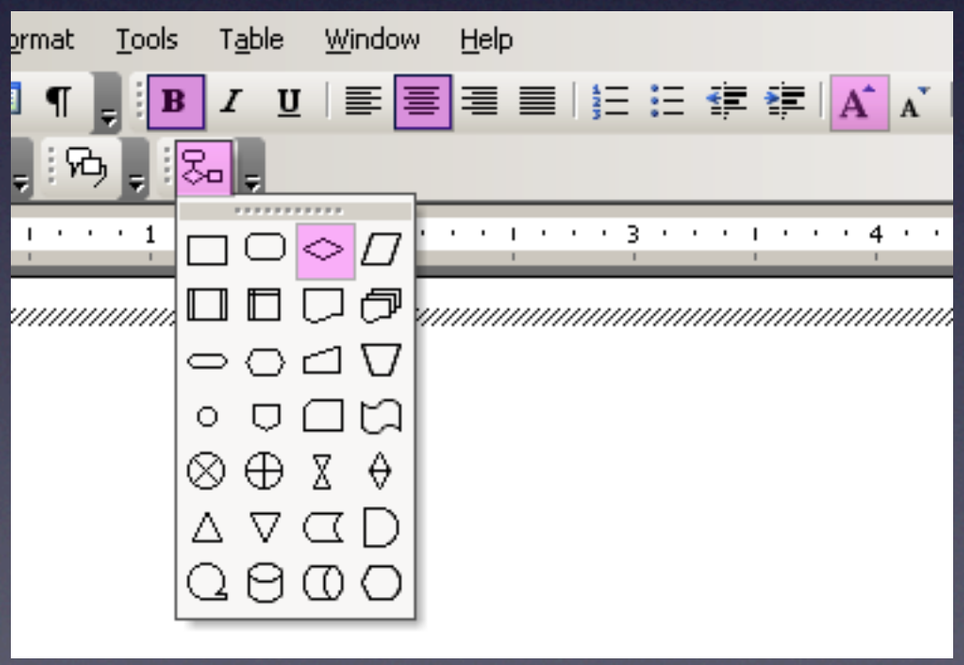
Graphical User Interfaces where the system automatically adapts the presentation of the functionality



The Moving Interface

Scope

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



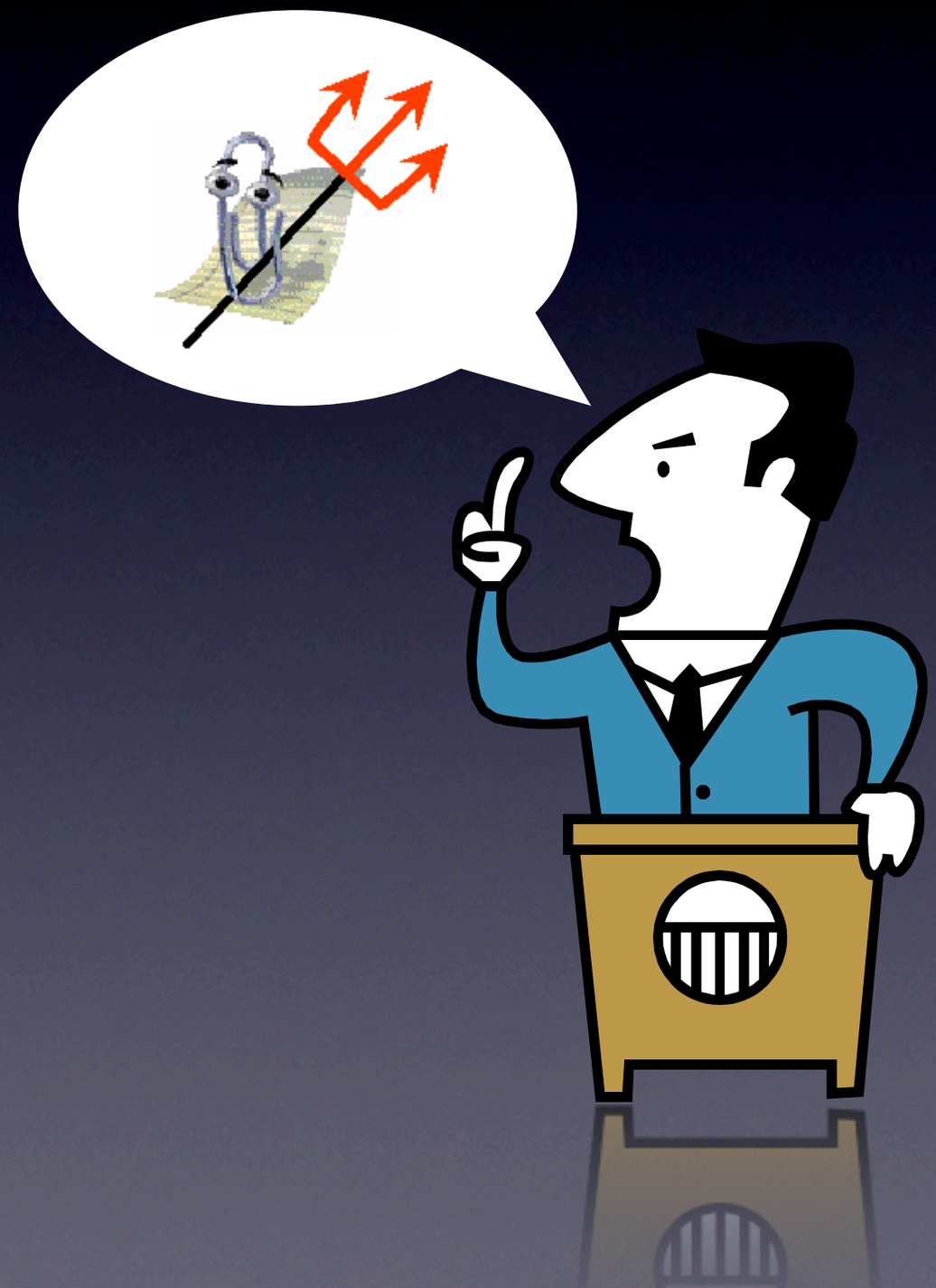
The Visual Popout Interface

Scope

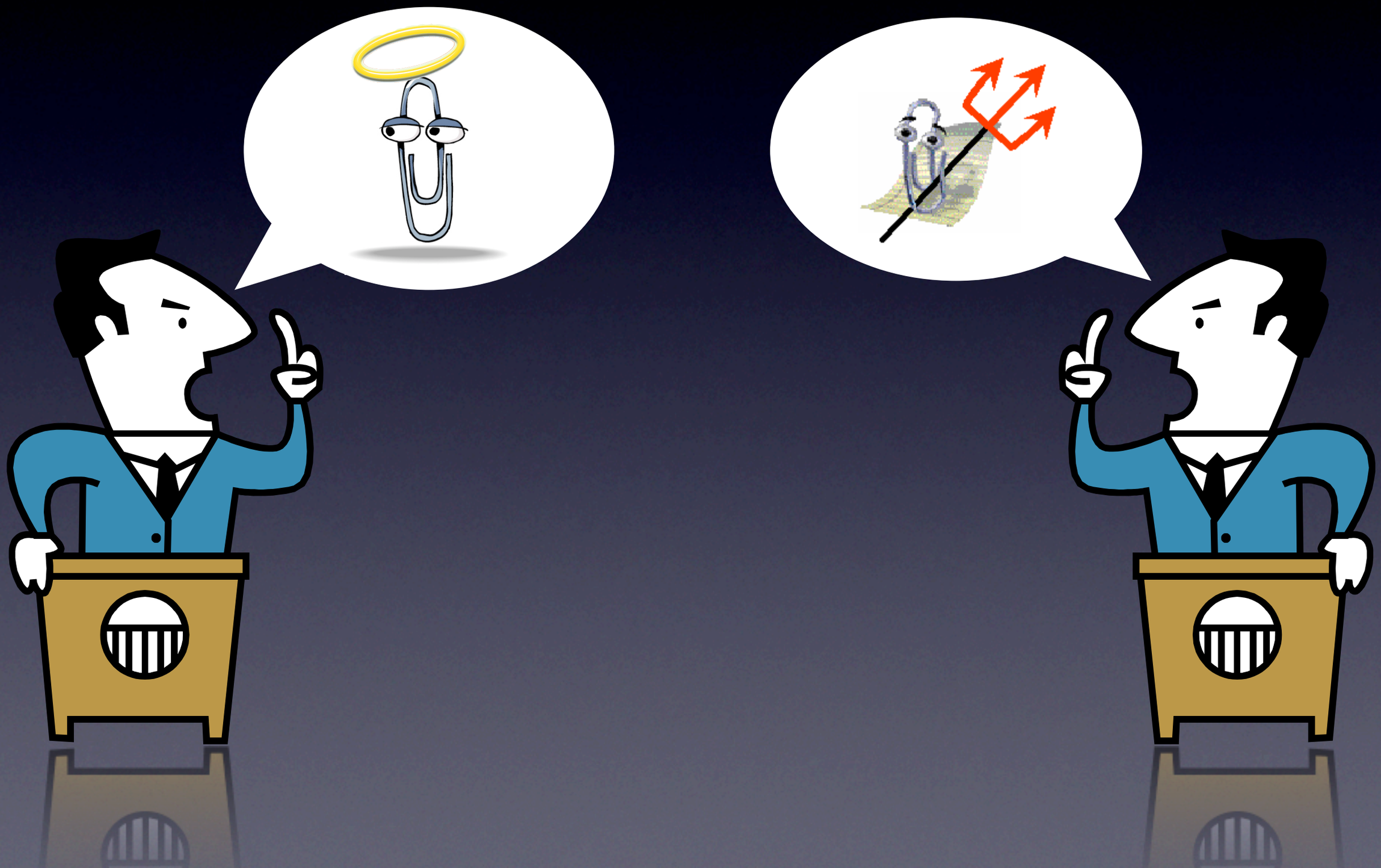
Graphical User Interfaces where the system automatically adapts the presentation of the functionality

Motivation

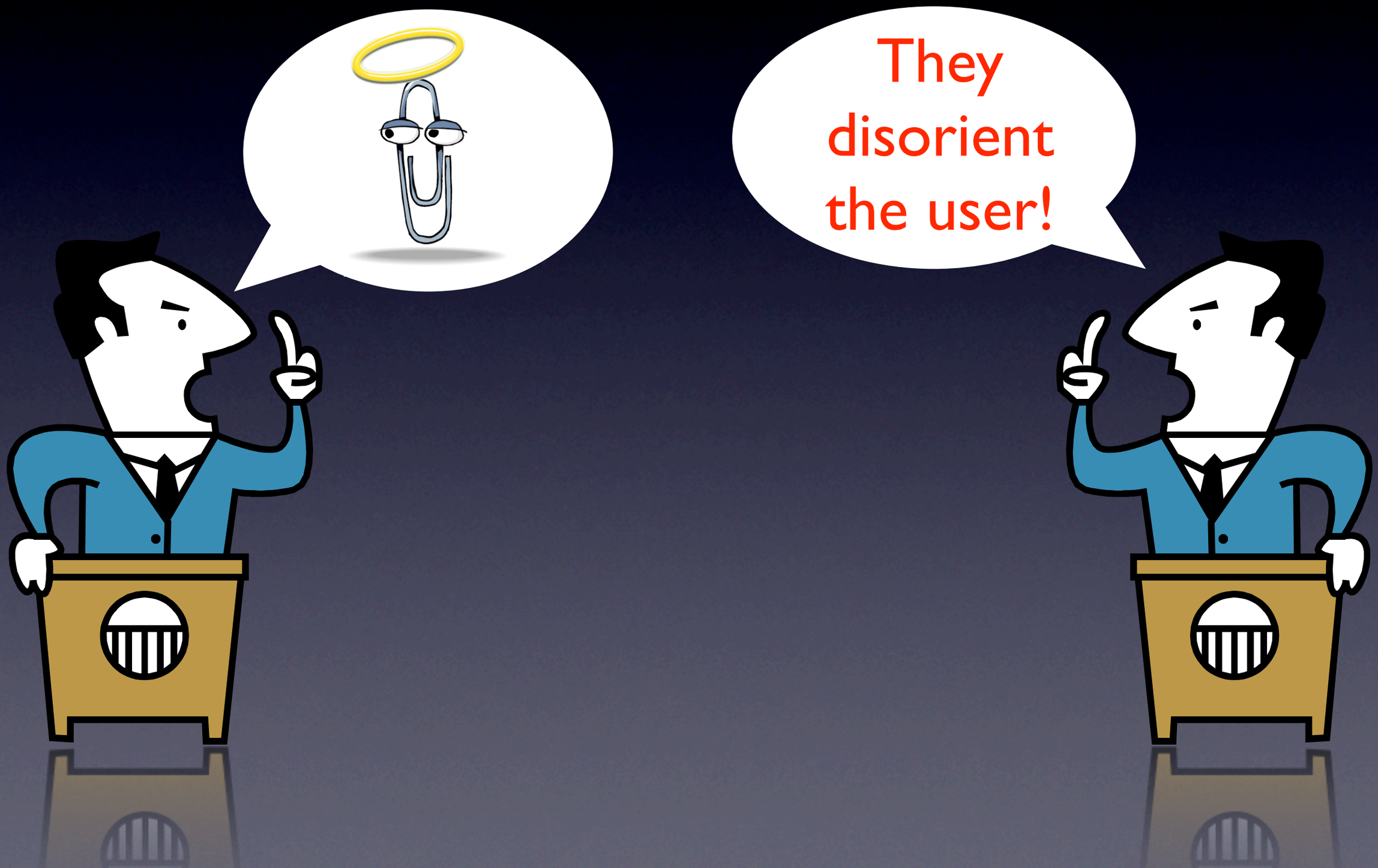
Motivation



Motivation



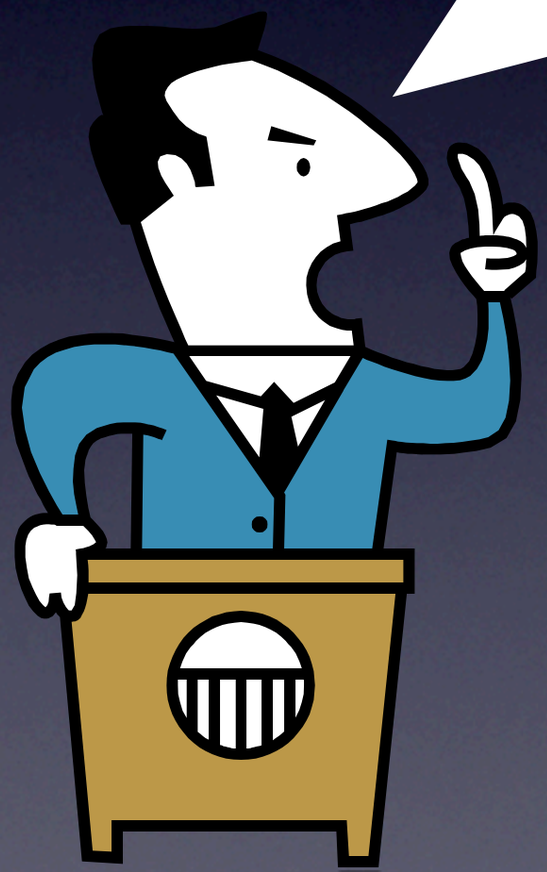
Motivation



Motivation

They optimize the UI for the individual!

They disorient the user!



Prior Work

Prior Work

↑ Greenberg and Witten [1985]

↕ Trevellyan and Browne [1987]

↓ Mitchell and Shneiderman [1989]

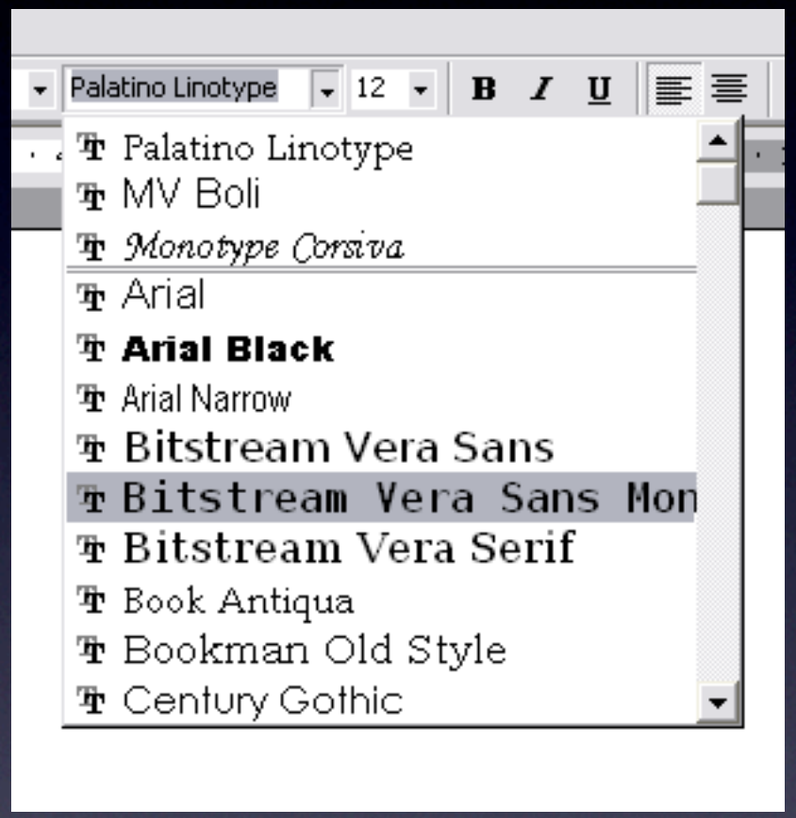
↑ Sears and Shneiderman [1994]

? McGrenere, Baecker and Booth [2002]

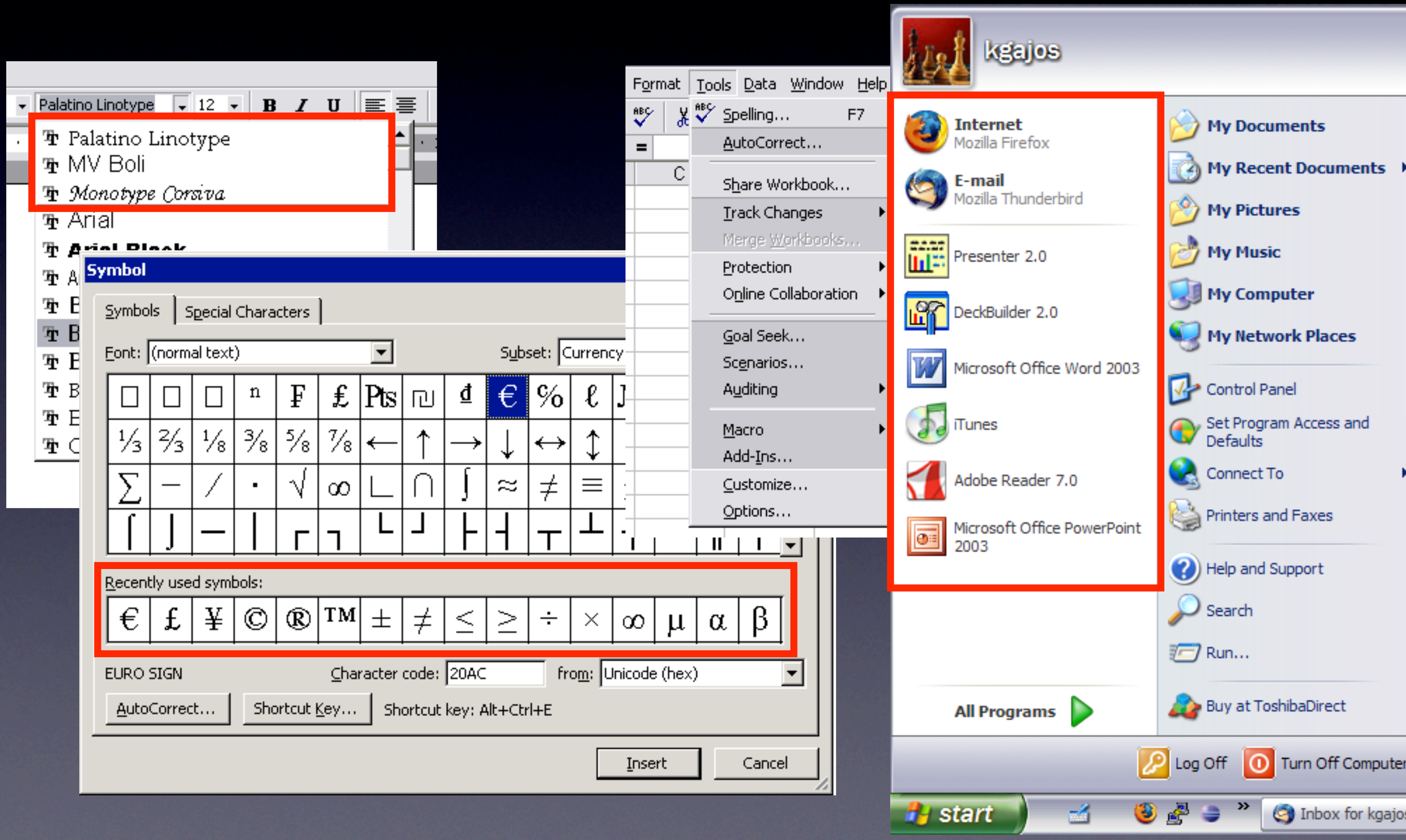
↓ Findlater and McGrenere [2004]

↔ Tsandilas and shraefel [2005]

Commercial Deployments



Commercial Deployments



Our Goal

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

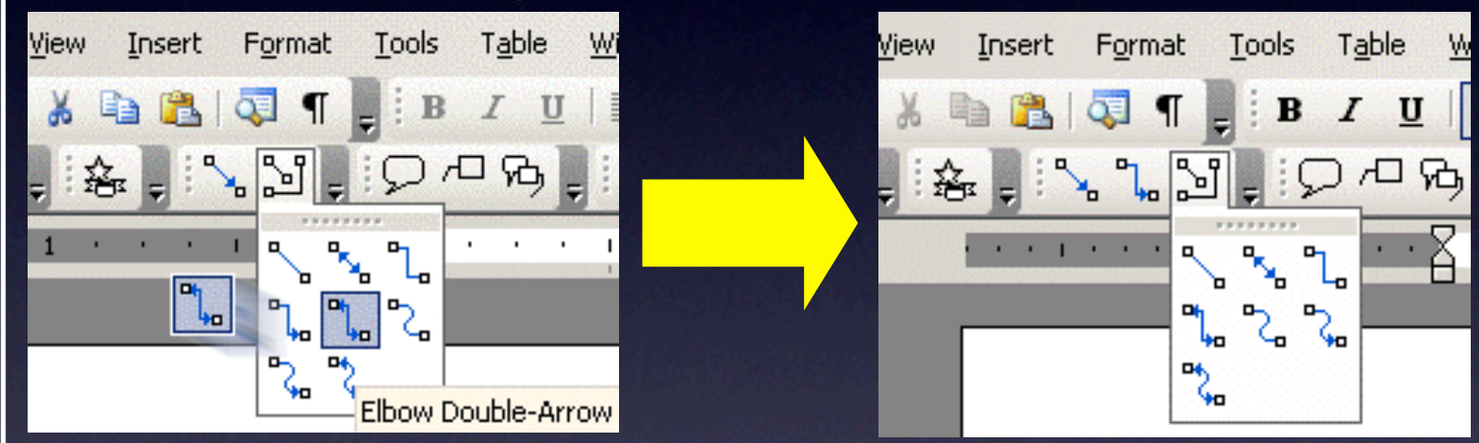
Road Map

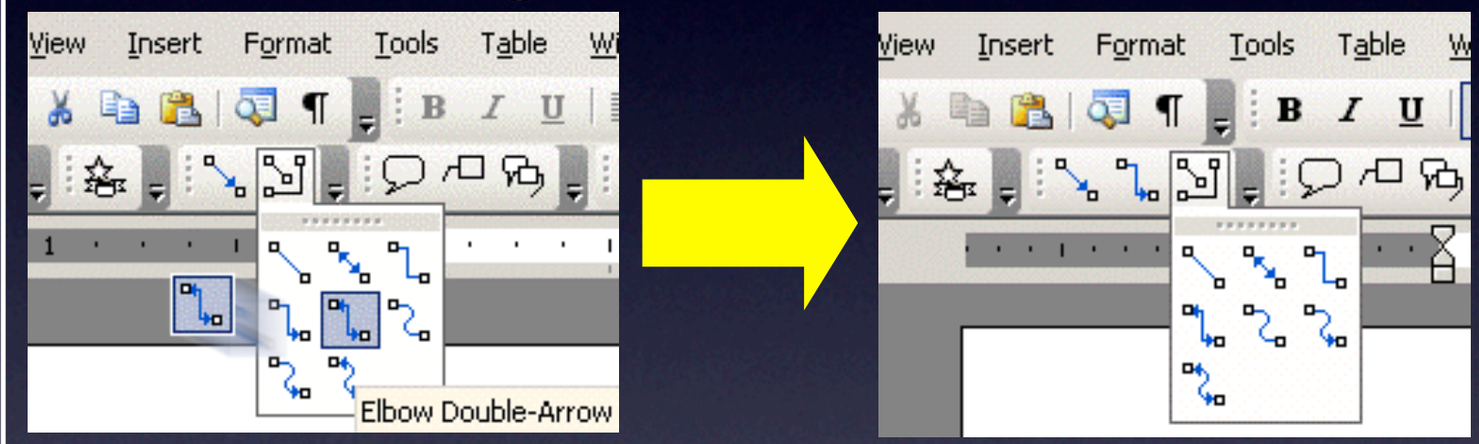
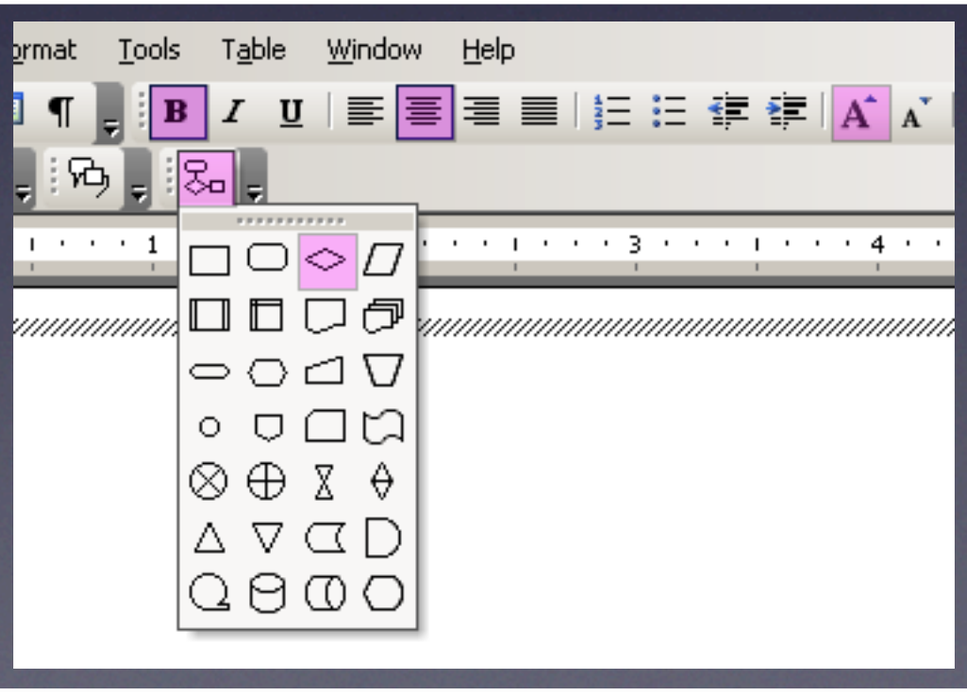
- ✓ Introduce and motivate the problem
- ☐ Video
- ☐ Experiment 1: qualitative results
- ☐ Experiment 2: quantitative results
- ☐ Synthesis
- ☐ Conclusions

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

	Potential Benefit	Potential Disorientation

	Potential Benefit	Potential Disorientation
The Split Interface 	Medium	Low

	Potential Benefit	Potential Disorientation
The Split Interface 	Medium	Low
The Moving Interface 	High	Medium

	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

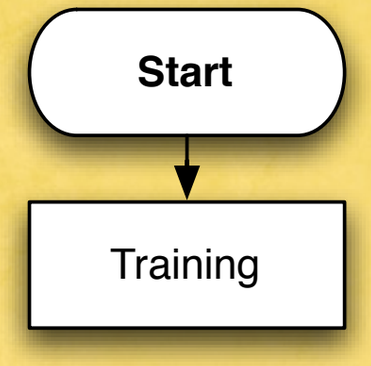
- 26 volunteers (10 female)
- aged 25 to 55 (mean=46)
- moderate to high experience using computers (as indicated by a validated screener)
- intermediate to expert users of MS Office (as indicated by a validated screener)
- participants received software gratuity

Tasks

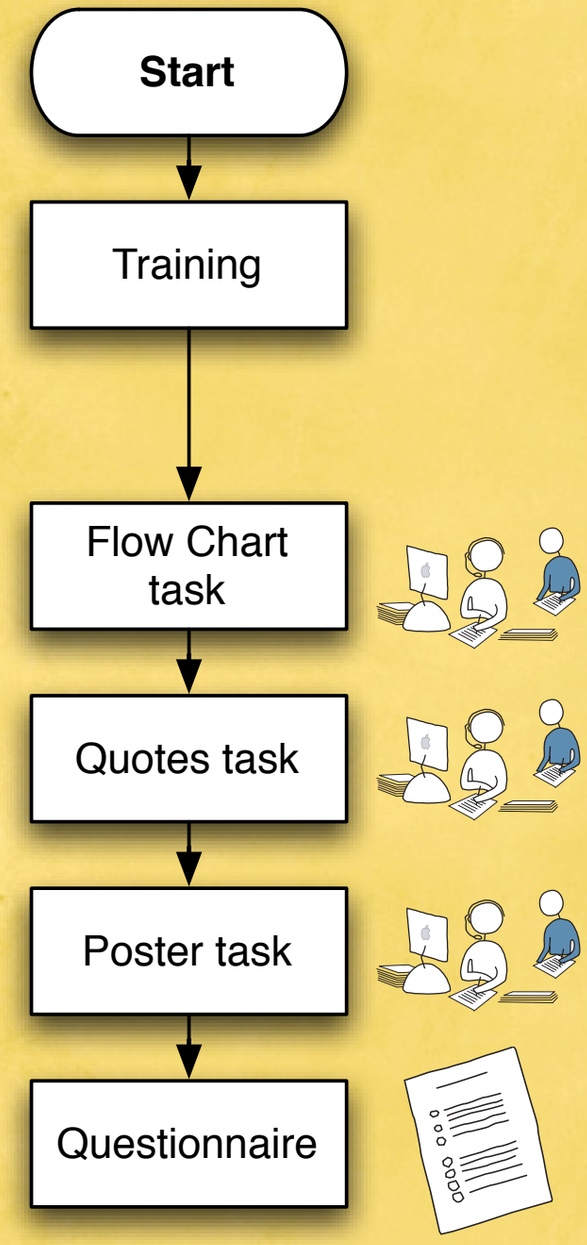
- Three classes of editing tasks:
  - Flow chart edits
  - Text edits
  - Combined text and graphical edits

Procedures

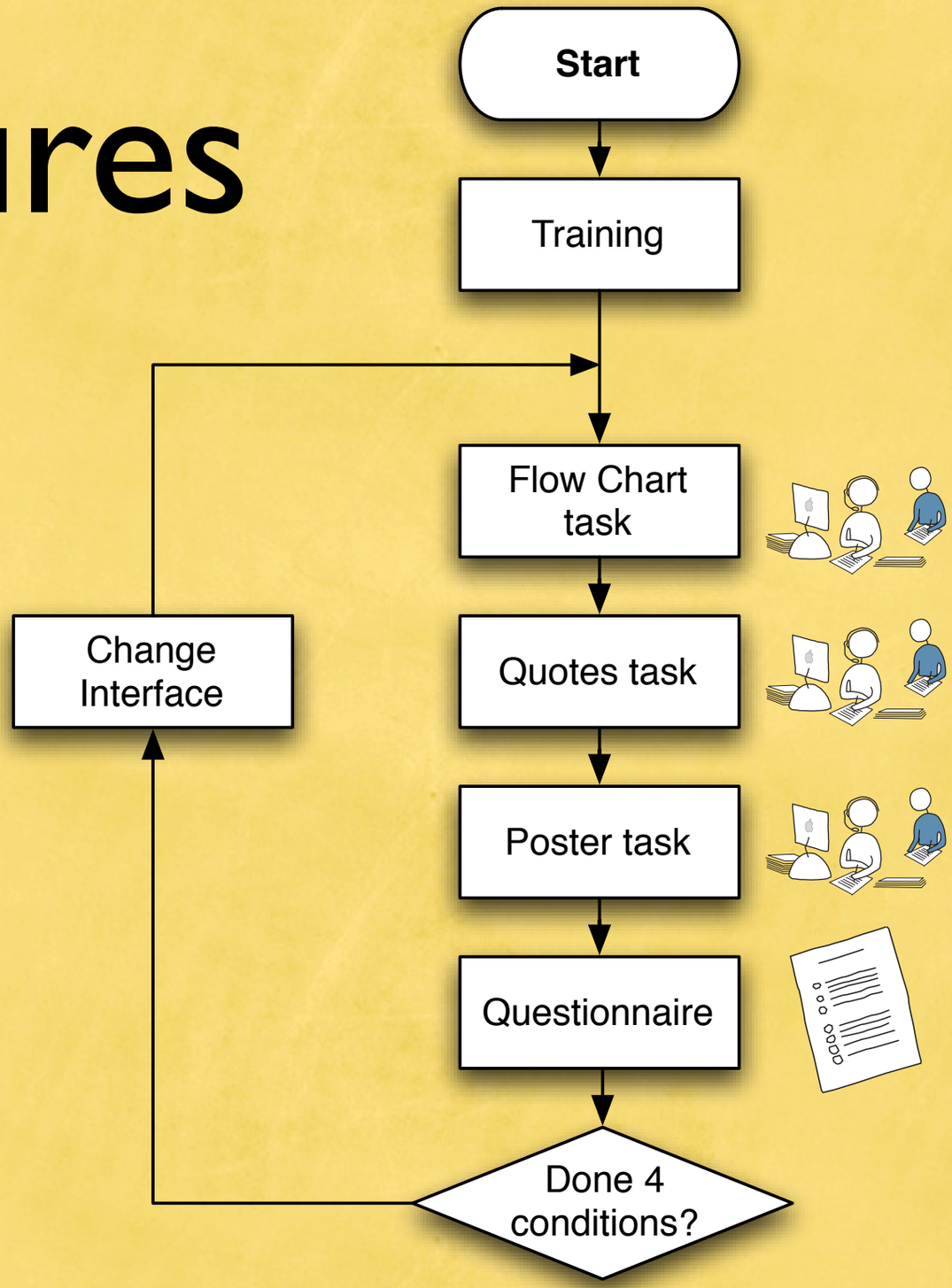
Procedures



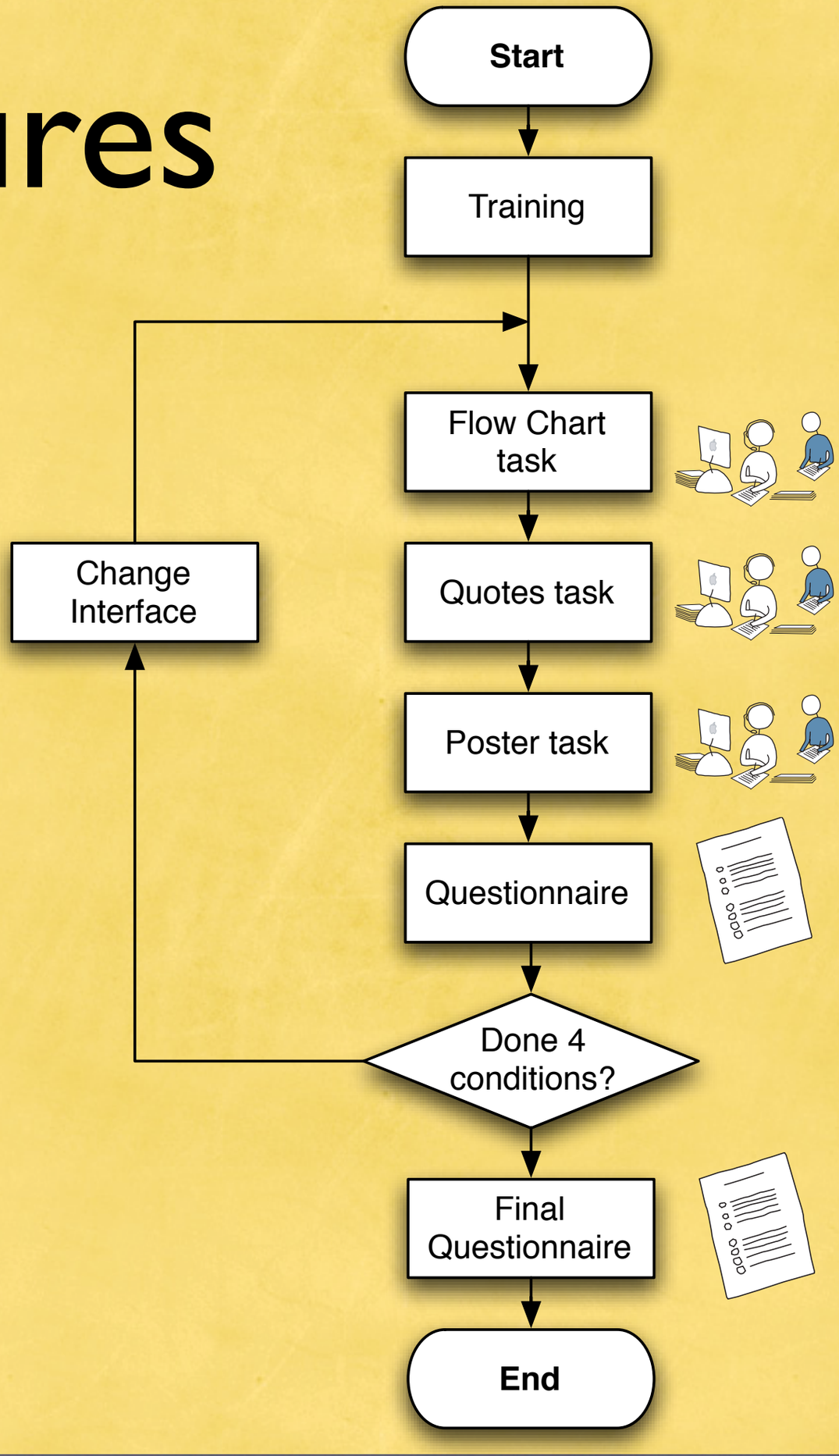
Procedures


Start
Training
Flow Chart task
Quotes task
Poster task
Questionnaire

Procedures


Start
Training
Flow Chart task
Quotes task
Poster task
Questionnaire
Done 4 conditions?
Change Interface

Procedures

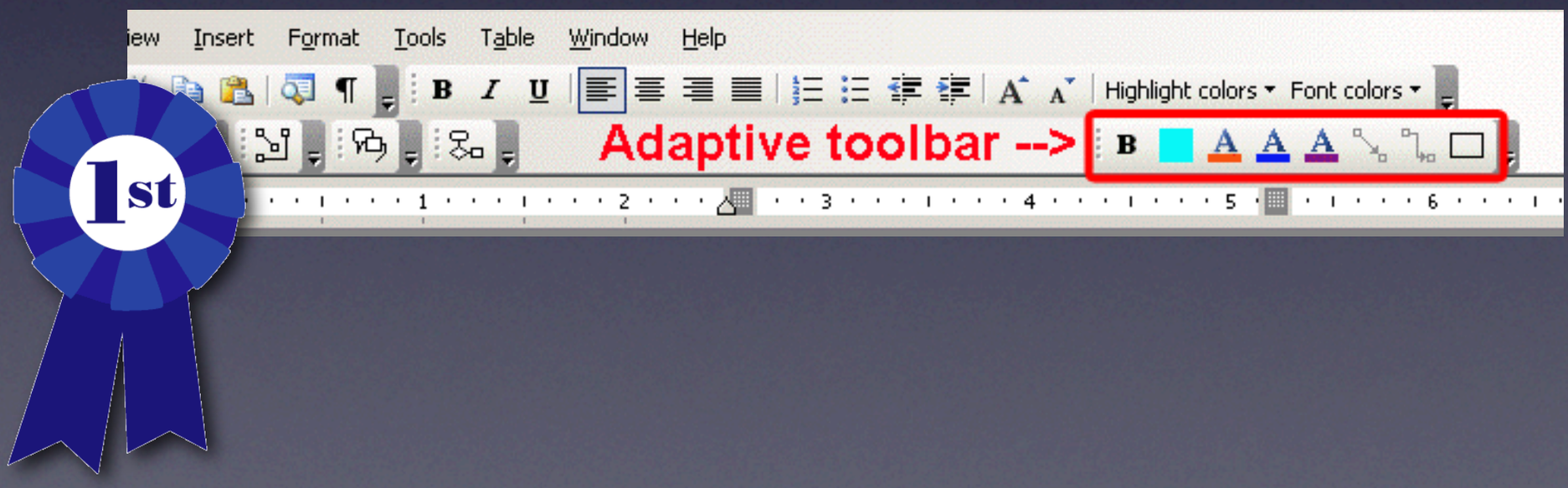

Start
Training
Flow Chart task
Quotes task
Poster task
Questionnaire
Done 4 conditions?
Final Questionnaire
End
Change Interface

Results: Ranking

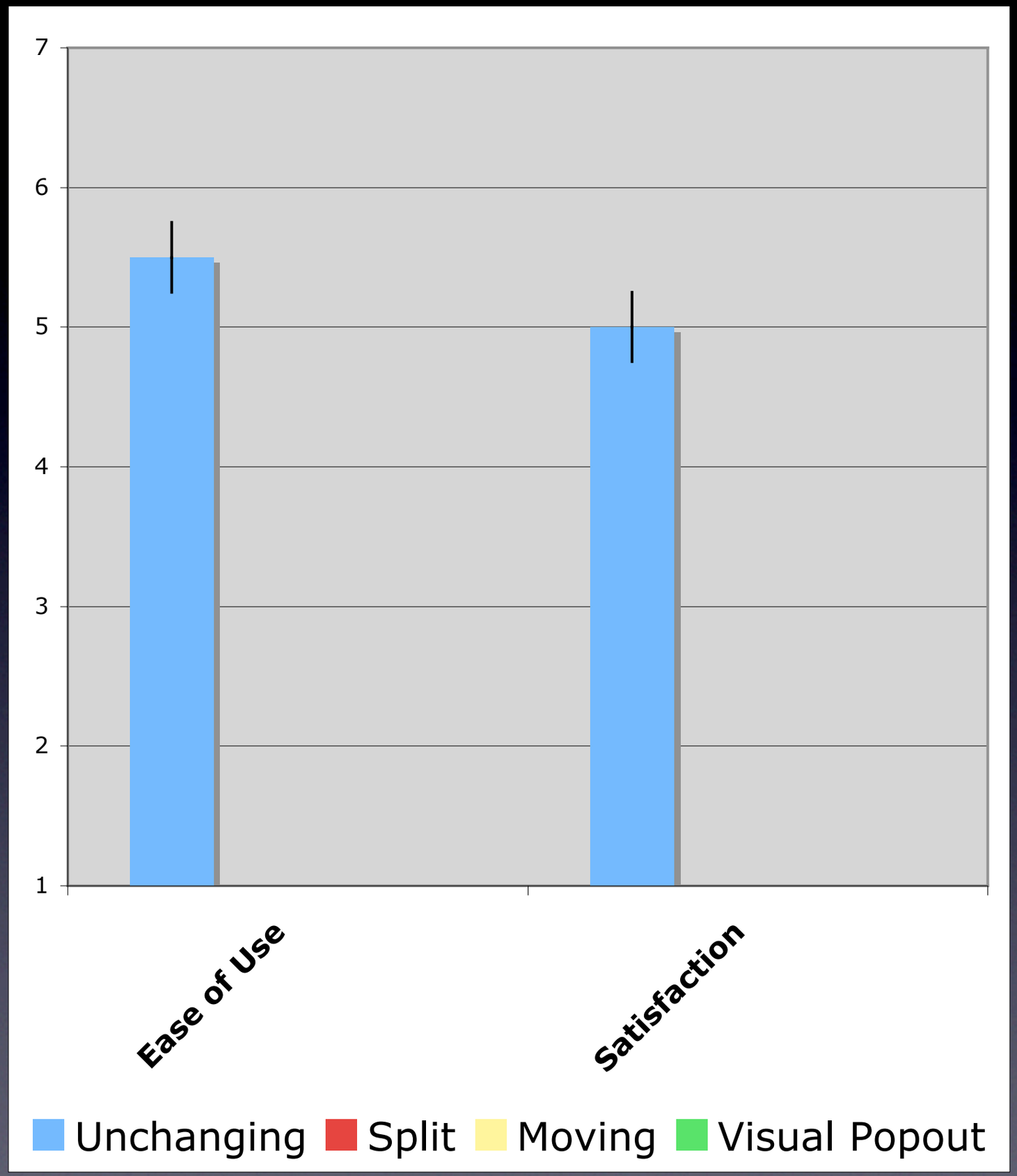
Users ranked the Split Interface the highest ($p<0.001$)

Results: Ranking

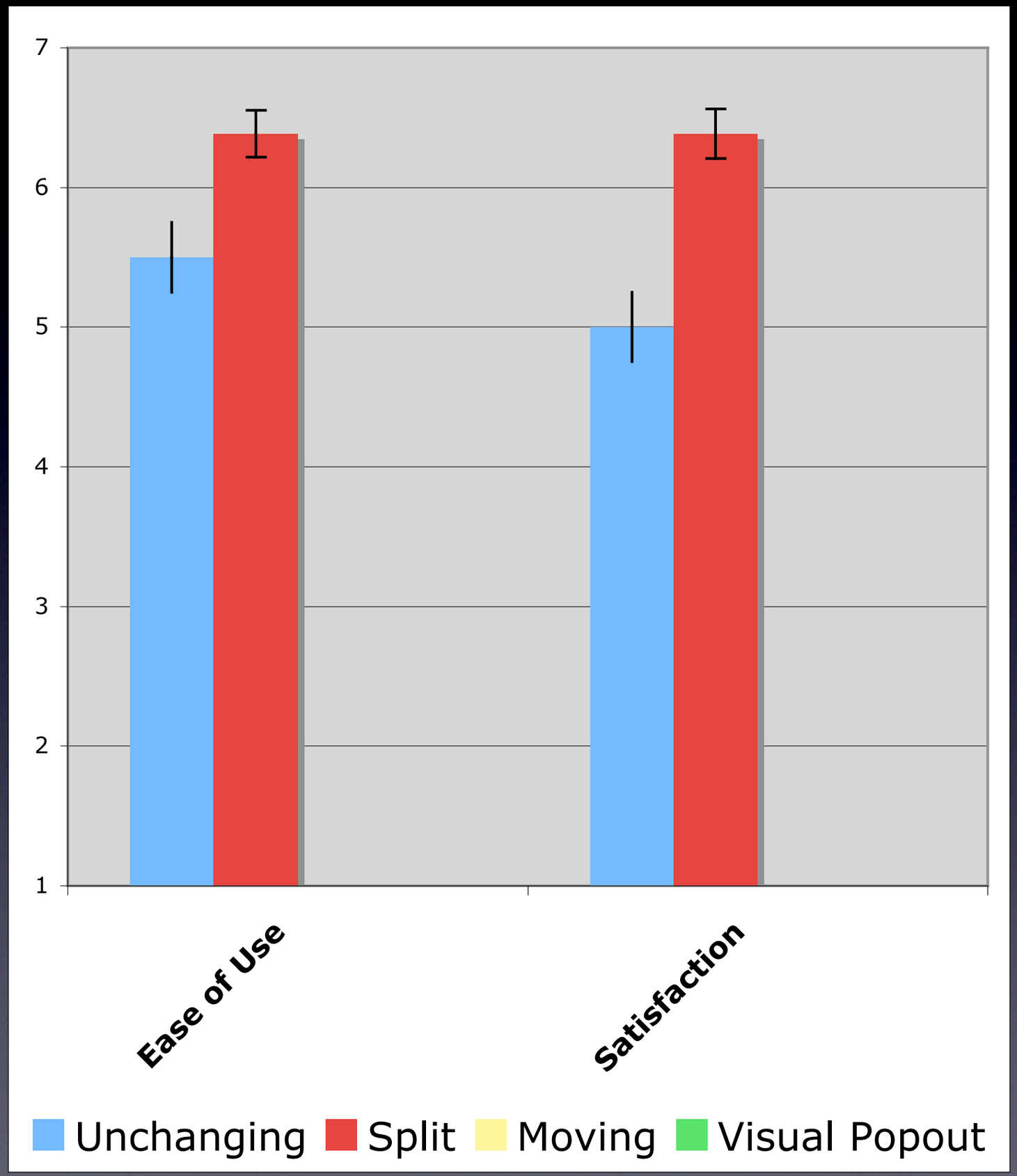
Users ranked the Split Interface the highest ($p<0.001$)



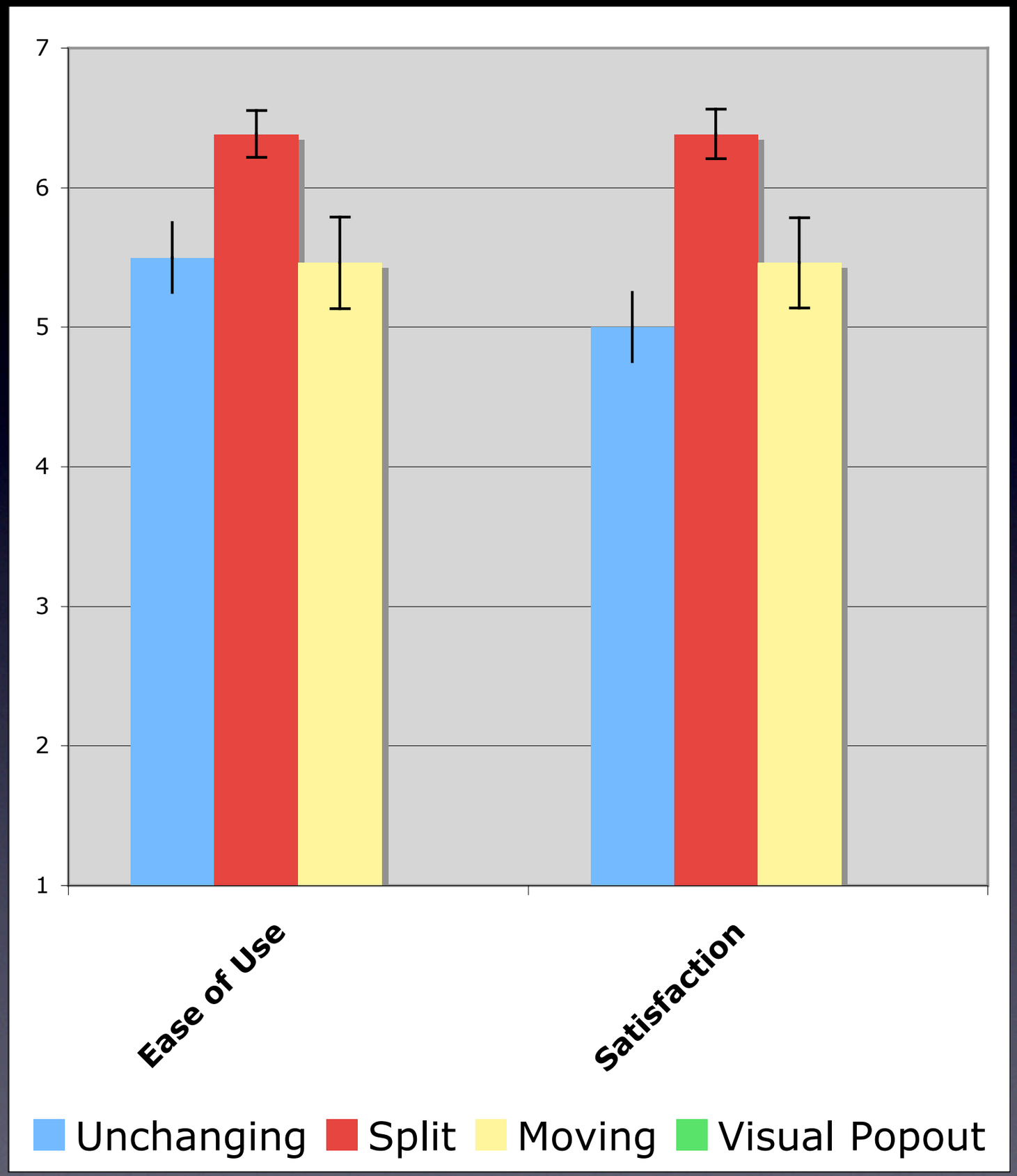
General Satisfaction



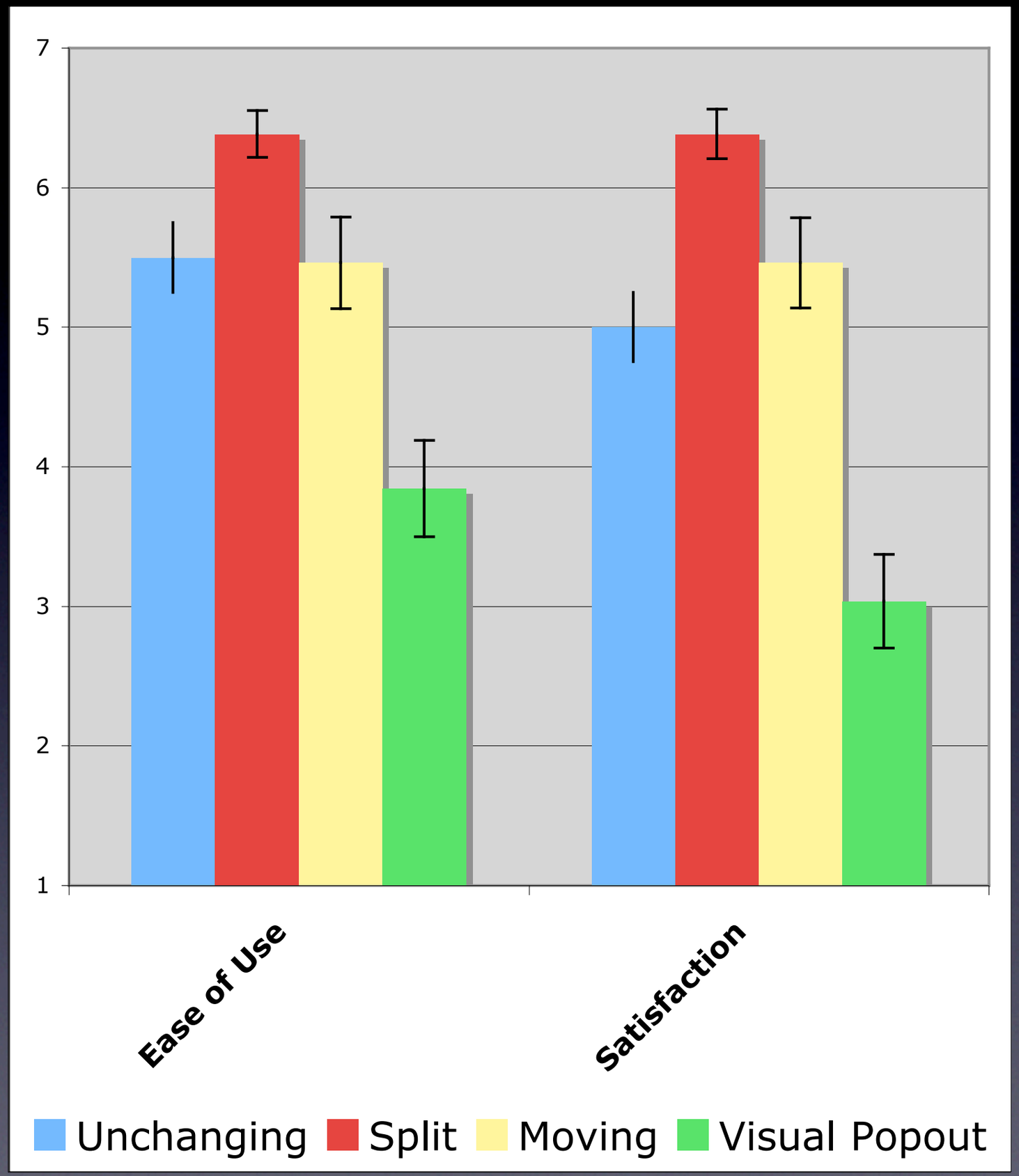
General Satisfaction



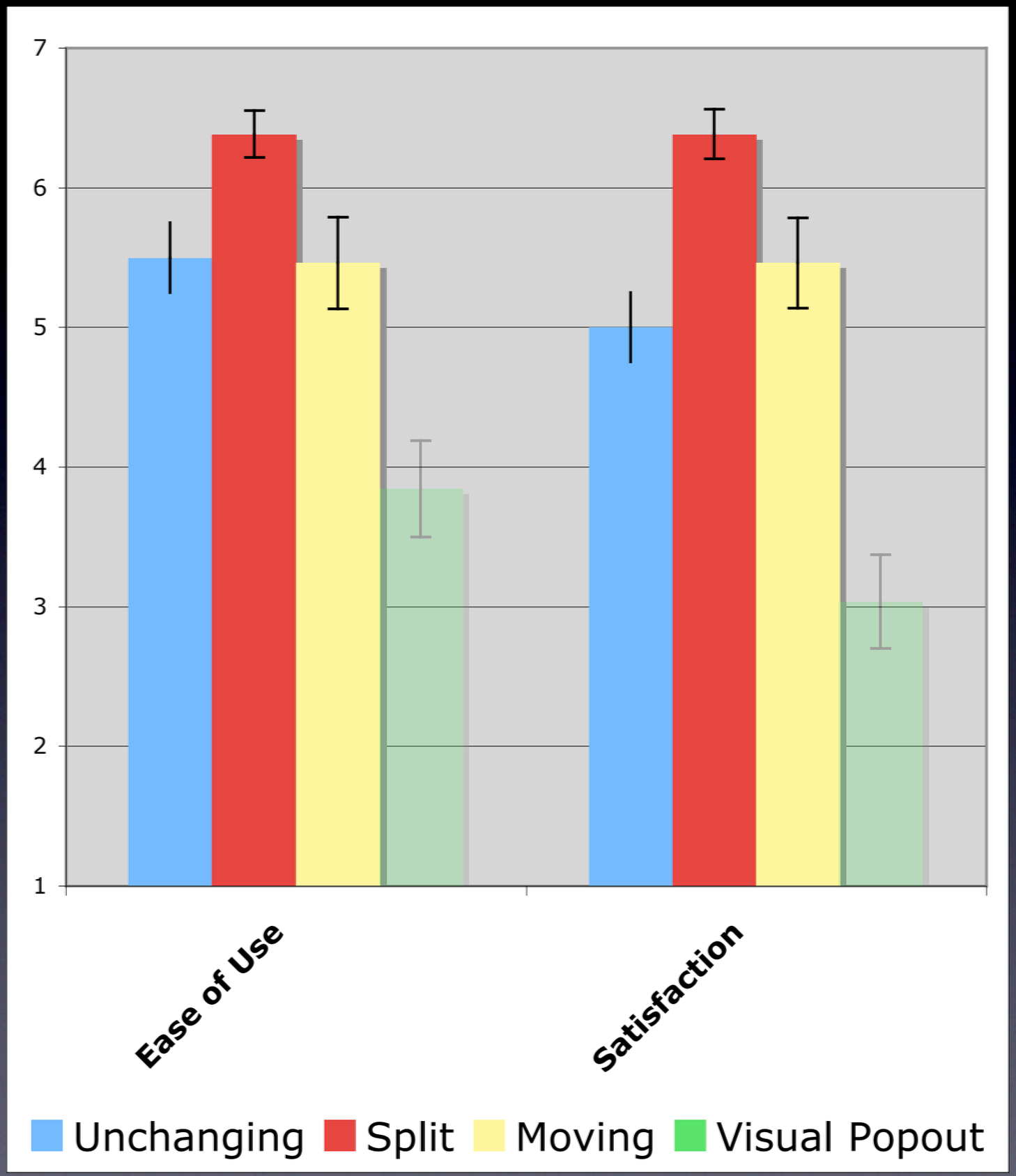
General Satisfaction



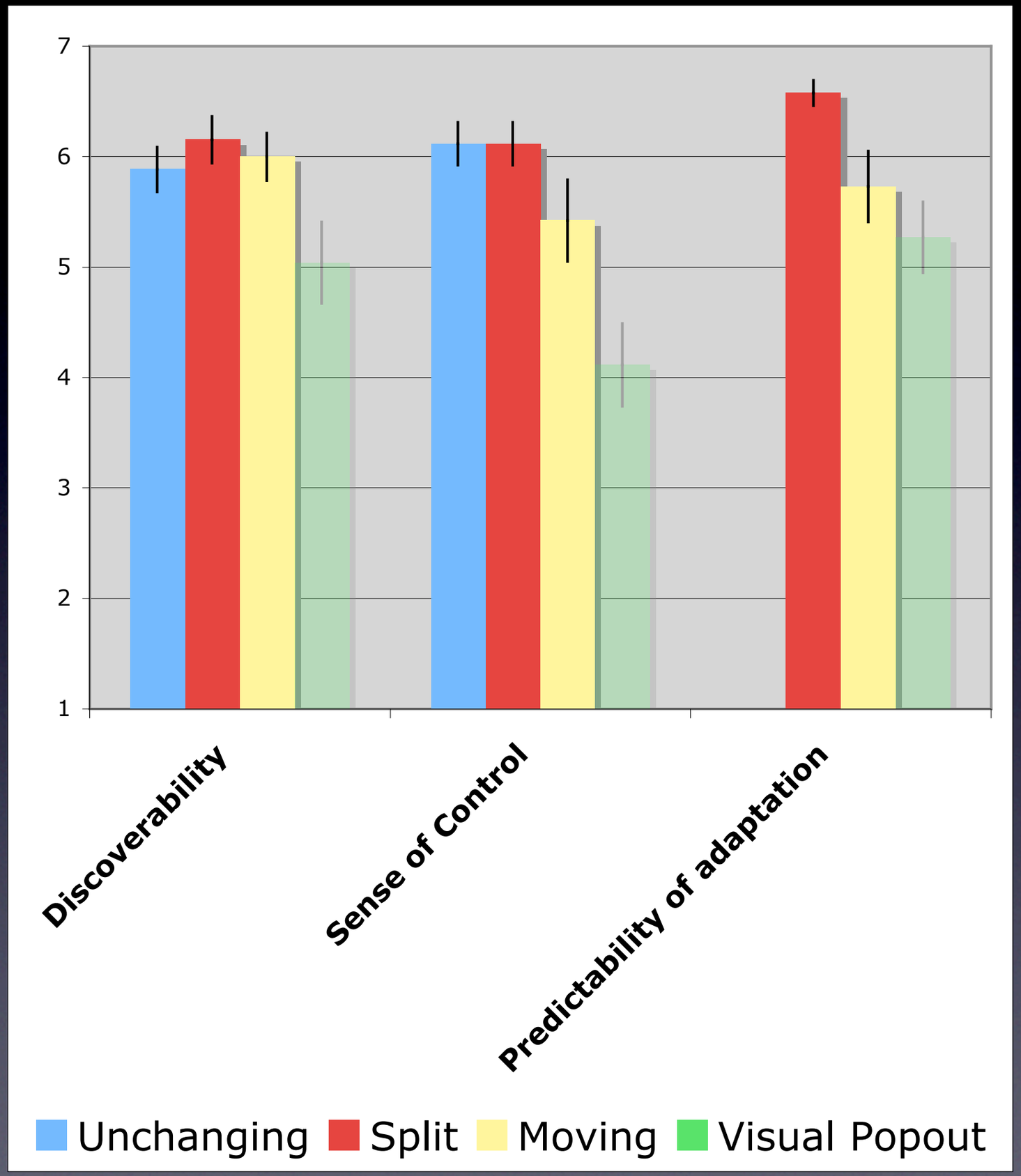
General Satisfaction



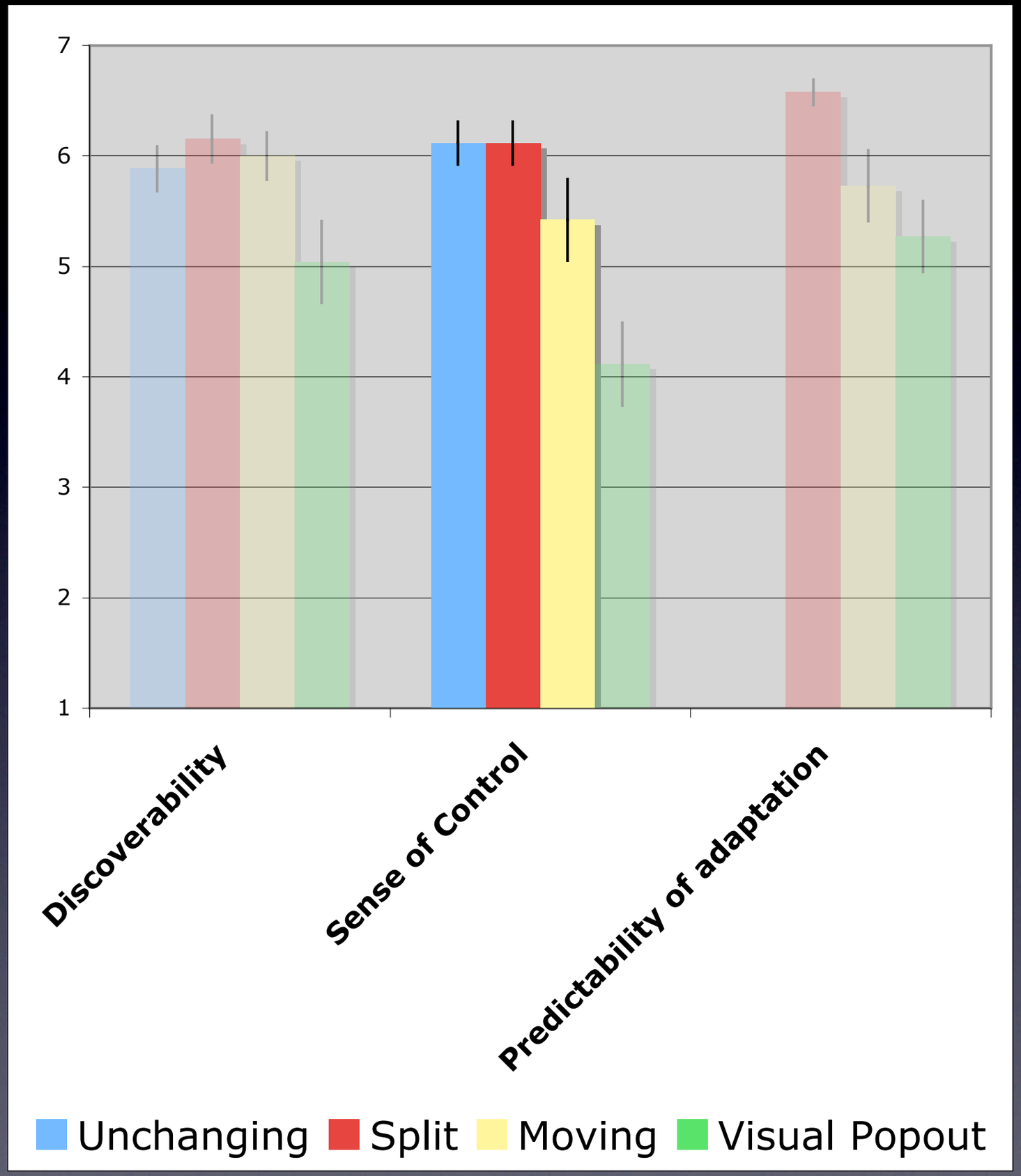
General Satisfaction



Usability


7
6
5
4
3
2
1
Discoverability
Sense of Control
Predictability of adaptation
Unchanging
Split
Moving
Visual Popout

Usability


7
6
5
4
3
2
1
Discoverability
Sense of Control
Predictability of adaptation
Unchanging
Split
Moving
Visual Popout

Subjective Cost and Benefit

Subjective Cost and Benefit

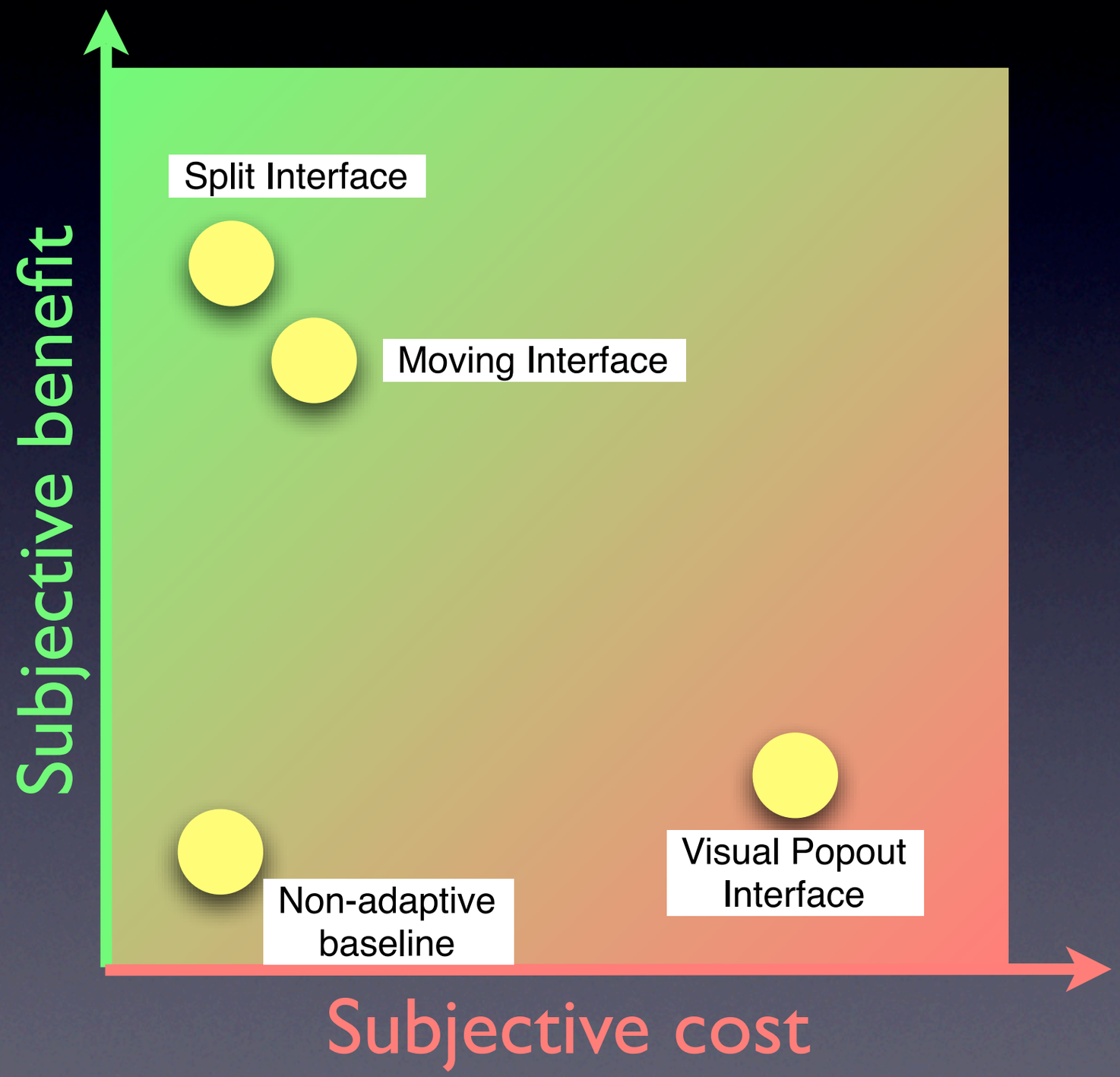
- Subjective cost
  based on:
  - Mental demand
  - Physical Demand
  - Frustration
  - Confusion due to adaptation

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

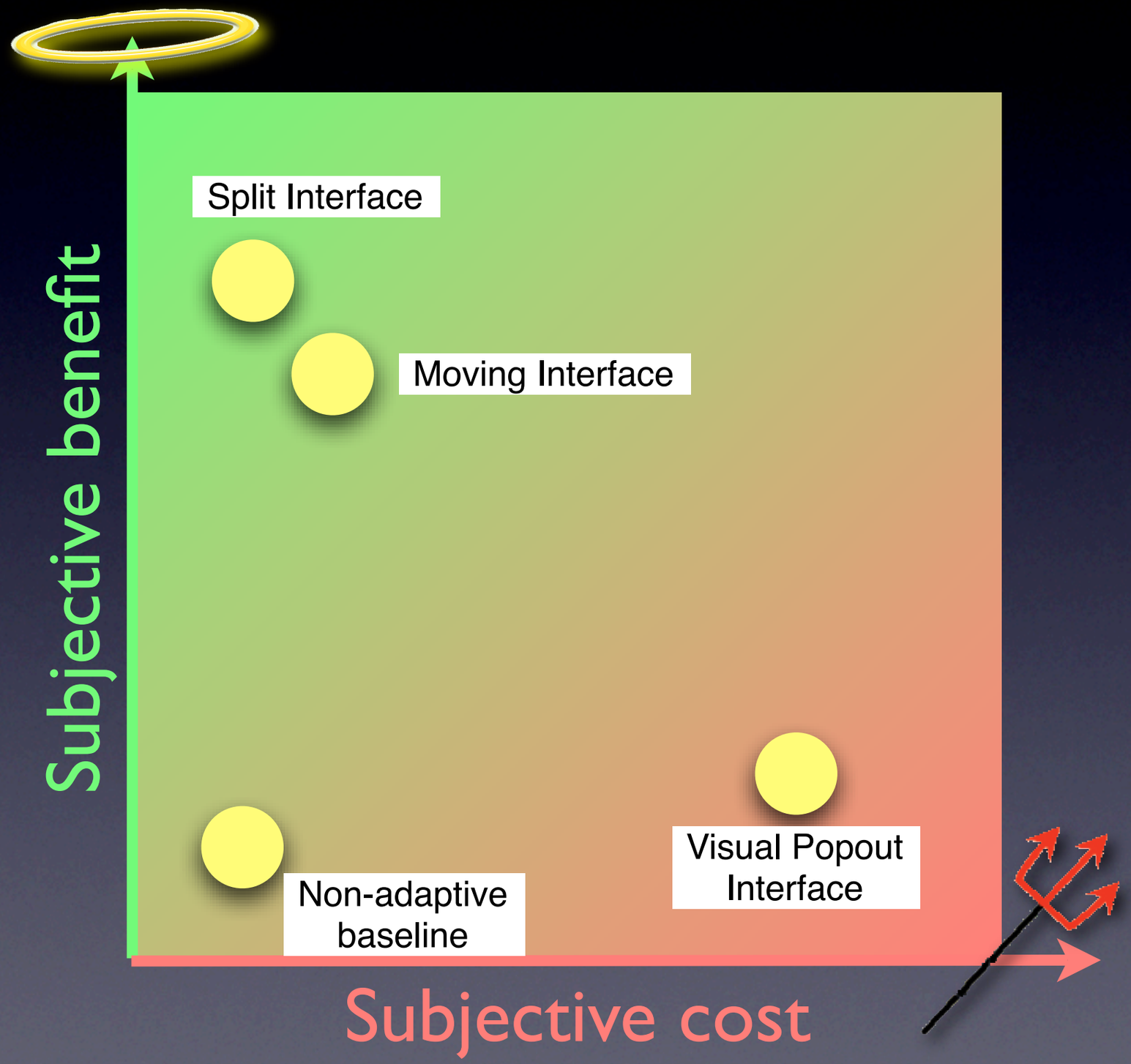
Subjective Cost and Benefit

- 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

User Comments

Split Interface	Moving Interface	Visual Popout Interface
- stability - semantic grouping		

User Comments

Split Interface	Moving Interface	Visual Popout Interface
- stability - semantic grouping	- discoverability	

User Comments

Split Interface	Moving Interface	Visual Popout Interface
- stability - semantic grouping	- discoverability	

User Comments

Split Interface	Moving Interface	Visual Popout Interface
- stability - semantic grouping	- discoverability	
- poor discoverability		

User Comments

Split Interface	Moving Interface	Visual Popout Interface
- stability - semantic grouping	- discoverability	
- poor discoverability	- instability	

User Comments

Split Interface	Moving Interface	Visual Popout Interface
- stability - semantic grouping	- discoverability	
- poor discoverability	- instability	- anti-salience

Road Map

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

Experiment 2

Goals:

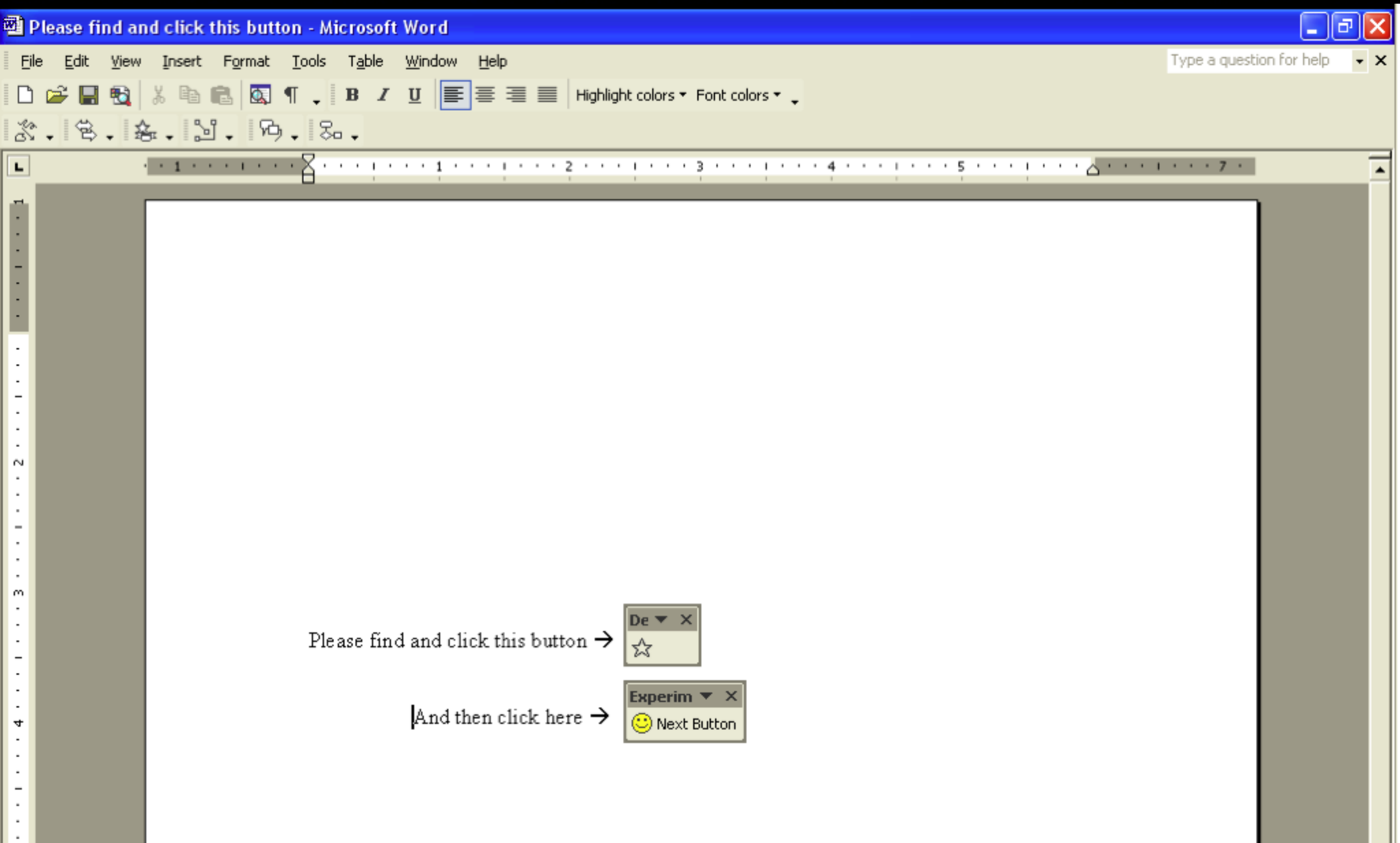
Collect accurate performance data

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

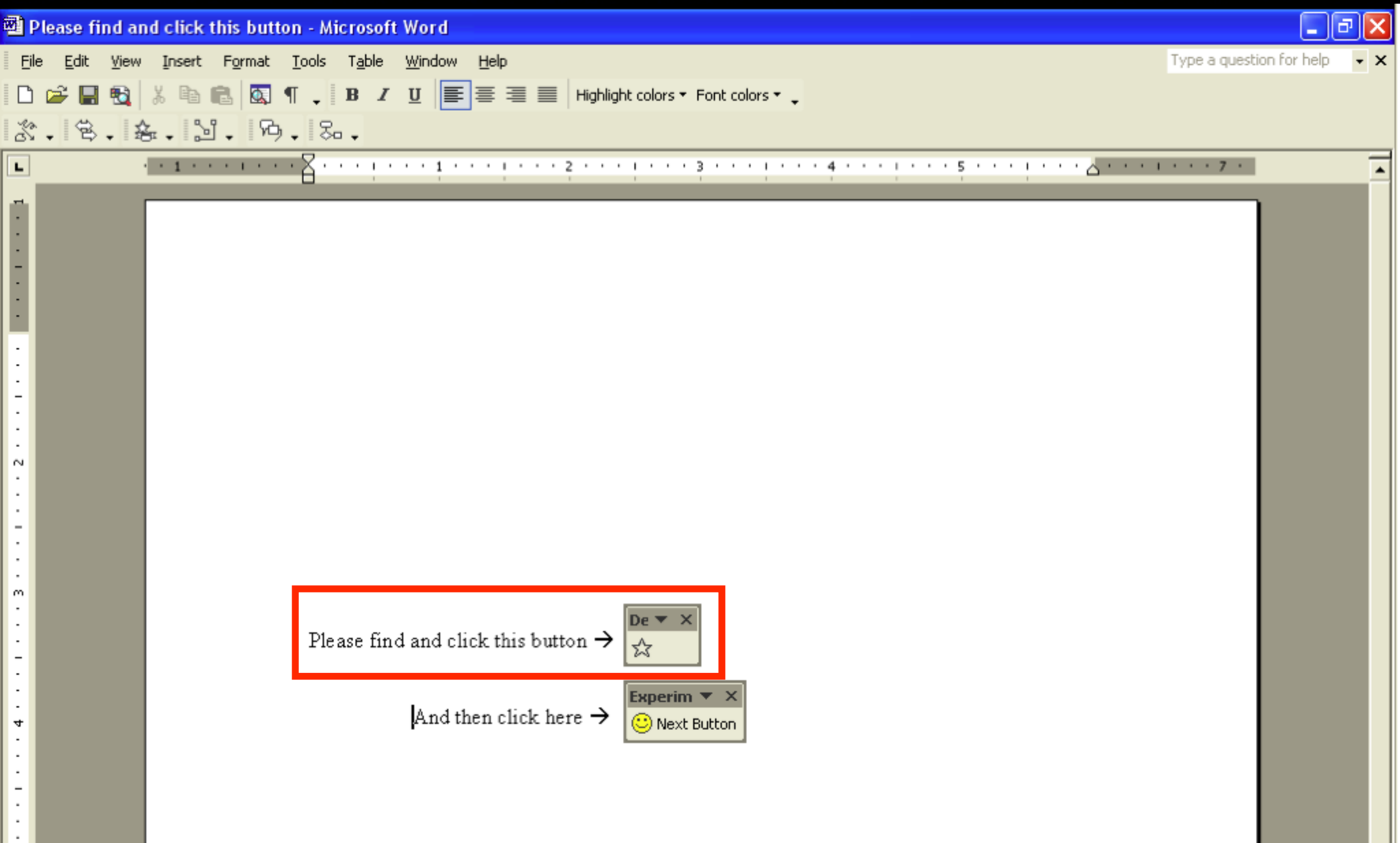
Participants

- 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

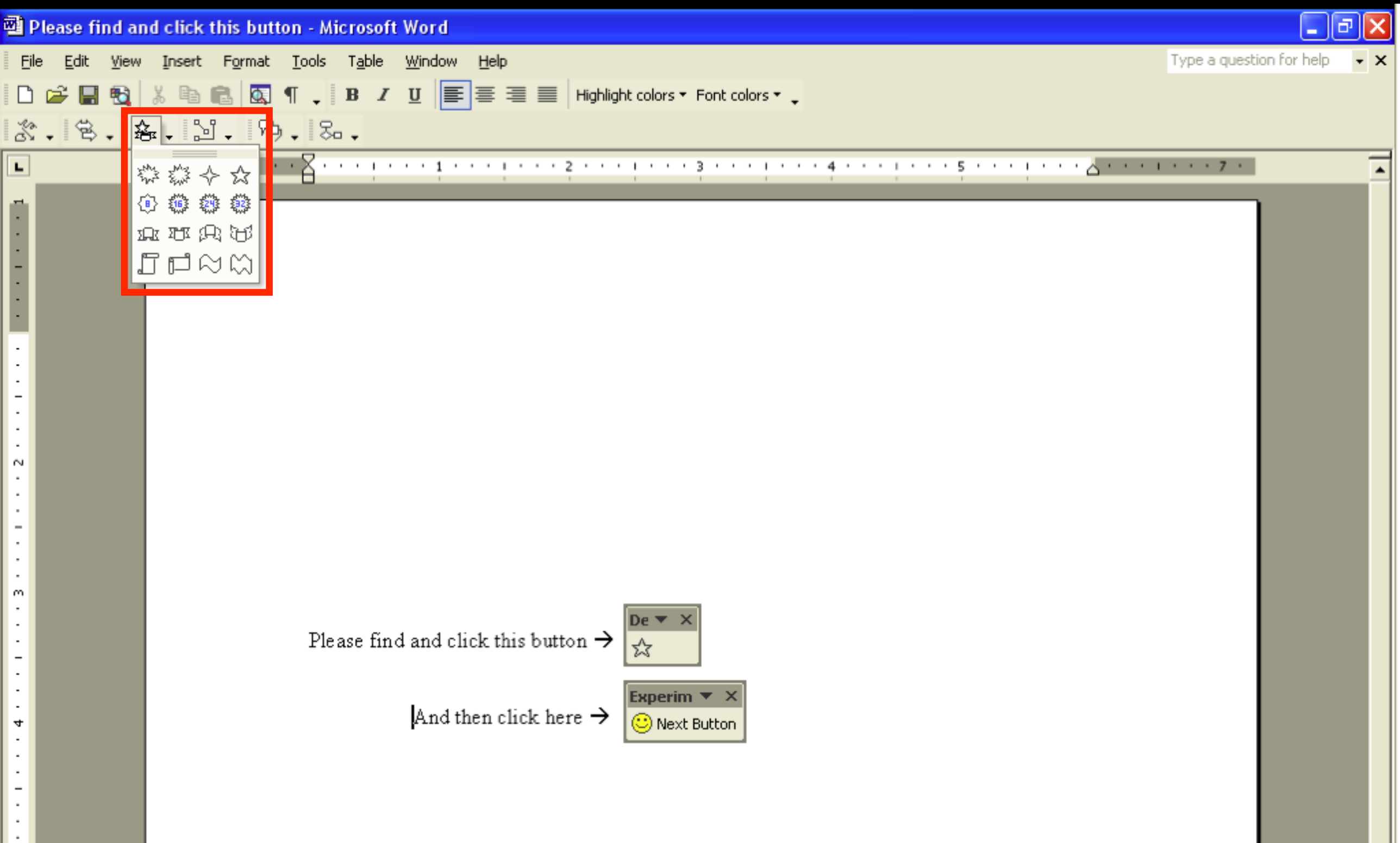
Tasks


Please find and click this button - Microsoft Word
File Edit View Insert Format Tools Table Window Help
Type a question for help
Highlight colors
Font colors
Please find and click this button →
De
And then click here →
Experim
Next Button

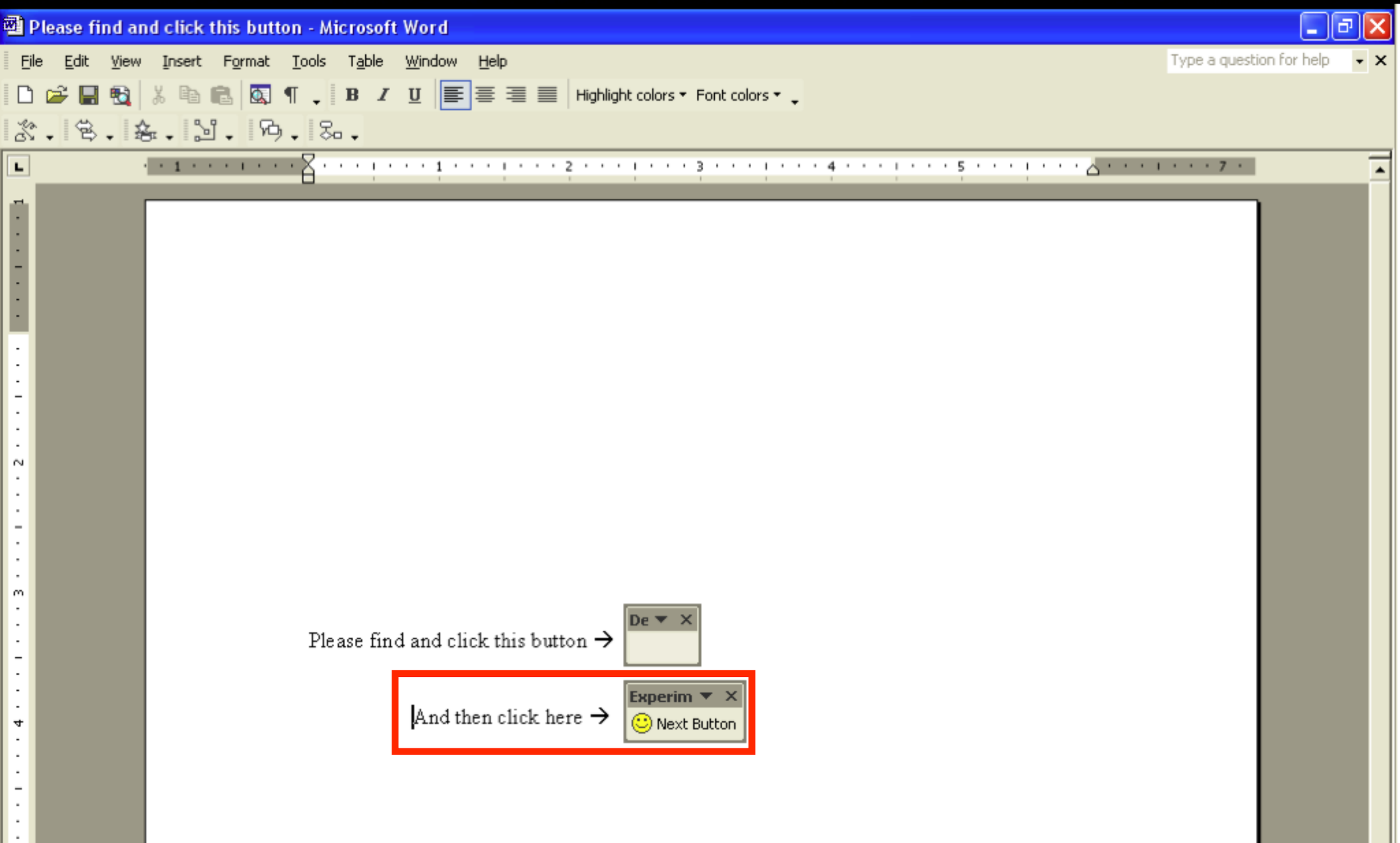
Tasks


Please find and click this button - Microsoft Word
File Edit View Insert Format Tools Table Window Help
Type a question for help
Highlight colors
Font colors
Please find and click this button →
De
And then click here →
Experim
Next Button

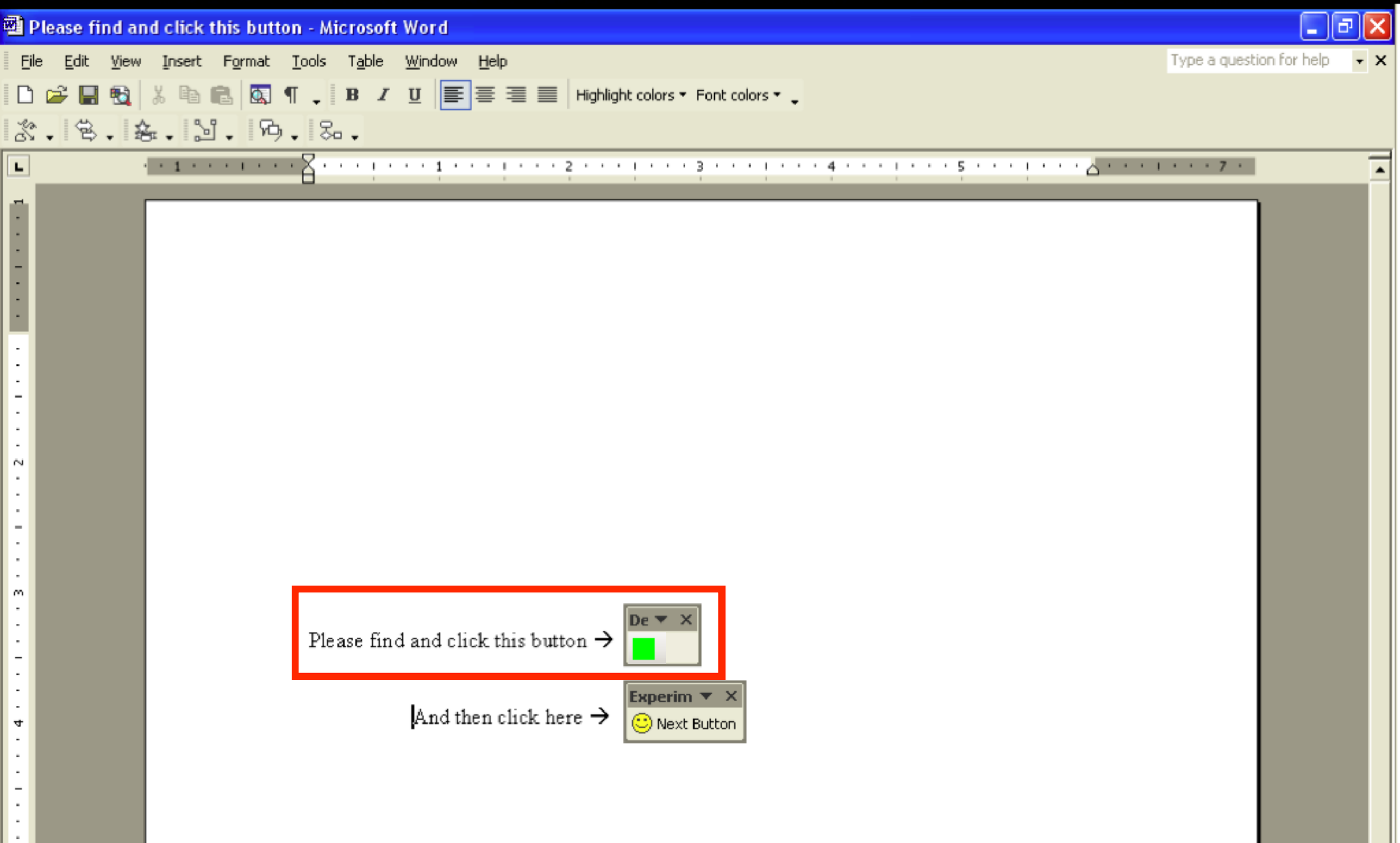
Tasks


Please find and click this button - Microsoft Word
File Edit View Insert Format Tools Table Window Help
Type a question for help
Highlight colors
Font colors
Please find and click this button →
De
And then click here →
Experim
Next Button

Tasks


Please find and click this button - Microsoft Word
File Edit View Insert Format Tools Table Window Help
Type a question for help
Highlight colors
Font colors
Please find and click this button →
De
And then click here →
Experim
Next Button

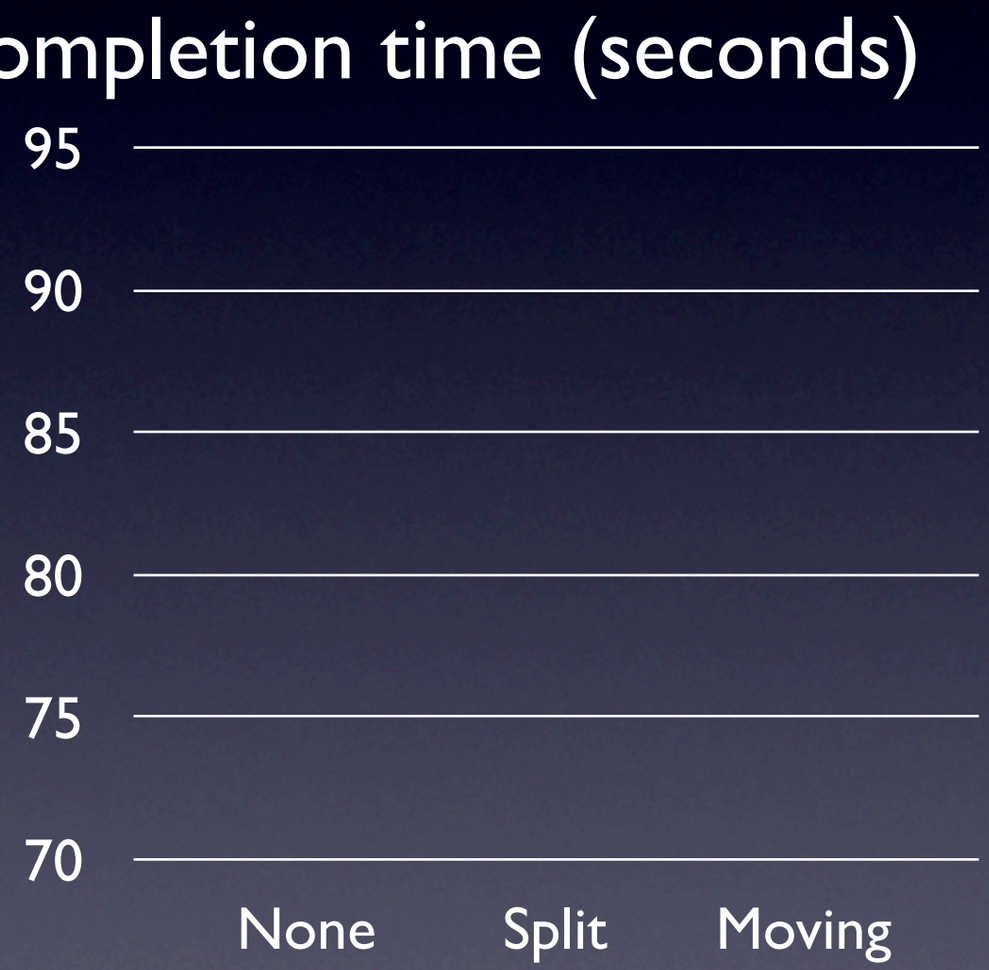
Tasks


Please find and click this button - Microsoft Word
File Edit View Insert Format Tools Table Window Help
Type a question for help
Highlight colors
Font colors
Please find and click this button →
De
And then click here →
Experim
Next Button

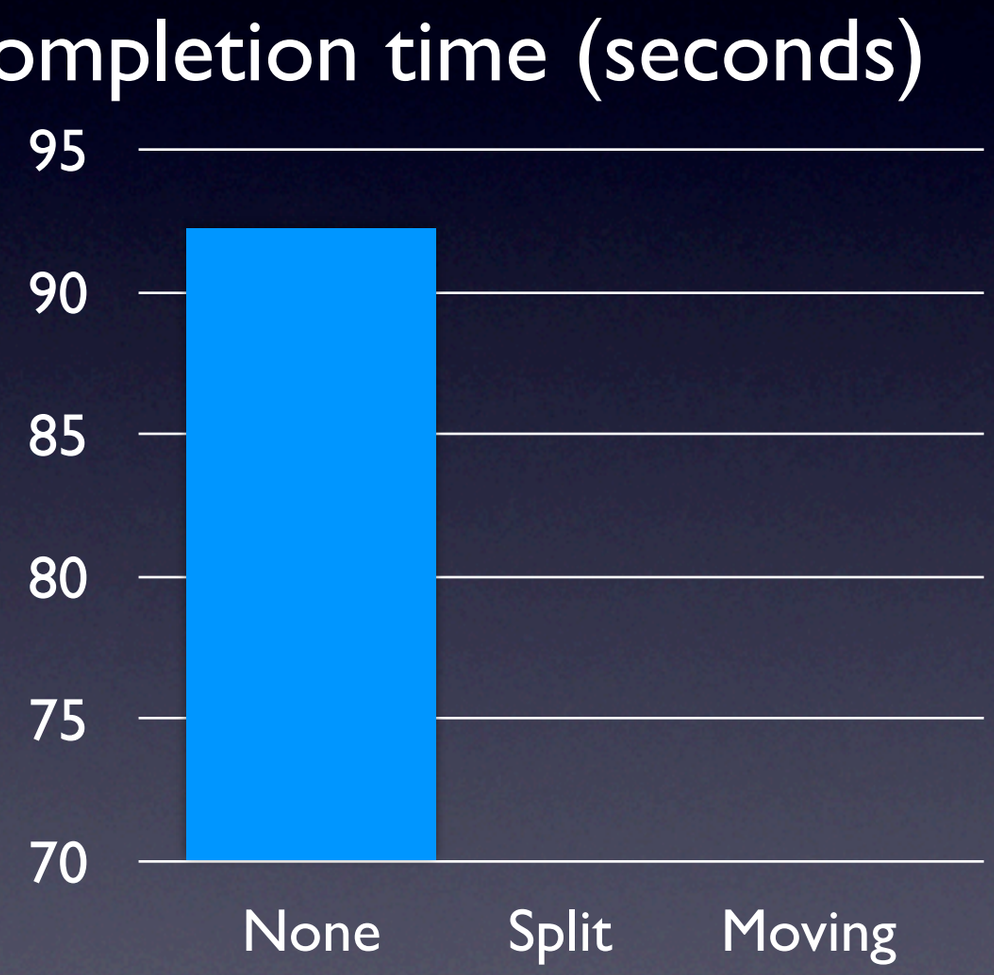
Procedures

- 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

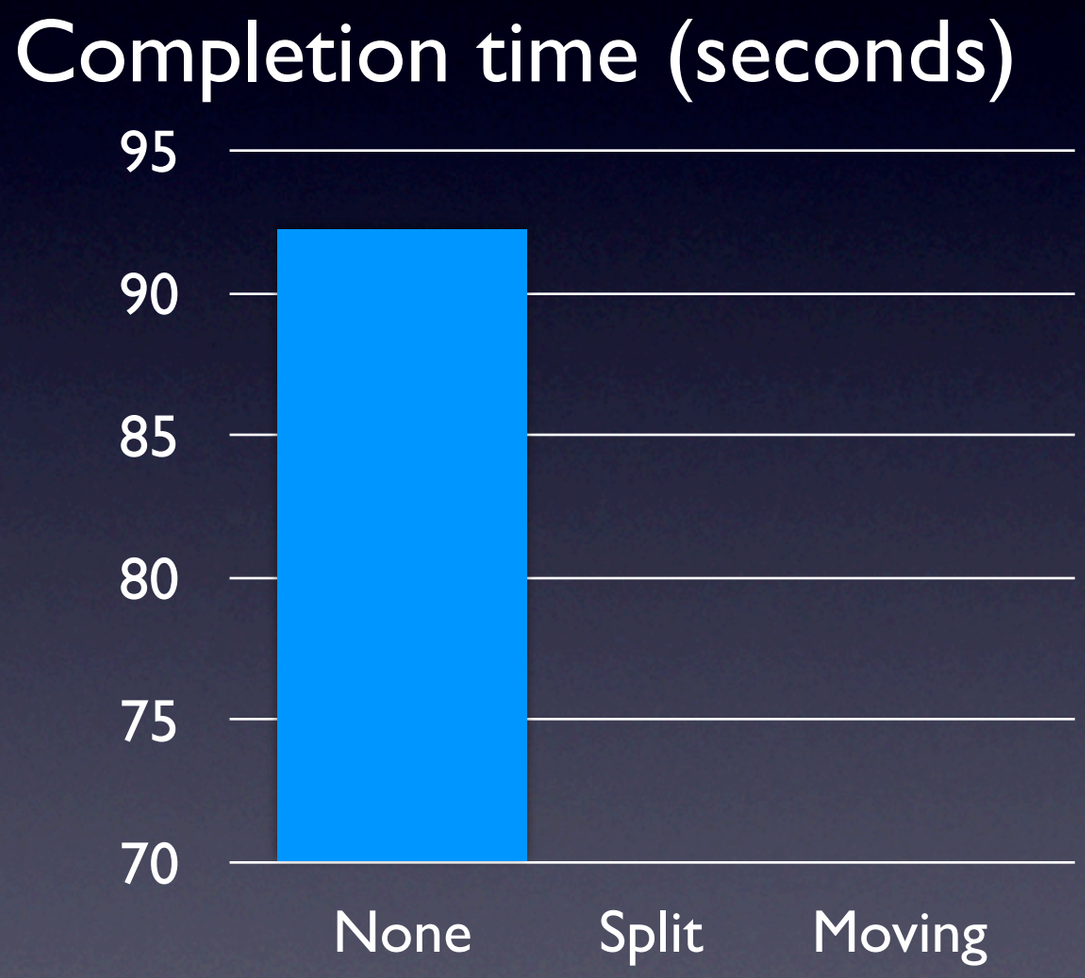


Performance Vs. Adaptation Type



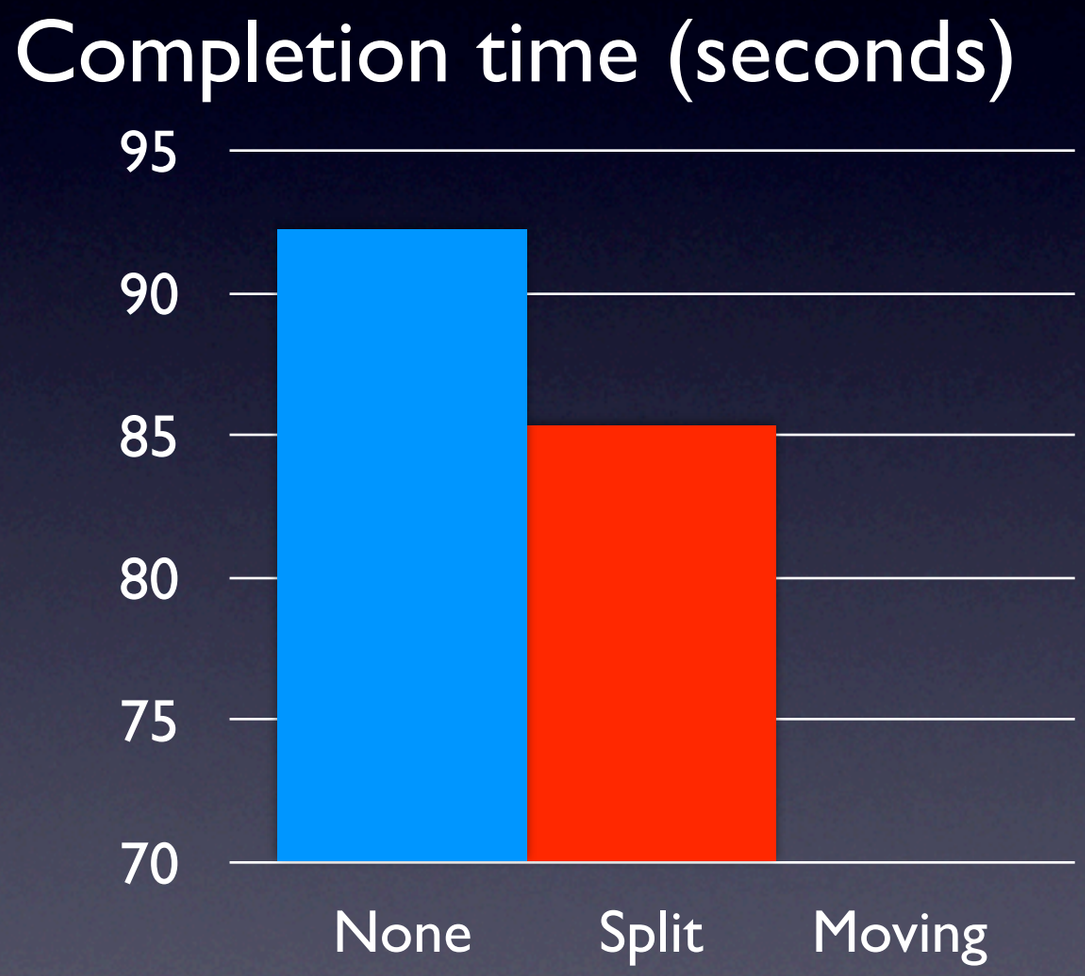
Performance Vs. Adaptation Type

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



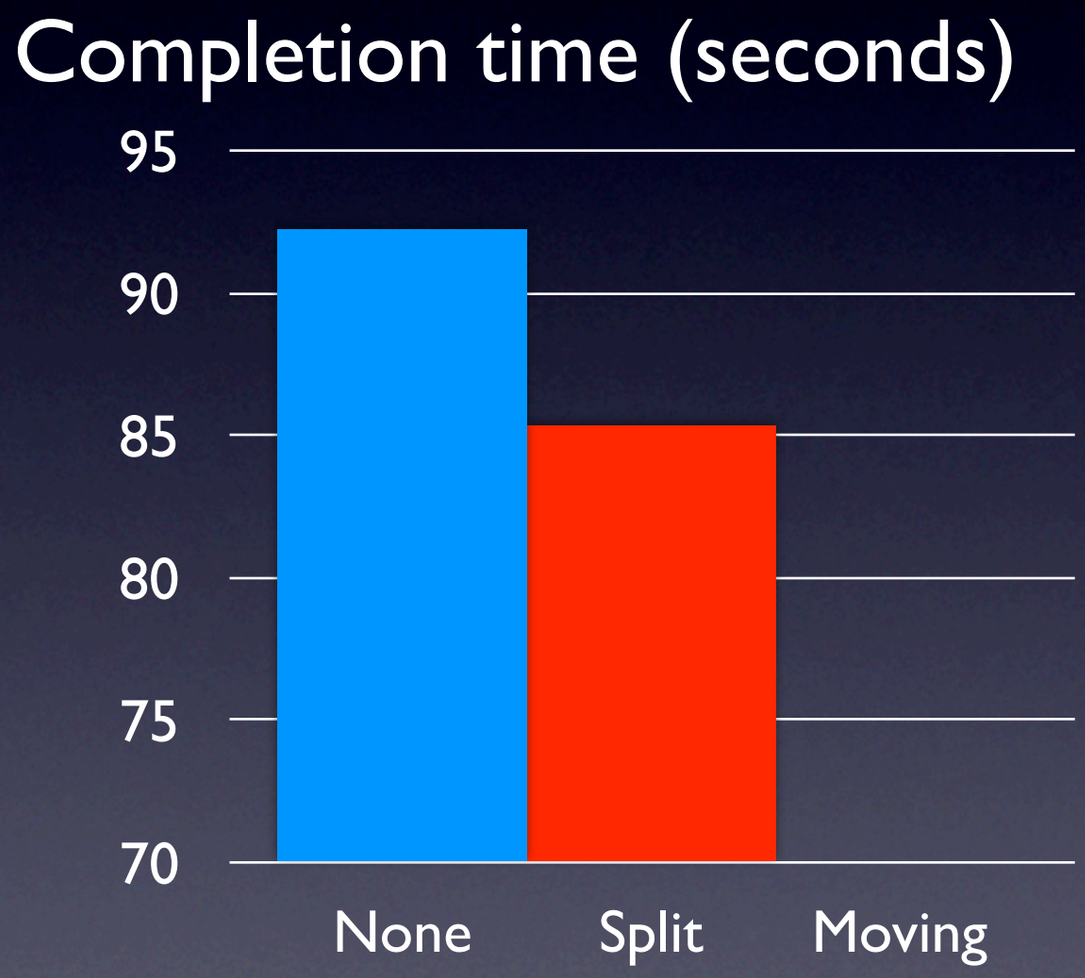
Performance Vs. Adaptation Type

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



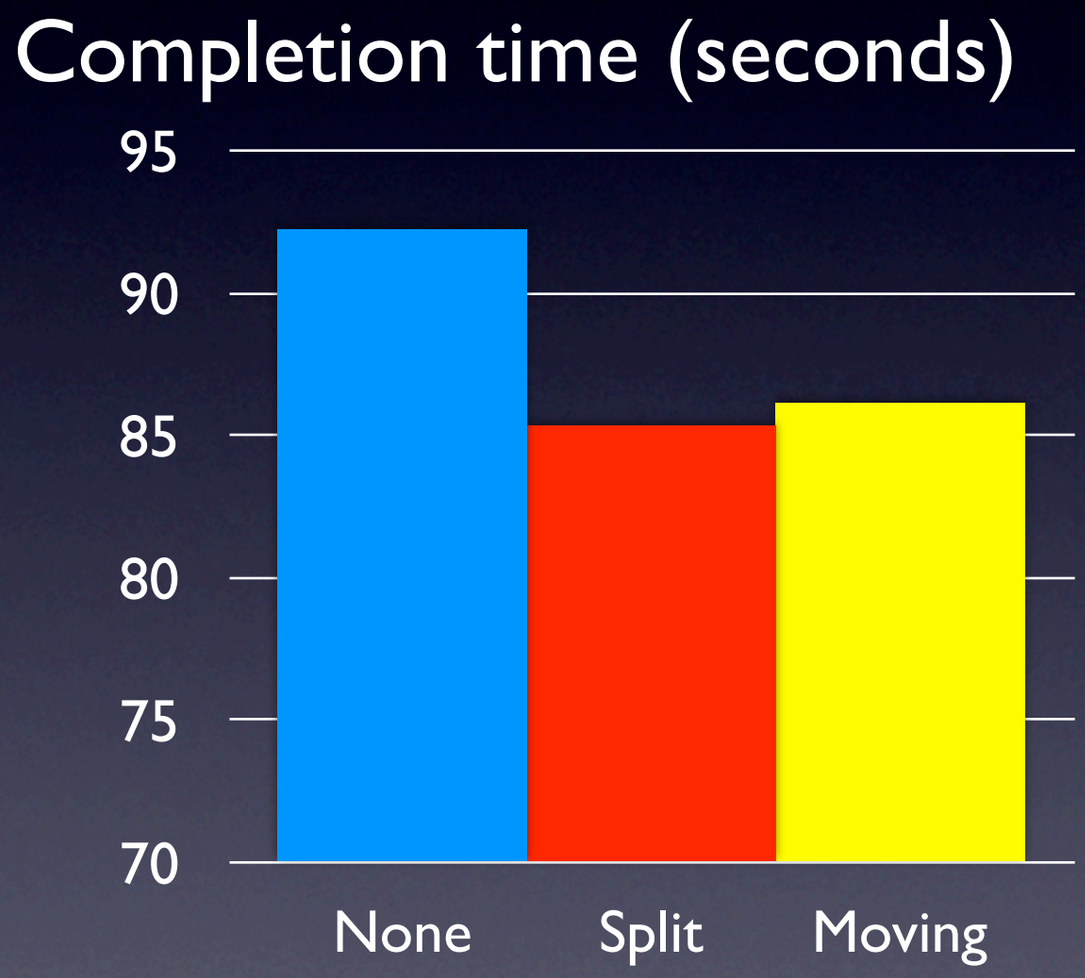
Performance Vs. Adaptation Type

- 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 ($p<0.073$)



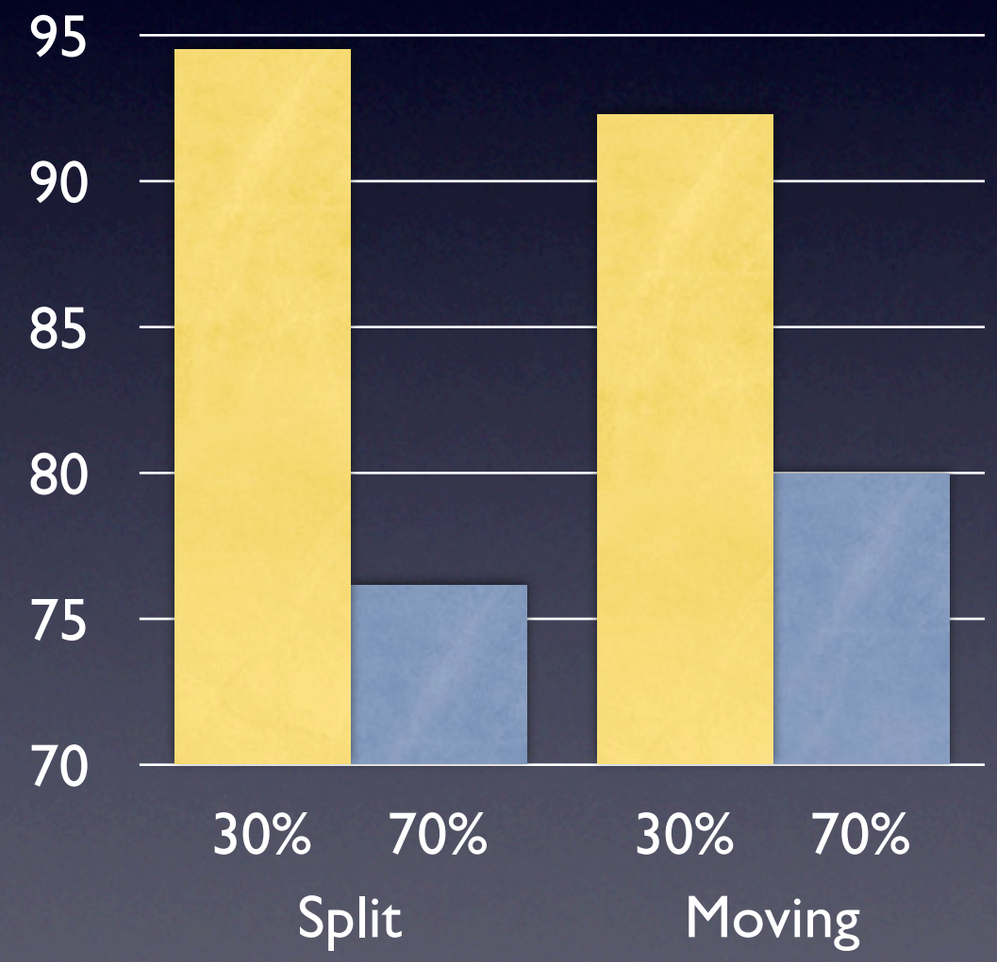
Performance Vs. Adaptation Type

- 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 ($p<0.073$)

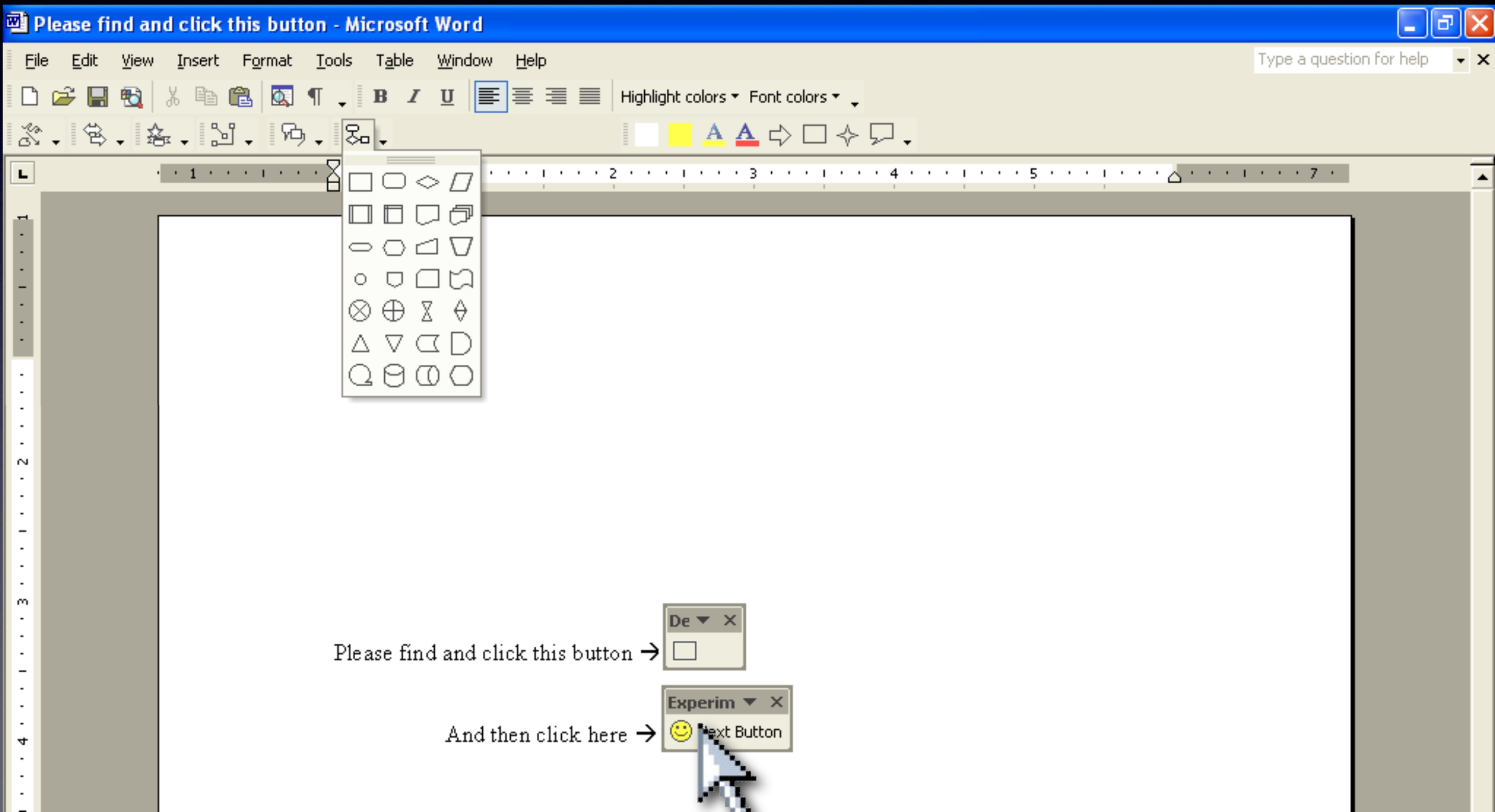


Performance Vs. Accuracy

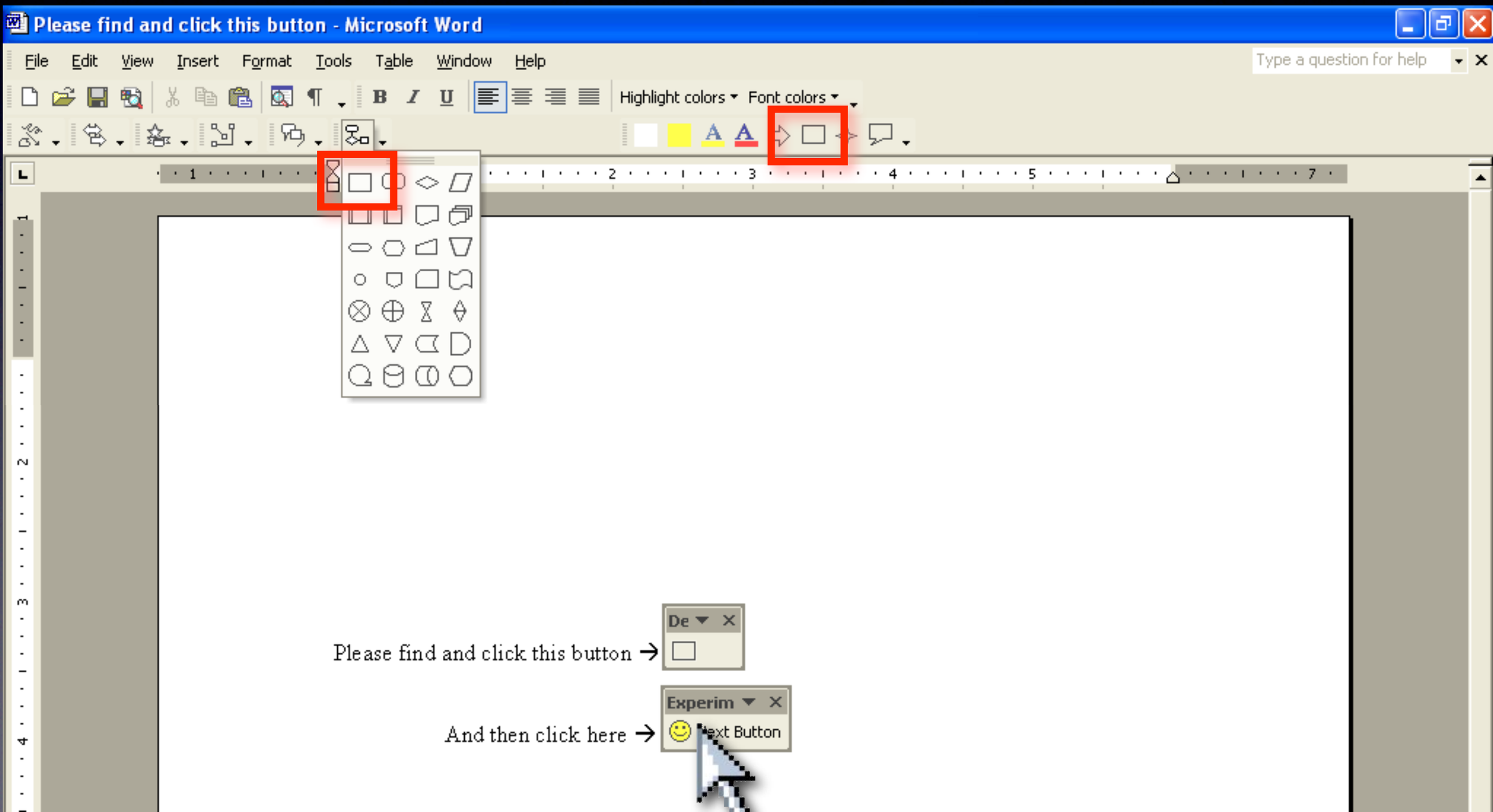
- Both adaptive interfaces resulted in faster performance at the higher (70%) accuracy level than at the lower (30%) level ($p<0.001$)



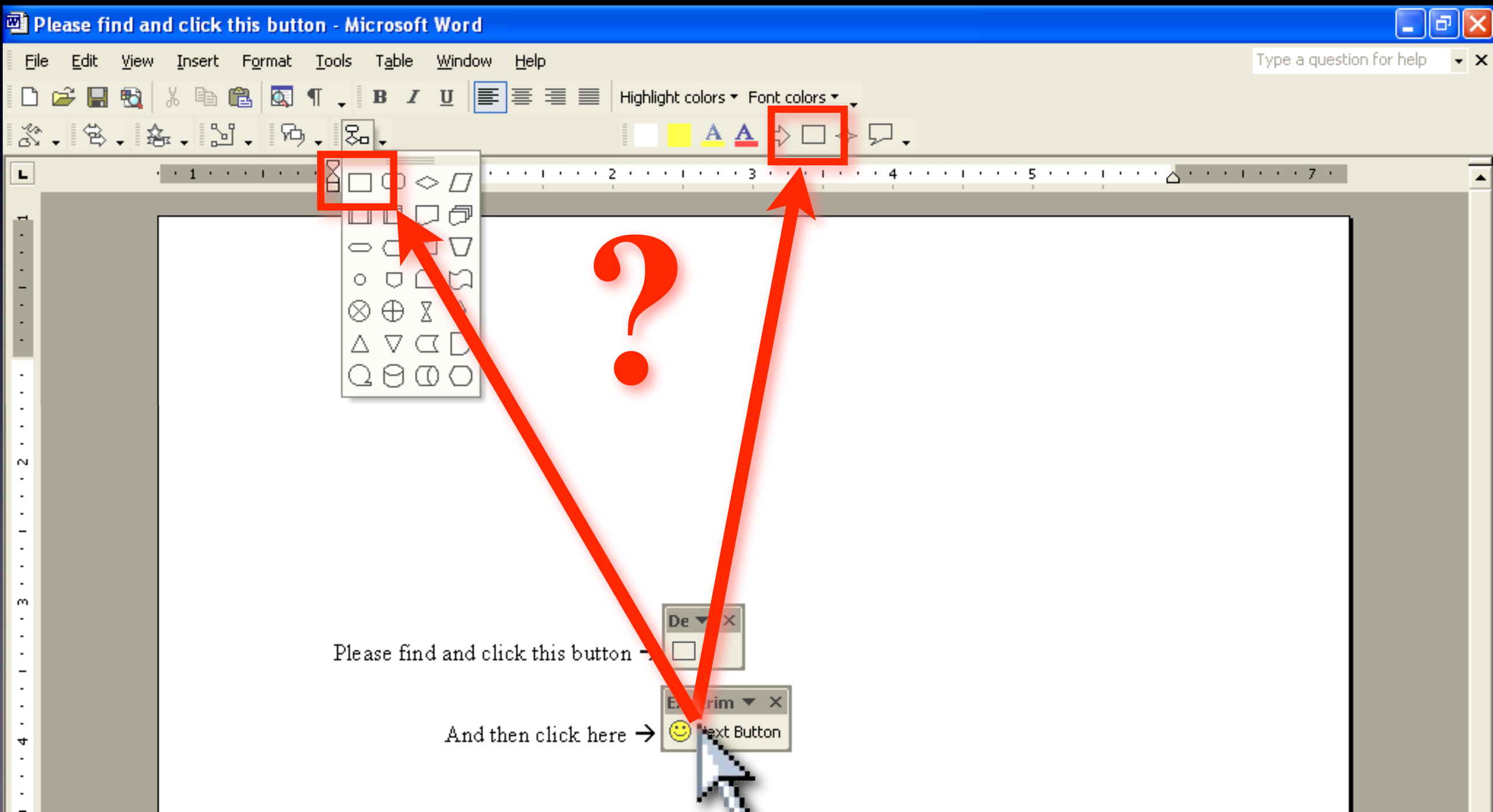
Frequency of Use Vs. Accuracy



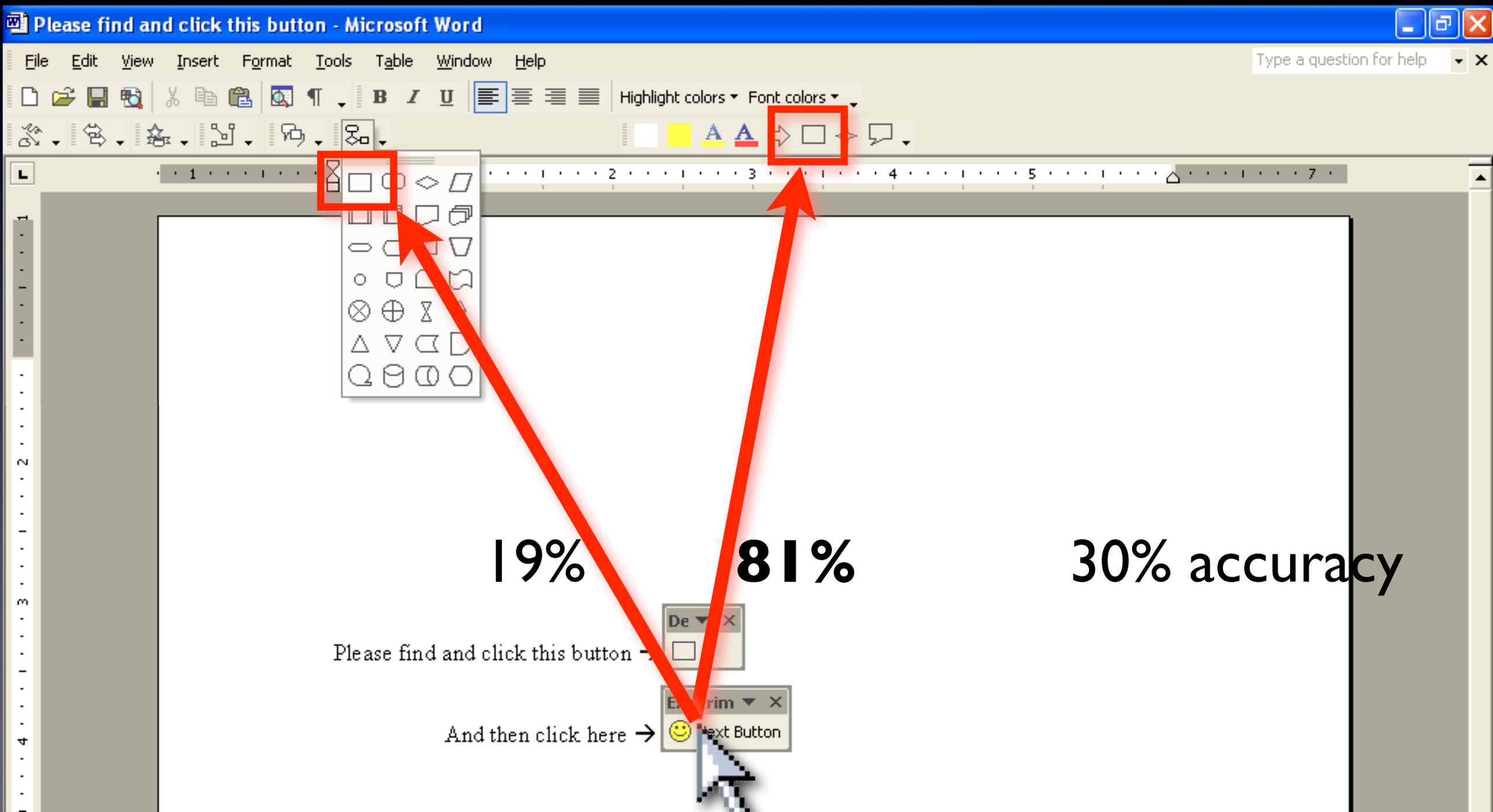
Frequency of Use Vs. Accuracy



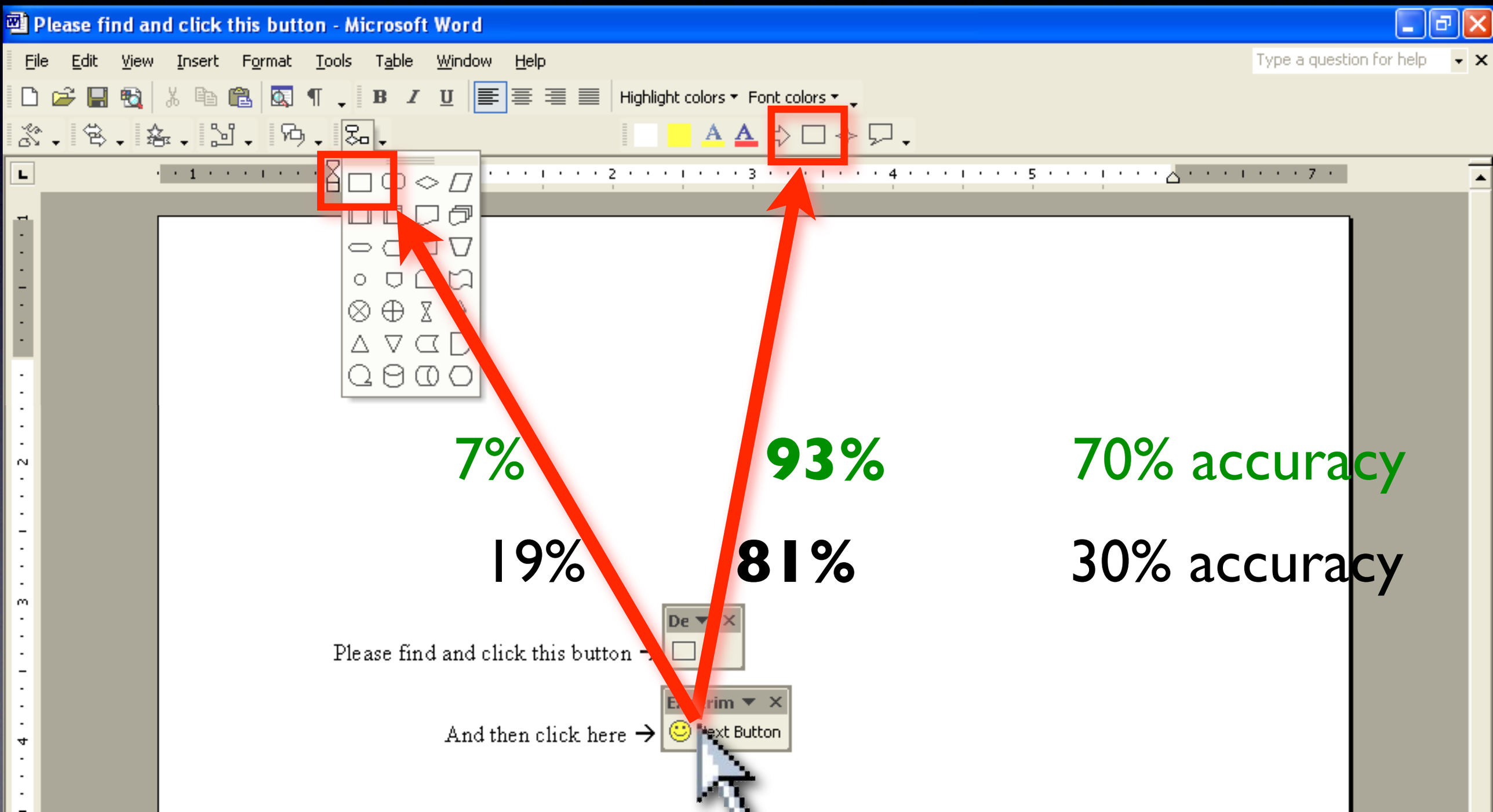
Frequency of Use Vs. Accuracy



Frequency of Use Vs. Accuracy



Frequency of Use Vs. Accuracy



User Comments

Split Interface	Moving Interface

User Comments

Split Interface	Moving Interface
	- discoverability

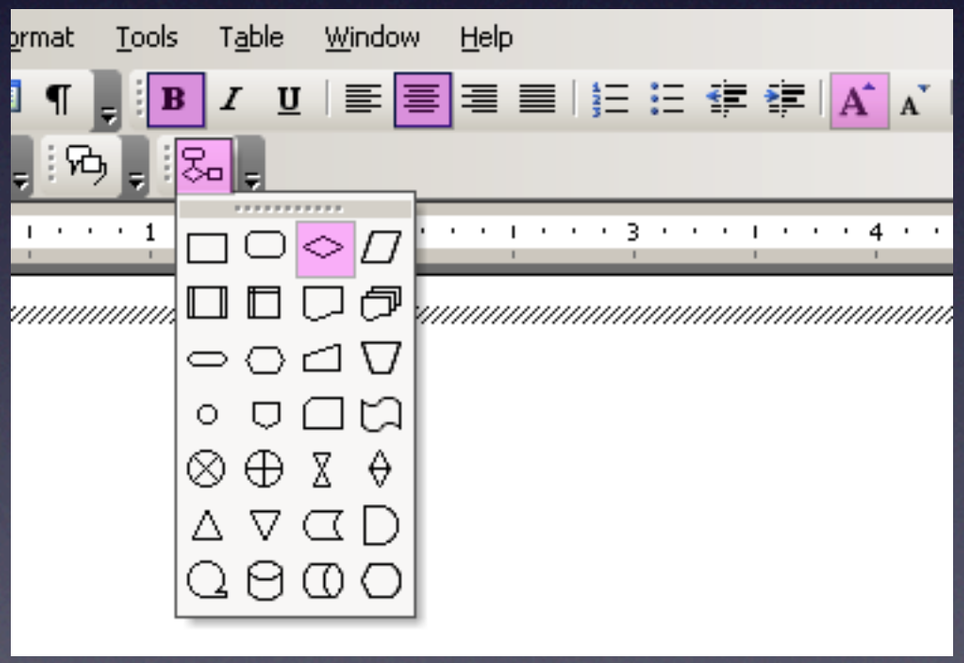
User Comments

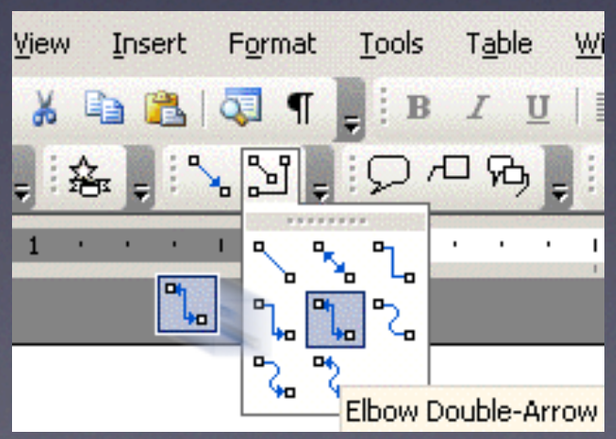
Split Interface	Moving Interface
	- discoverability
- poor discoverability	

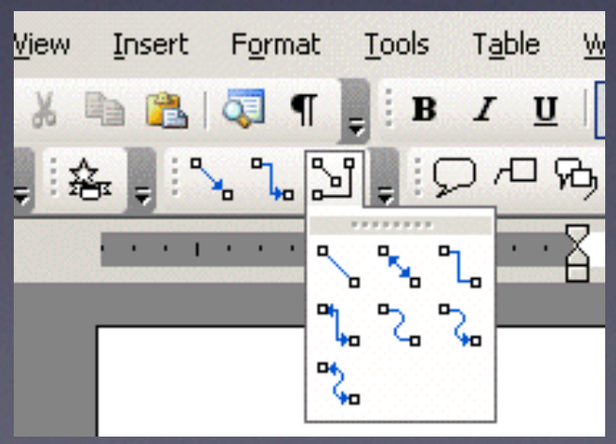
User Comments

Split Interface	Moving Interface
	- discoverability
- poor discoverability	- instability

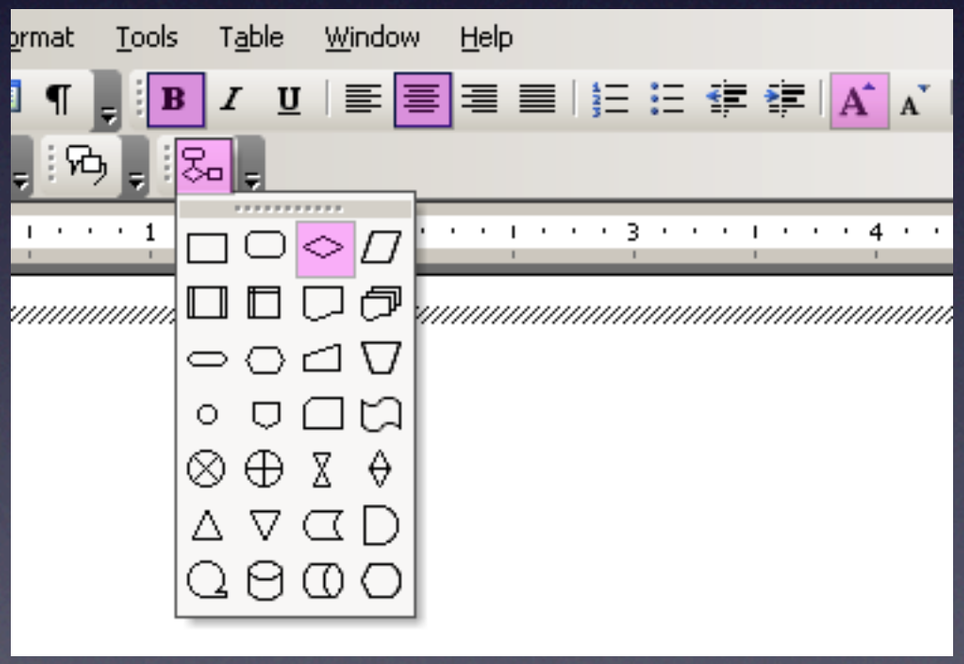
Exploring the Design Space for Adaptive Graphical User Interfaces

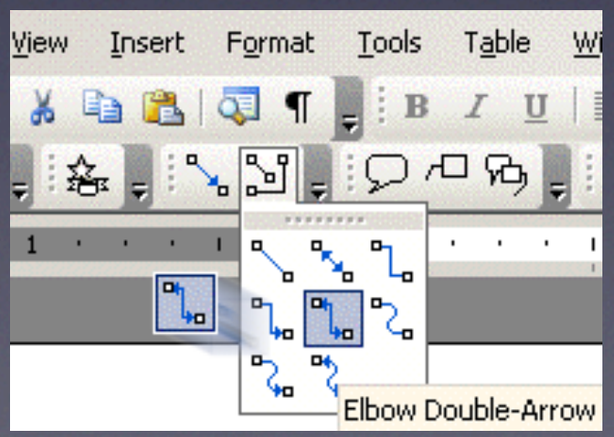


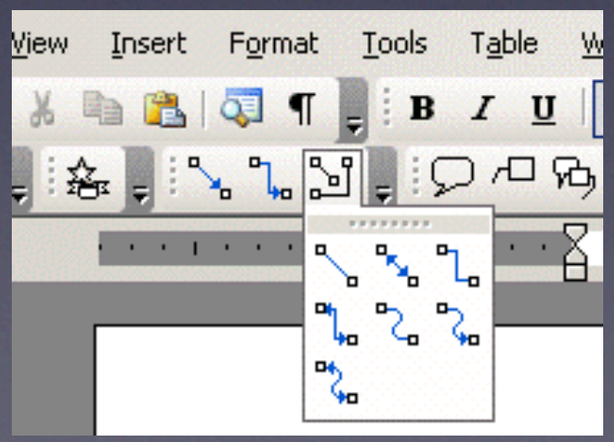




Exploring the Design Space for Adaptive Graphical User Interfaces







Putting It All Together

Putting It All Together

Interaction Mechanics

stability

locality

Putting It All Together

Interaction Mechanics
stability
locality

Algorithm Behavior
frequency of adaptation
accuracy
predictability

Putting It All Together

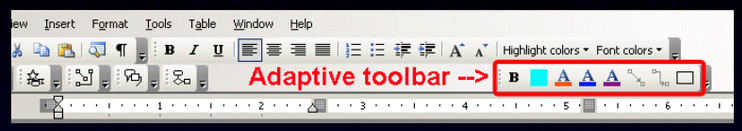
Interaction Mechanics	Algorithm Behavior	Context
stability	frequency of adaptation	interaction frequency
locality	accuracy	task complexity
	predictability	

Stability

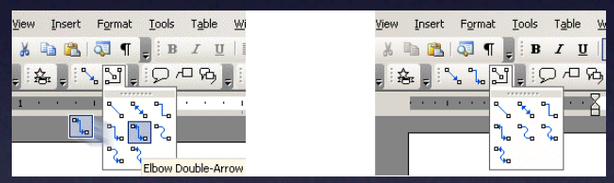
Interaction Mechanics	Algorithm Behavior	Context
stability	frequency of adaptation	interaction frequency
locality	accuracy	task complexity
	predictability	

User satisfaction

Split Interfaces



Moving Interface



Low stability

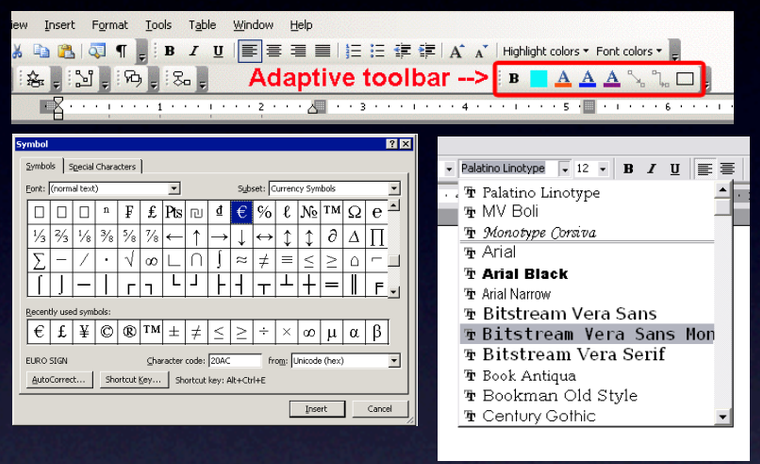
High stability

Stability

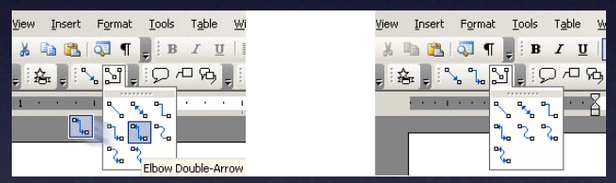
Interaction Mechanics	Algorithm Behavior	Context
stability	frequency of adaptation	interaction frequency
locality	accuracy	task complexity
	predictability	

User satisfaction

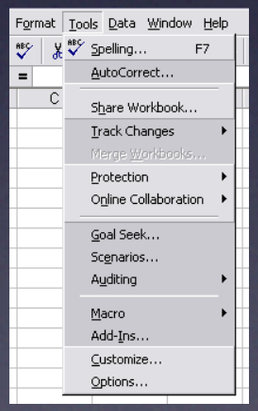
Split Interfaces



Moving Interface



MS Smart Menus



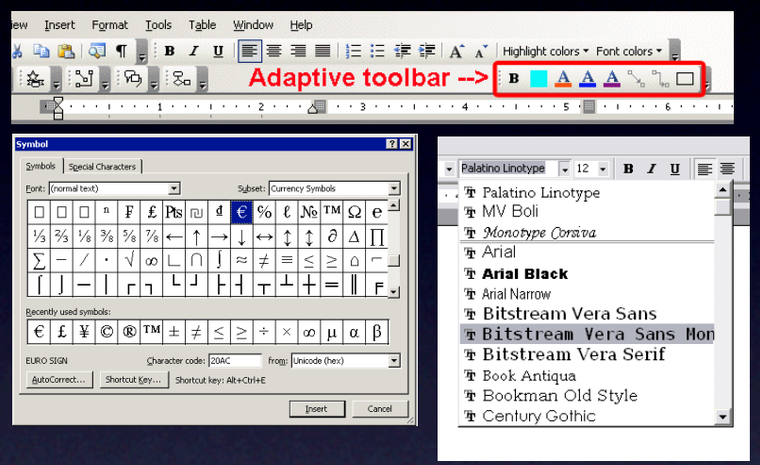
Low stability *High stability*

Stability

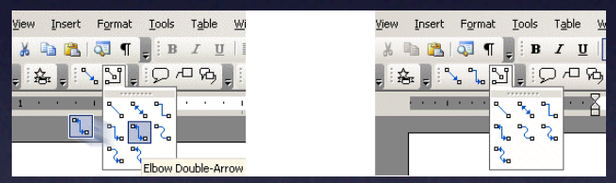
Interaction Mechanics	Algorithm Behavior	Context
stability	frequency of adaptation	interaction frequency
locality	accuracy	task complexity
	predictability	

User satisfaction

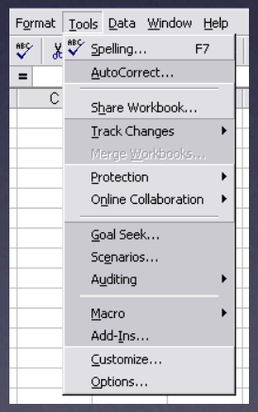
Split Interfaces



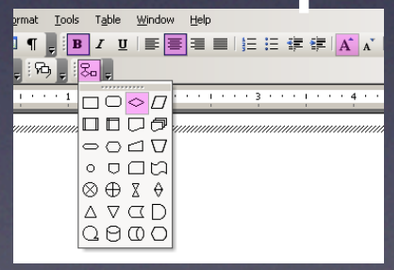
Moving Interface



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

Two studies of Split Menus:

↑ Sears and Shneiderman [1994]

↓ Findlater and McGrenere [2004]

Adaptation Frequency

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

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

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

Accuracy

- Participants performed faster at higher accuracy levels

(also in [Tsandilas and schraefel CHI'05])

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

Accuracy

- 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

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

Accuracy

- 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

- More disorienting interfaces affected more by reduced accuracy

[Tsandilas and schraefel CHI'05]

Predictability

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

A study in progress!

Interaction Frequency

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

Two studies of adaptive deep hierarchical menus:

↑ Greenberg and Witten [1985]

↕ Trevellyan and Browne [1987]

Interaction Frequency

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

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

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

Task Complexity

Experiment 1

Split Interface	Moving Interface
- stability - semantic grouping	- discoverability
- poor discoverability	- instability

Experiment 2

Split Interface	Moving Interface
	- discoverability
- poor discoverability	- instability

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

Task Complexity

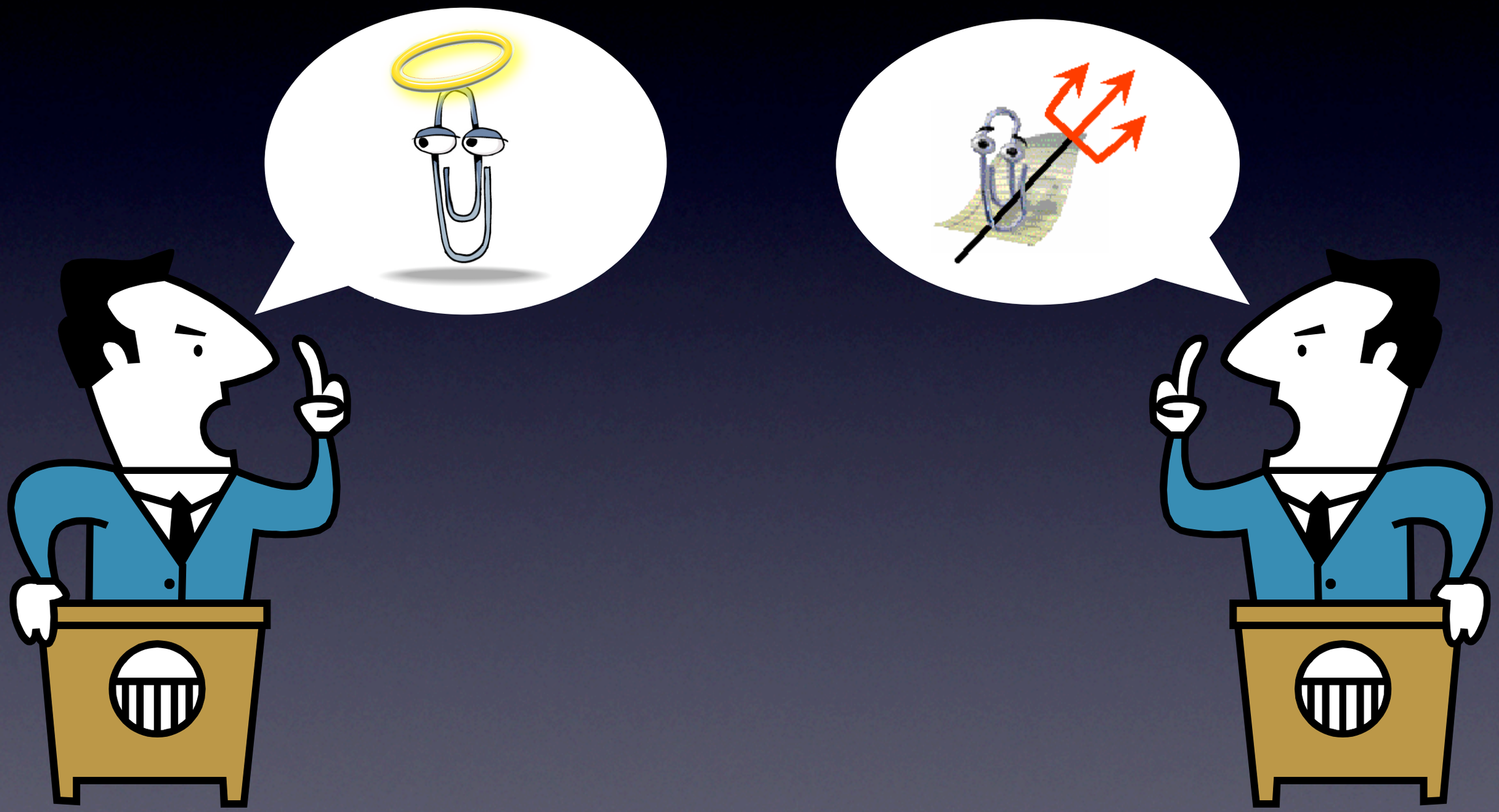
Experiment 1

Split Interface	Moving Interface
- stability - semantic grouping	- discoverability
- poor discoverability	- instability

Experiment 2

Split Interface	Moving Interface
	- discoverability
- poor discoverability	- instability

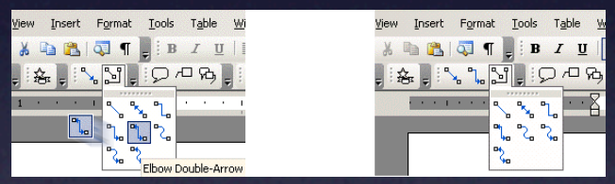
Conclusions



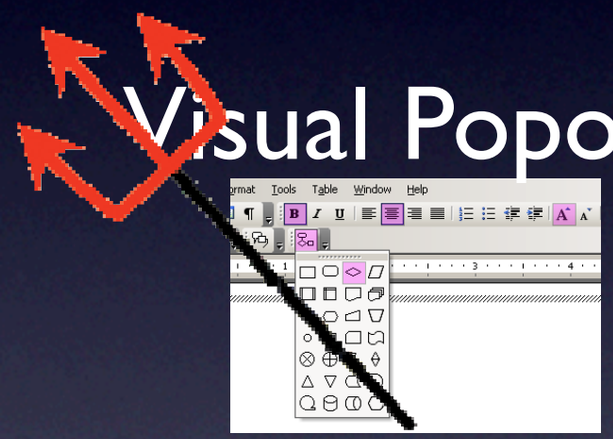
Conclusions

Split Interface

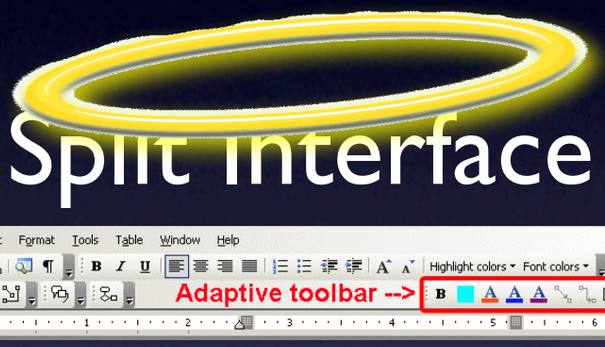
Moving Interface



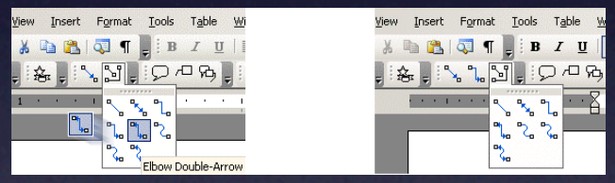
Visual Popout



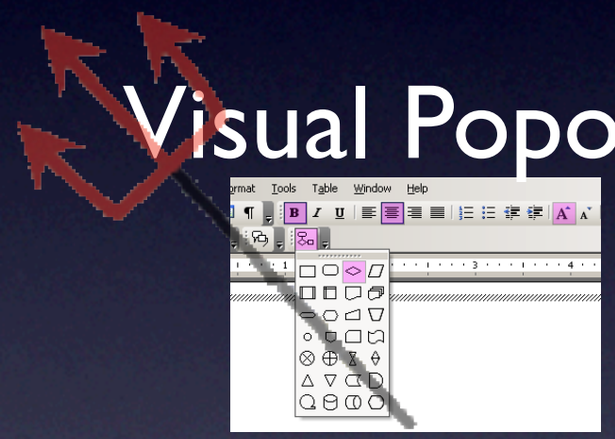
Conclusions



Split Interface



Moving Interface



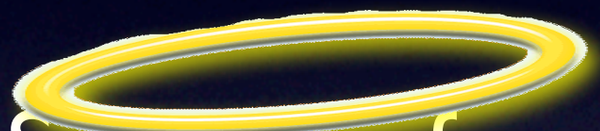
Visual Popout

Preferred

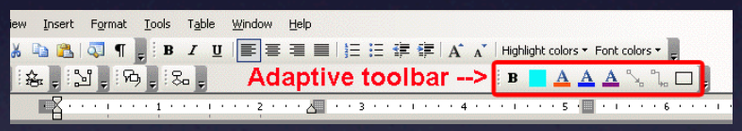
[Experiment 1]

Disliked

Conclusions

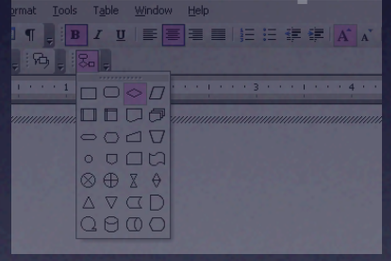


Split Interface



Moving Interface

Visual Popout



Preferred

Faster

[Experiment 2]

Disliked

Conclusions

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

Acknowledgments

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

Contact Information

- Krzysztof Gajos:
  kgajos@cs.washington.edu
- Mary Czerwinski:
  marycz@microsoft.com
- Desney Tan:
  desney@microsoft.com
- Daniel Weld:
  weld@cs.washington.edu