

# MenuOptimizer

## Interactive Optimization of Menu Systems



Gilles  
Bailly



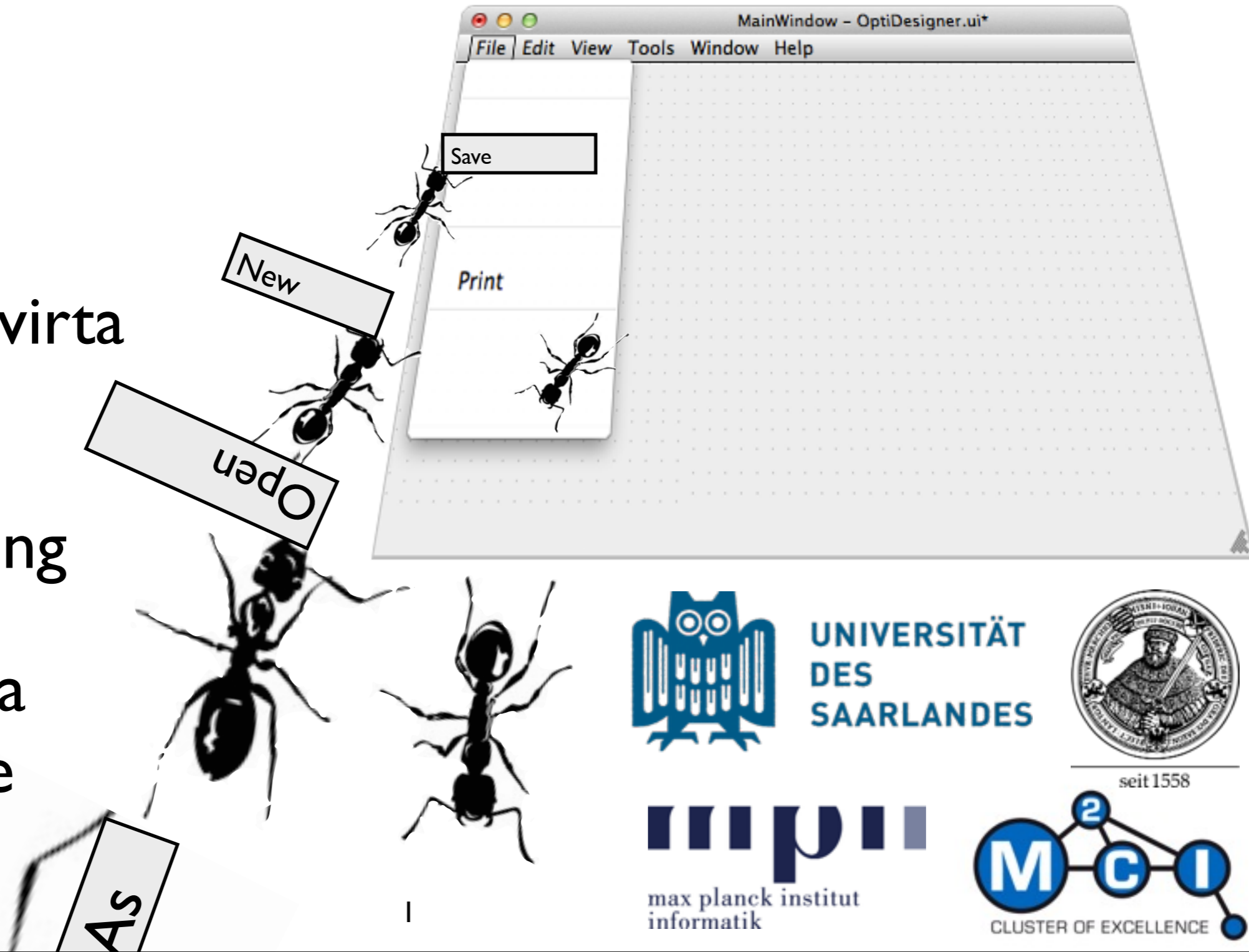
Antti  
Oulasvirta



Timo  
Koetzing



Sabrina  
Hoppe



UNIVERSITÄT  
DES  
SAARLANDES



seit 1558



max planck institut  
informatik



CLUSTER OF EXCELLENCE

Edit Insert Slide Format Arrange View Play Window Share

Undo ⌘Z  
Redo ⇧⌘Z

Cut ⌘X  
Copy ⌘C  
Paste ⌘V  
Paste and Match Style ⇧⇧⌘V  
Delete  
Clear All

Duplicate ⌘D  
Select All ⌘A  
Deselect All ⇧⌘A

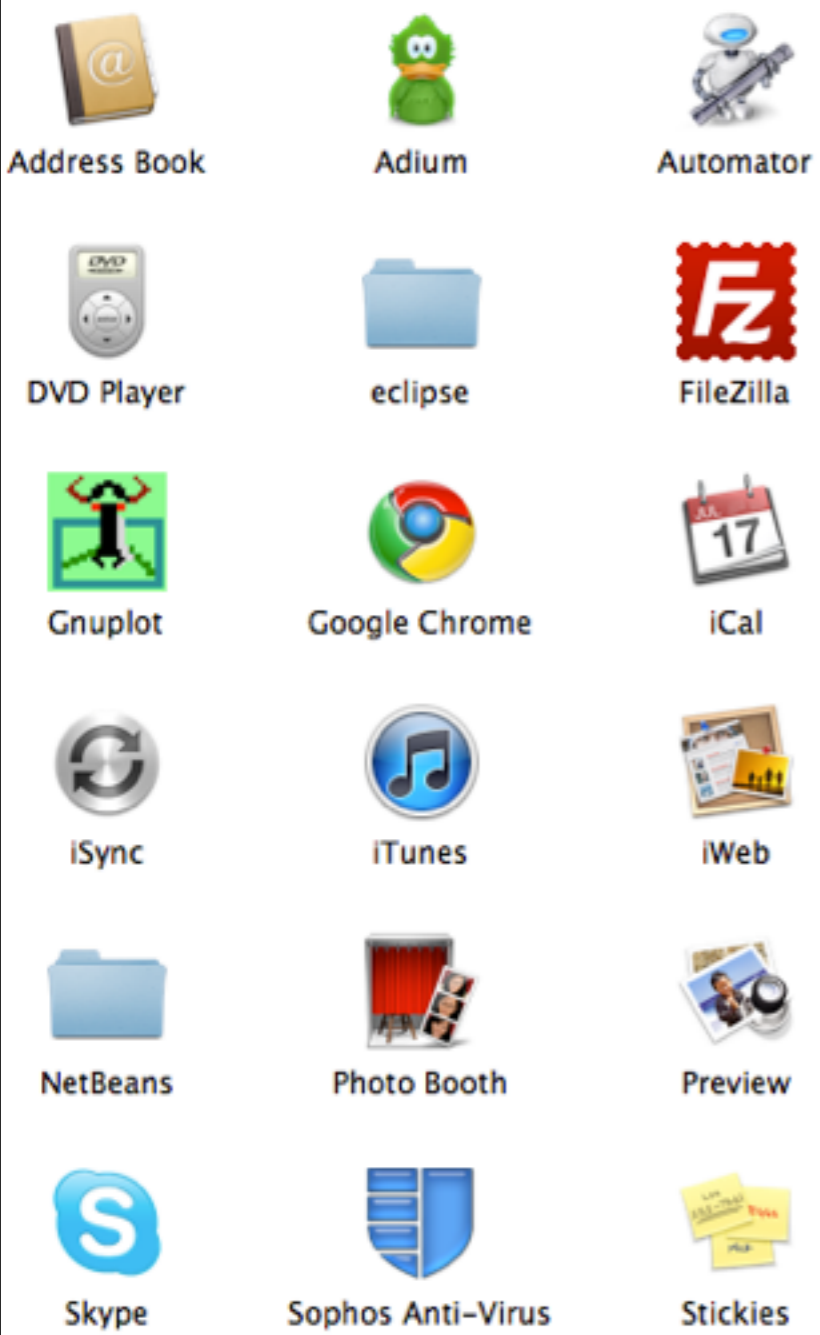
Find ▶

Spelling ▶  
Special Characters...

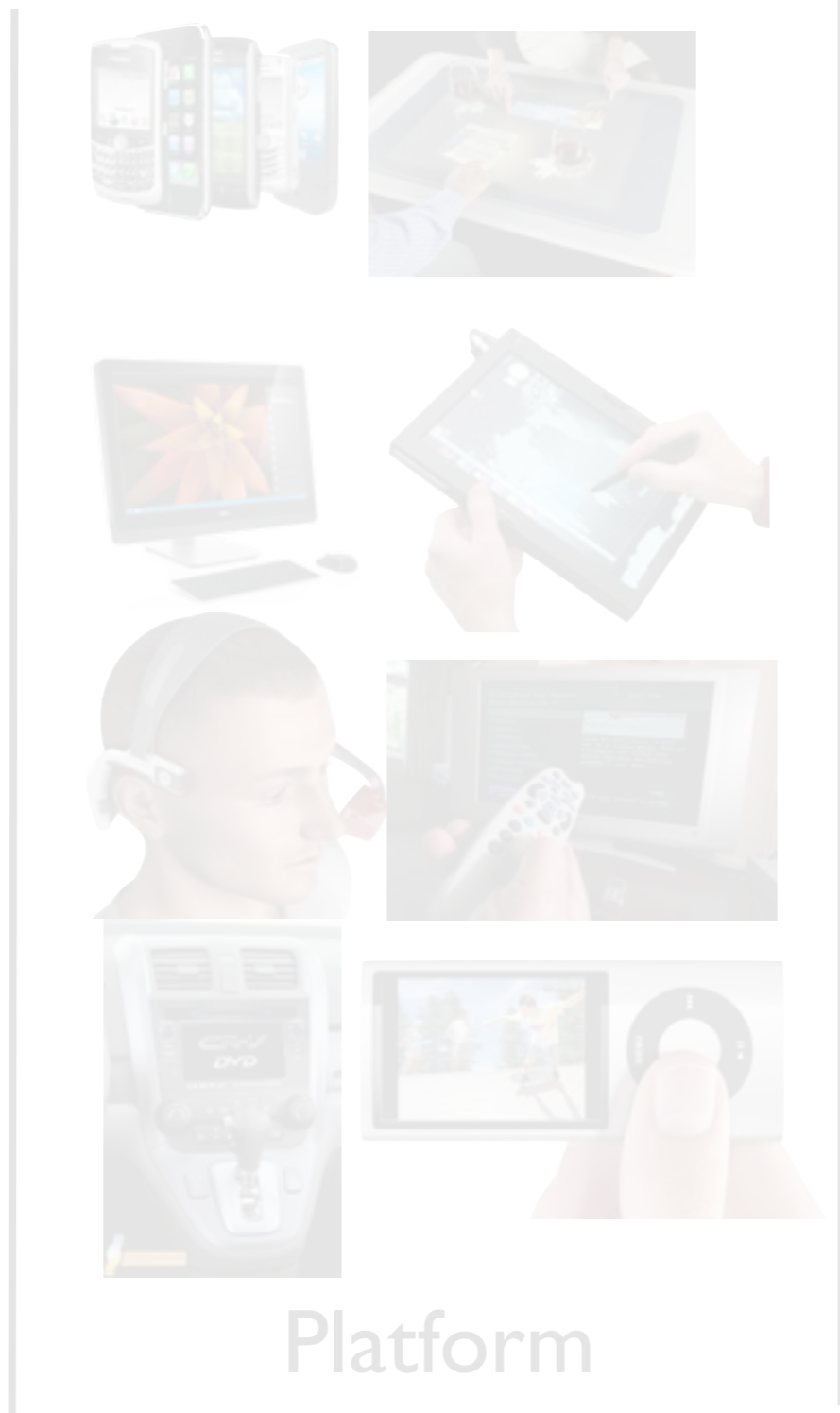
Find... ⌘F  
Find Next ⌘G  
Find Previous ⇧⌘G  
Use Selection for Find ⌘E  
Jump to Selection ⌘J

Menu Systems are widespread...

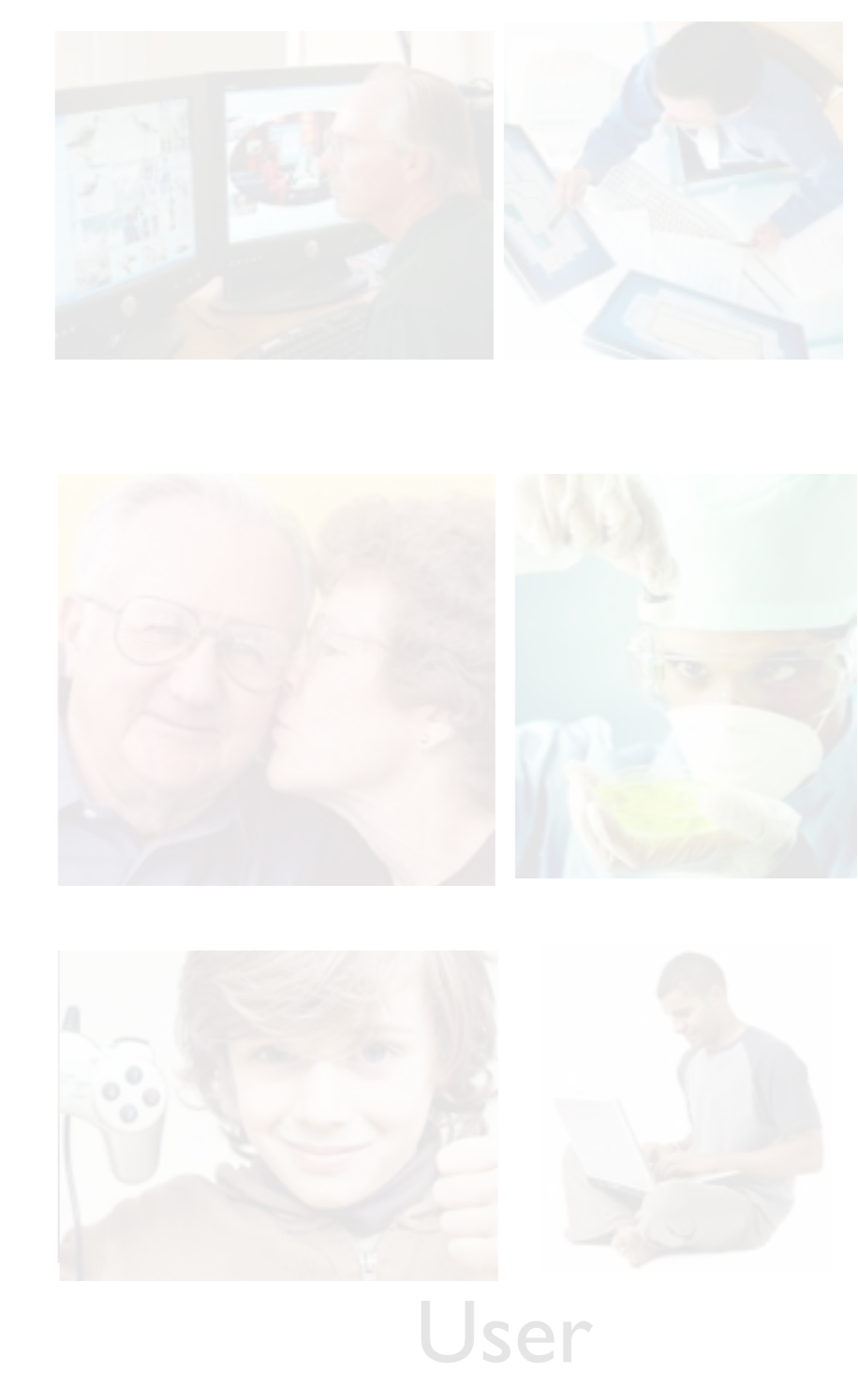
eHotkey  
d.mp4



Application

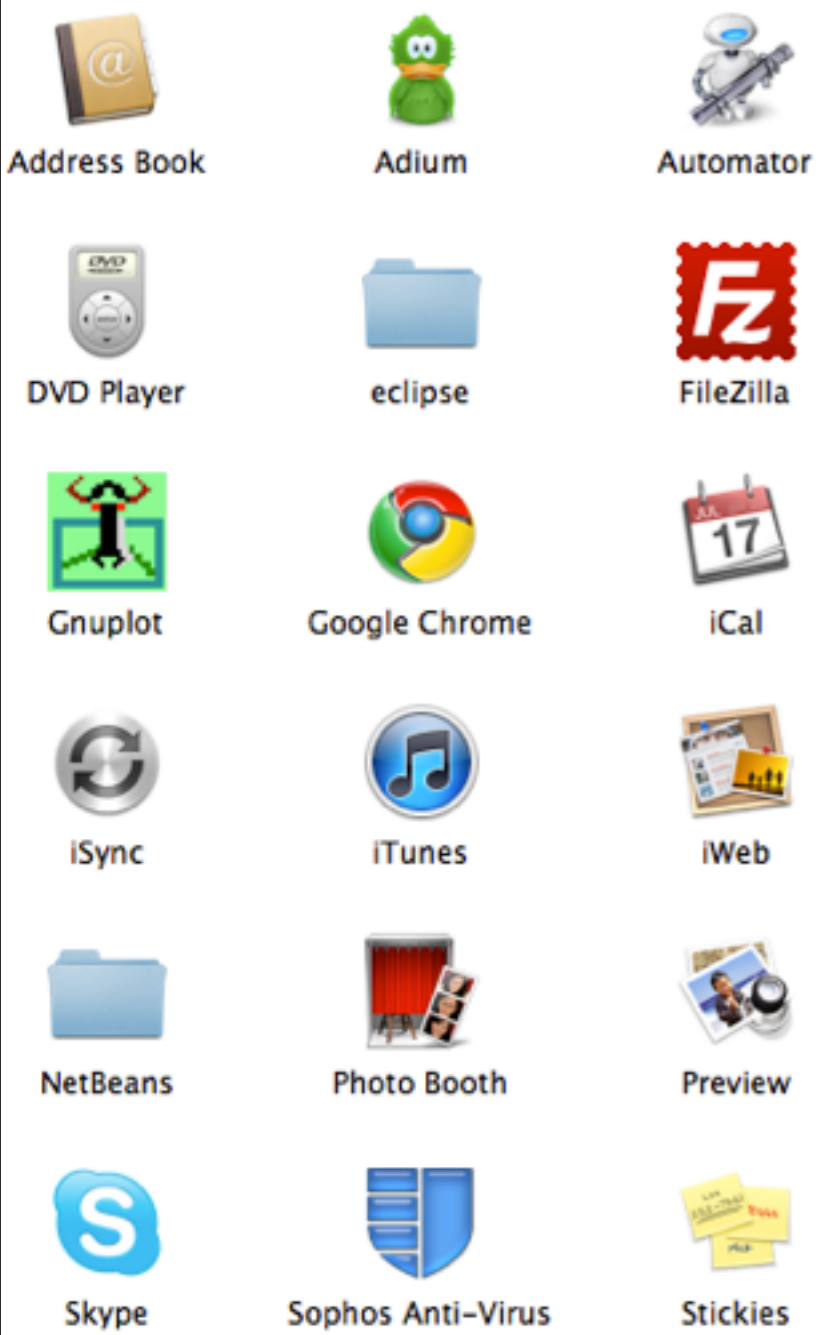


Platform



User

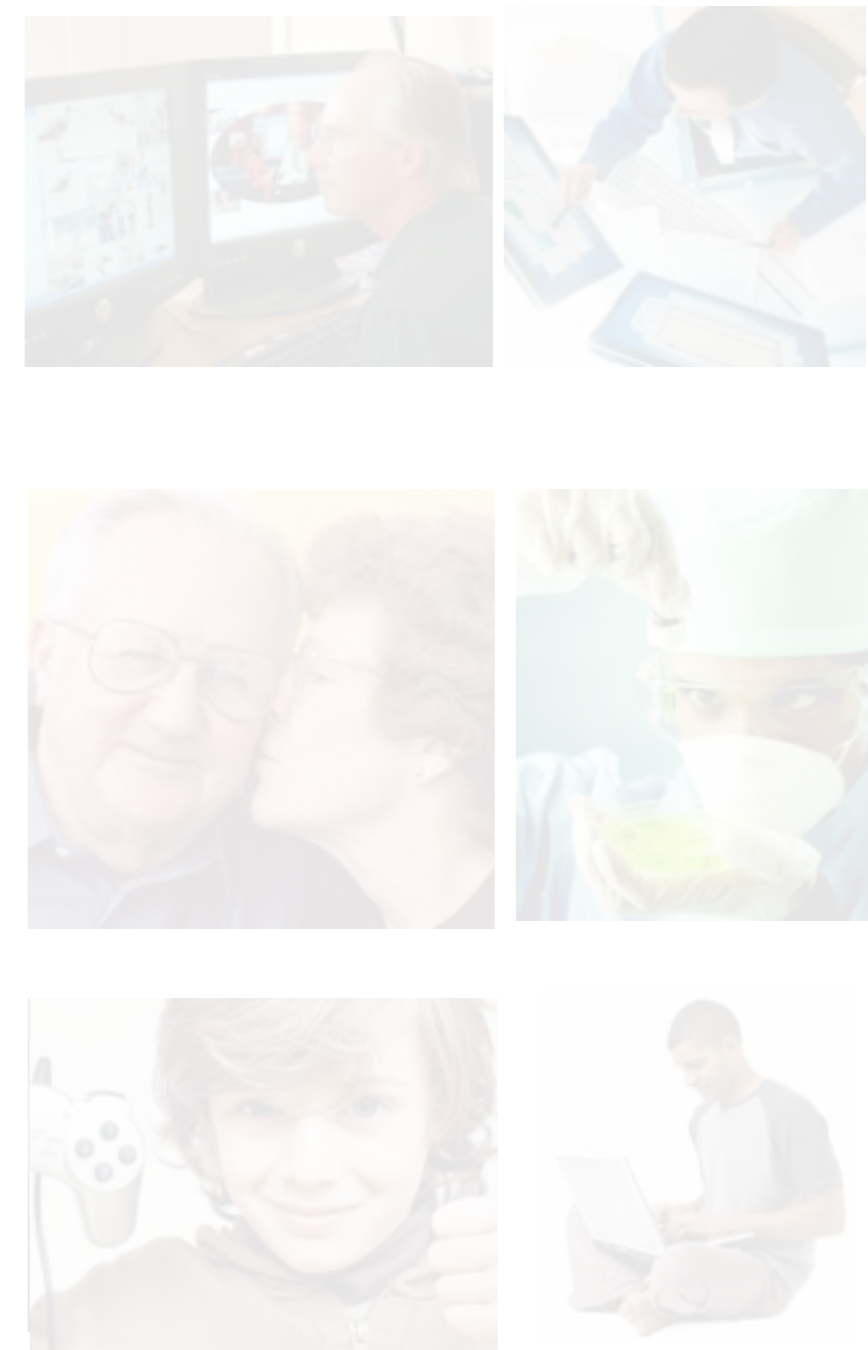
Menu Systems are widespread...



Application



Platform



User

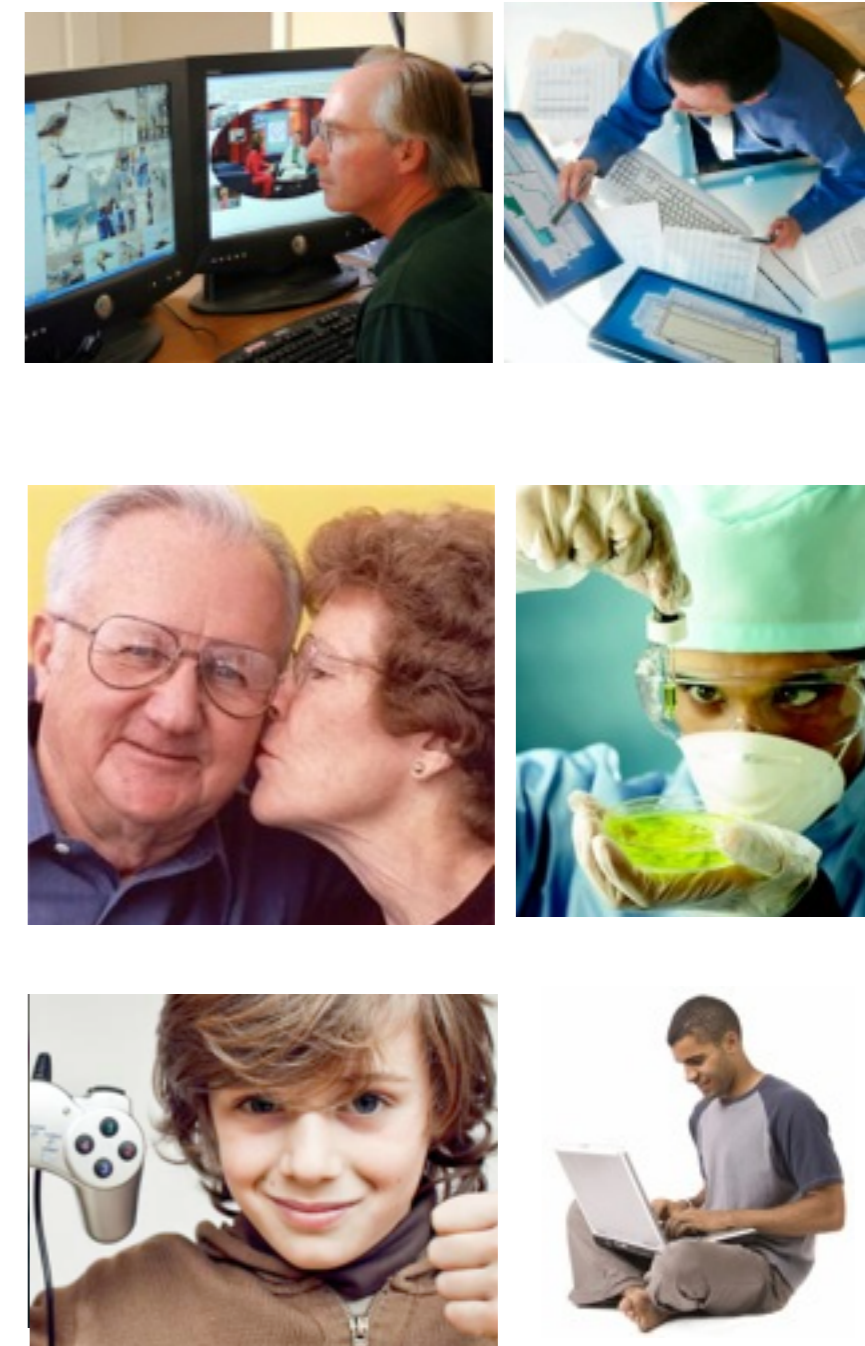
Menu Systems are widespread...



Application



Platform



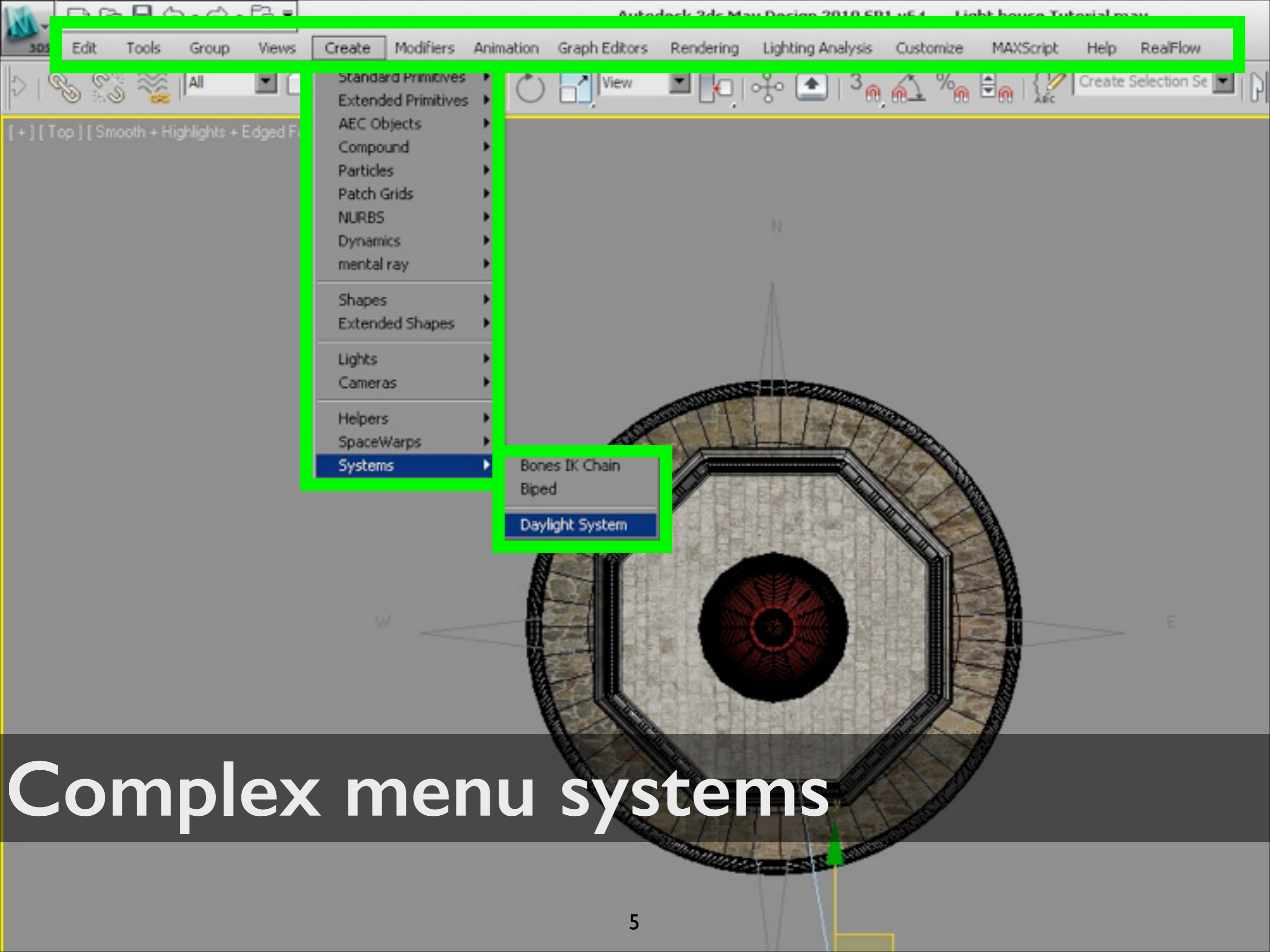
User

Menu Systems are widespread...

Designing menu systems is **easy**

Designing menu systems is *easy*

Designing **usable** menu systems is **difficult**



Autodesk 3ds Max Design 2010.601.v64 - Light house Tutorial.max  
Edit Tools Group Views Create Modifiers Animation Graph Editors Rendering Lighting Analysis Customize MAXScript Help RealFlow

- Standard Primitives
- Extended Primitives
- AEC Objects
- Compound
- Particles
- Patch Grids
- NURBS
- Dynamics
- mental ray
- Shapes
- Extended Shapes
- Lights
- Cameras
- Helpers
- SpaceWarps
- Systems

- Bones IK Chain
- Biped
- Daylight System

Complex menu systems



- Interview of 6 experienced menu designers
  - 1-3 complex menu systems per year (~ 1000 commands)

- Findings

1. Designing menus is difficult
2. Designing menus is an interactive process
3. Designers focus too much on novice users  
"Satisfy the *immediate expectations* of their clients"

Designers do not focus enough on expert users and long-term efficiency.

# Interviews

How to help **designers**

to design **usable** menu Systems?

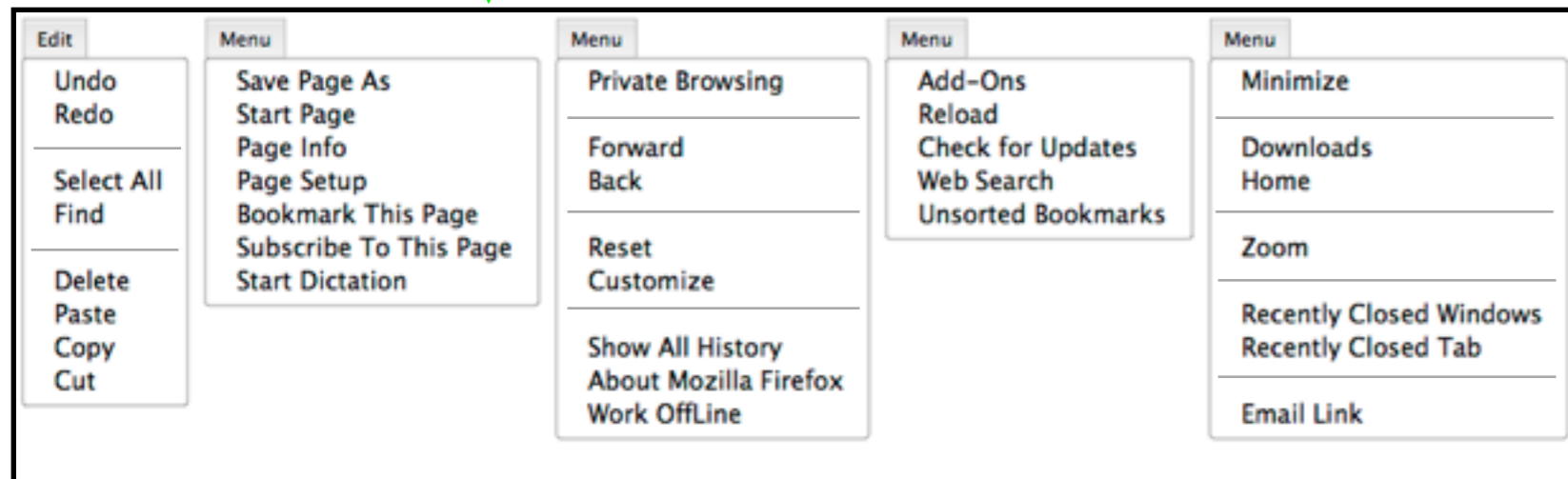
**Research question**

# MenuOptimizer

Designer



Edit



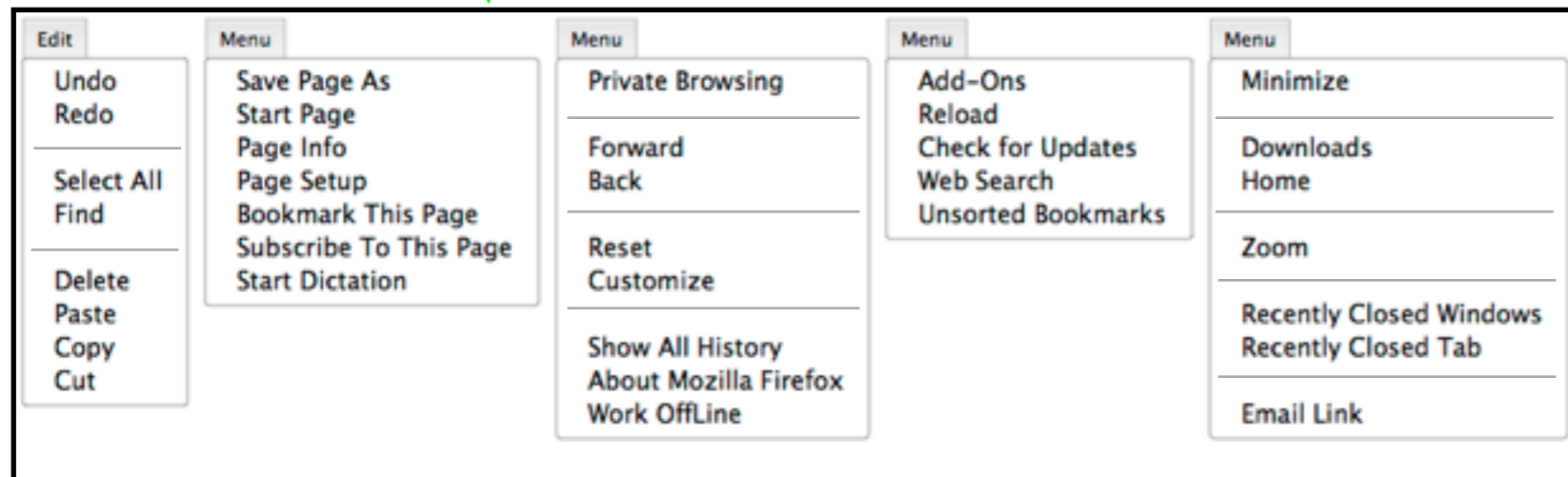
# MenuOptimizer

Designer



Optimizer

Edit



# MenuOptimizer

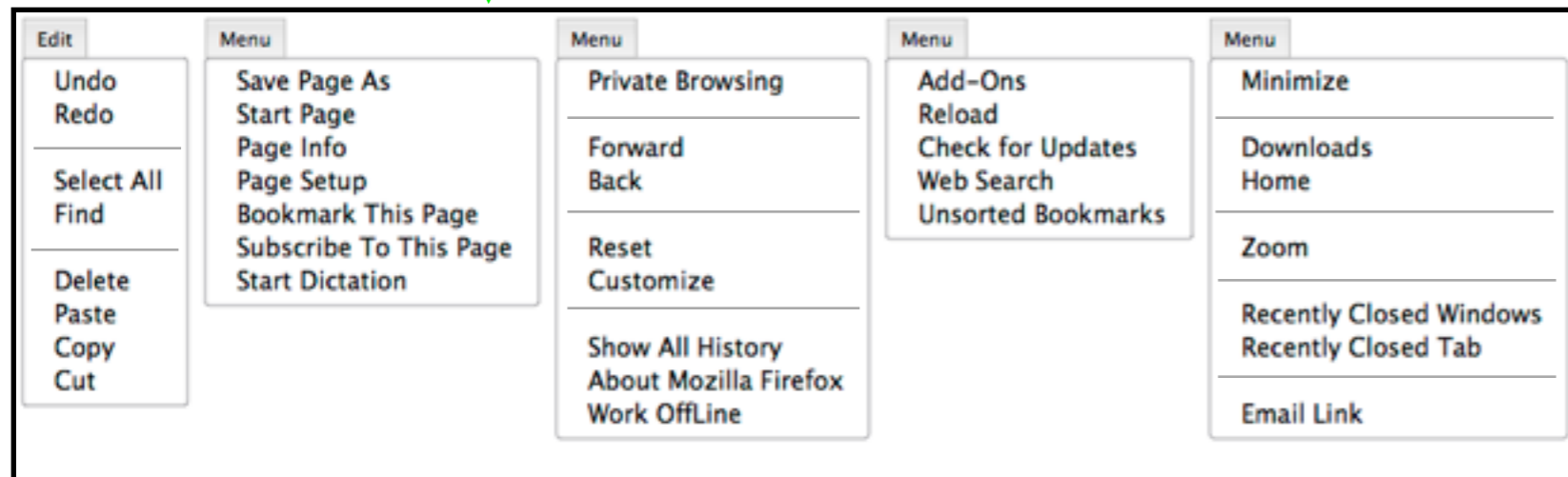
Edit goals  
and assumptions

Designer

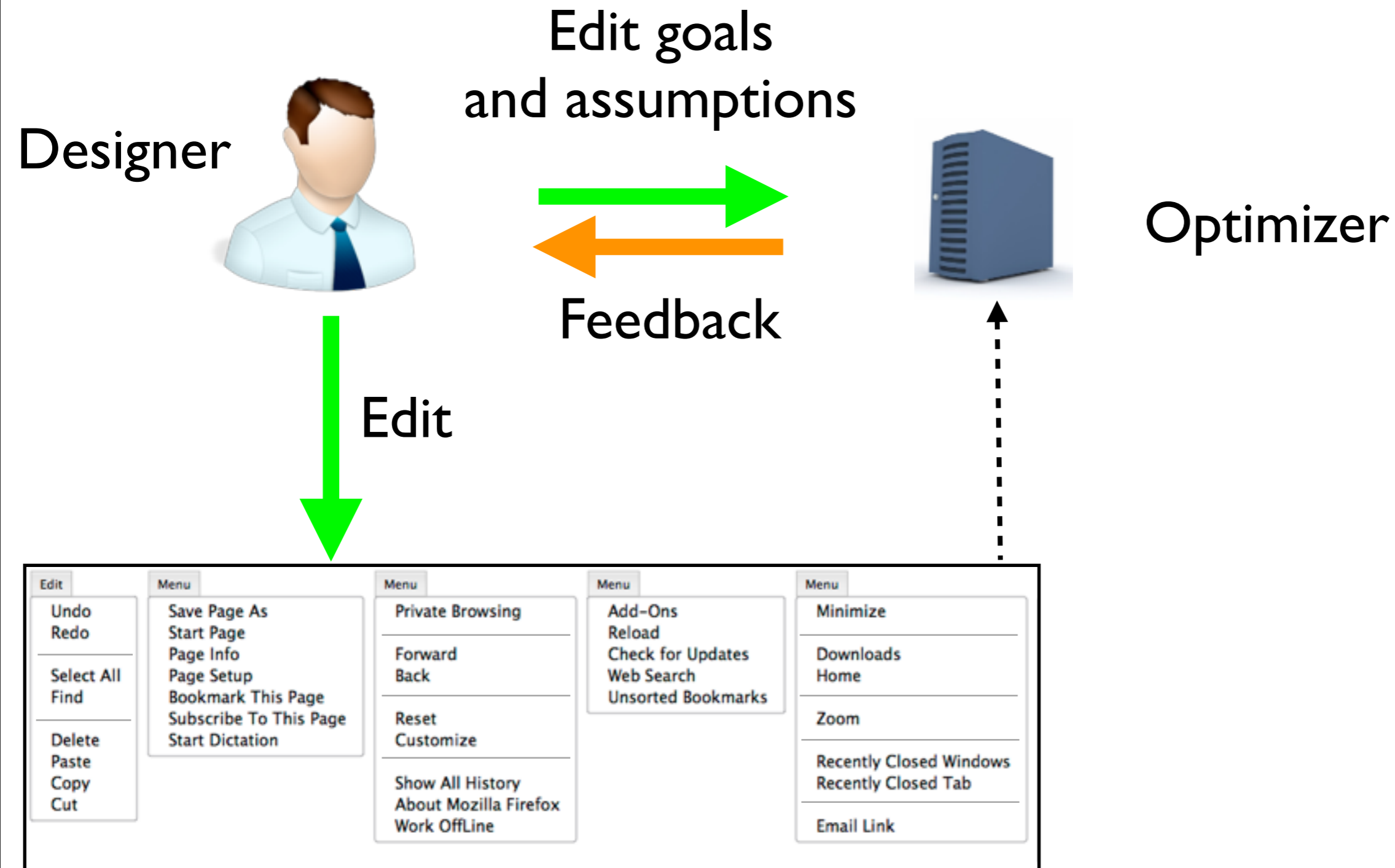


Optimizer

Edit



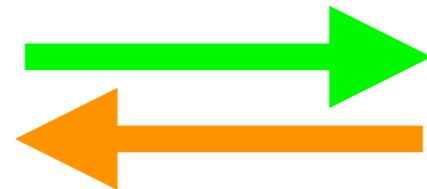
# MenuOptimizer



# MenuOptimizer

Edit goals  
and assumptions

Designer



Feedback

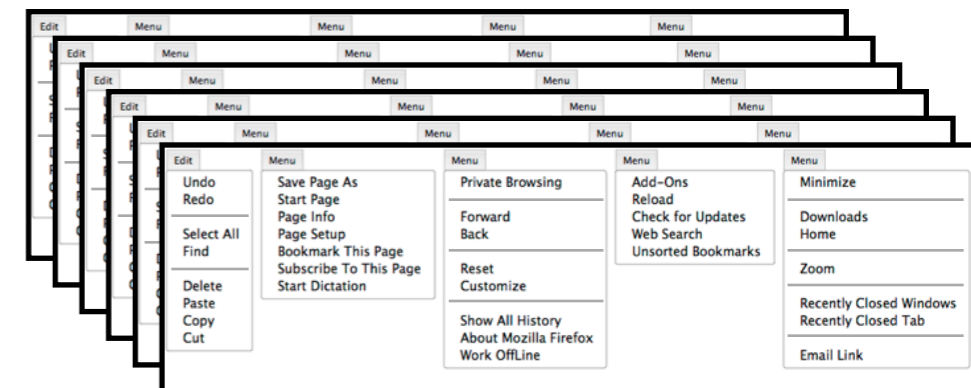
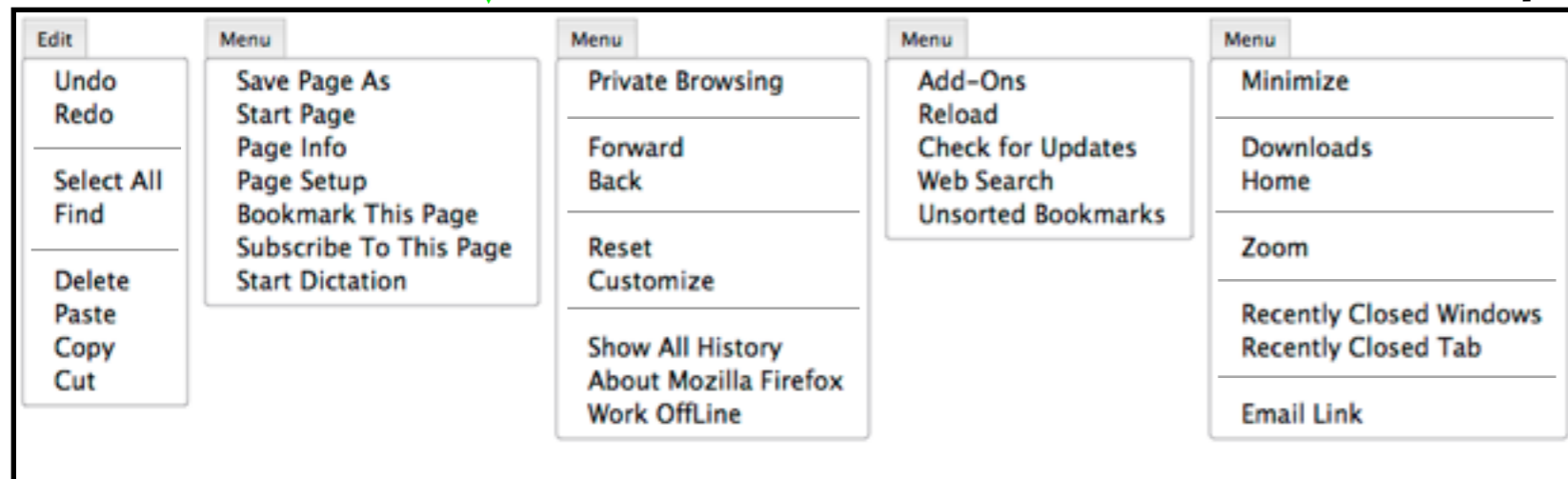


Optimizer

Edit



suggestions





Widget Box

- Layouts
  - Vertical Layout
  - Horizontal Layout
  - Grid Layout
- Spacers
  - Horizontal Spacer
  - Vertical Spacer
- Buttons
  - OK Push Button
  - Tool Button
  - Radio Button
  - Checkbox
  - Button
- Item View
  - List Widget
  - Tree Widget
  - Table Widget
  - Column View
- Item Widget (Item-Based)
  - List Widget
  - Tree Widget
  - Table Widget
- Containers
  - Group Box
  - Tool Box

Add a torrent - addtorrentform.ui

Select a torrent source

Torrent file:

Tracker URL: <none>

Creator: <none>

Comment: <none>

Size: 0

File(s):

Destination:

Object Inspector

Object: C1

- AddTorrentFile: QD
- <noname>: QH

Property Editor

Property: Value

- QObject
- objectName: ...
- QWidget

Signal/Slot Editor

Sender	Signal	Receiver
okButton	clicked()	...
cancelButton	clicked()	...

Resource Editor: addtorren...

Current Resource: <no resource files>

Action Editor

Filter:



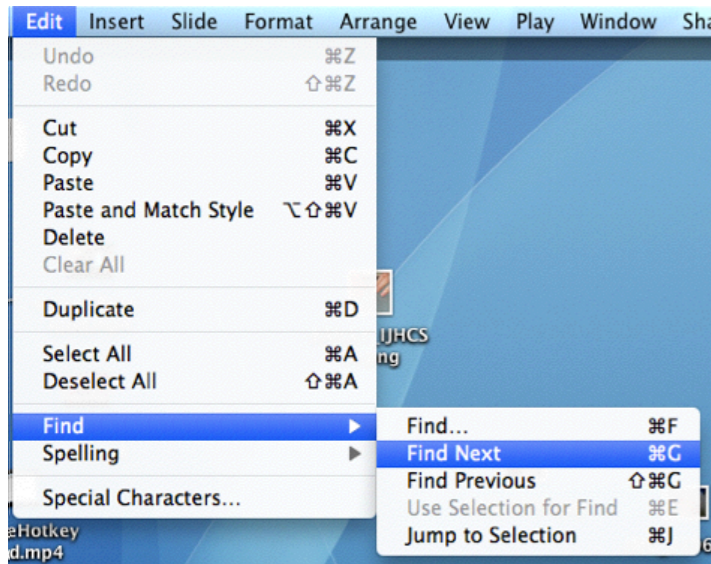
# Designer



**Designing** menu systems is

**a combinatorial problem**

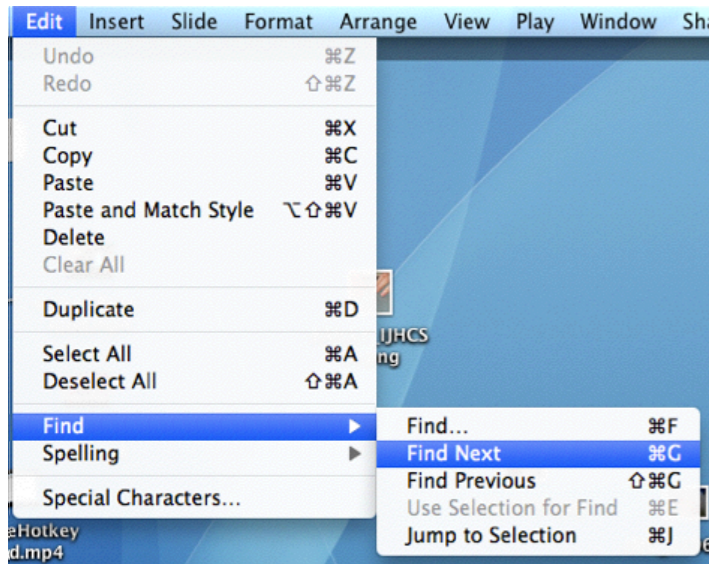
# Combinatorial Problem



50 items :  
~ $10^{158}$  designs

**Huge**  
Design Space

# Combinatorial Problem



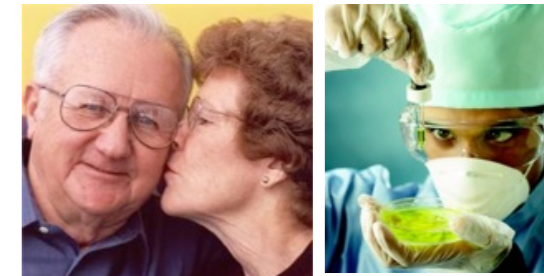
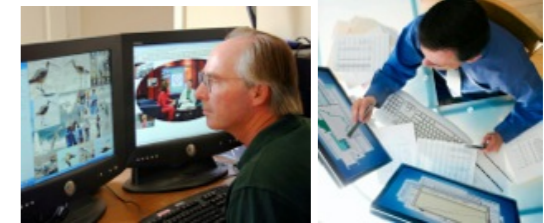
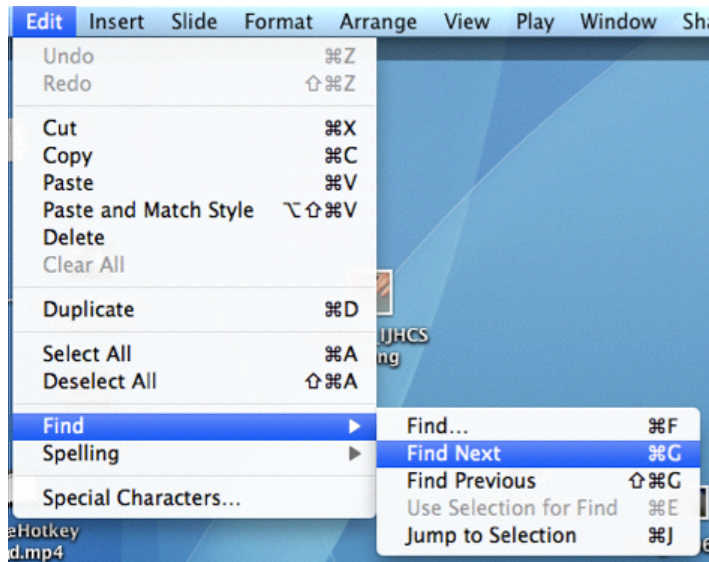
Speed, Accuracy  
Aesthetics, etc.

50 items :  
 $\sim 10^{158}$  designs

**Huge**  
Design Space

**Multiple**  
Objectives

# Combinatorial Problem



Speed, Accuracy  
Aesthetics, etc.

50 items :  
 $\sim 10^{158}$  designs

**Huge**  
Design Space

**Multiple**  
Objectives

**Diversity of**  
User Population

# Design Process

Define problems  
Define constraints  
Cope with uncertainty  
Recognize good solutions



Designer

Off-line  
Optimization

# Design Process

Define problems  
Define constraints  
Cope with uncertainty  
Recognize good solutions



Designer

## Combinatorial problem

- Huge Design space
- Multiple objectives
- Diversity of user Population



Off-line  
Optimization

# Design Process

Define problems  
Define constraints  
Cope with uncertainty  
Recognize good solutions



Designer

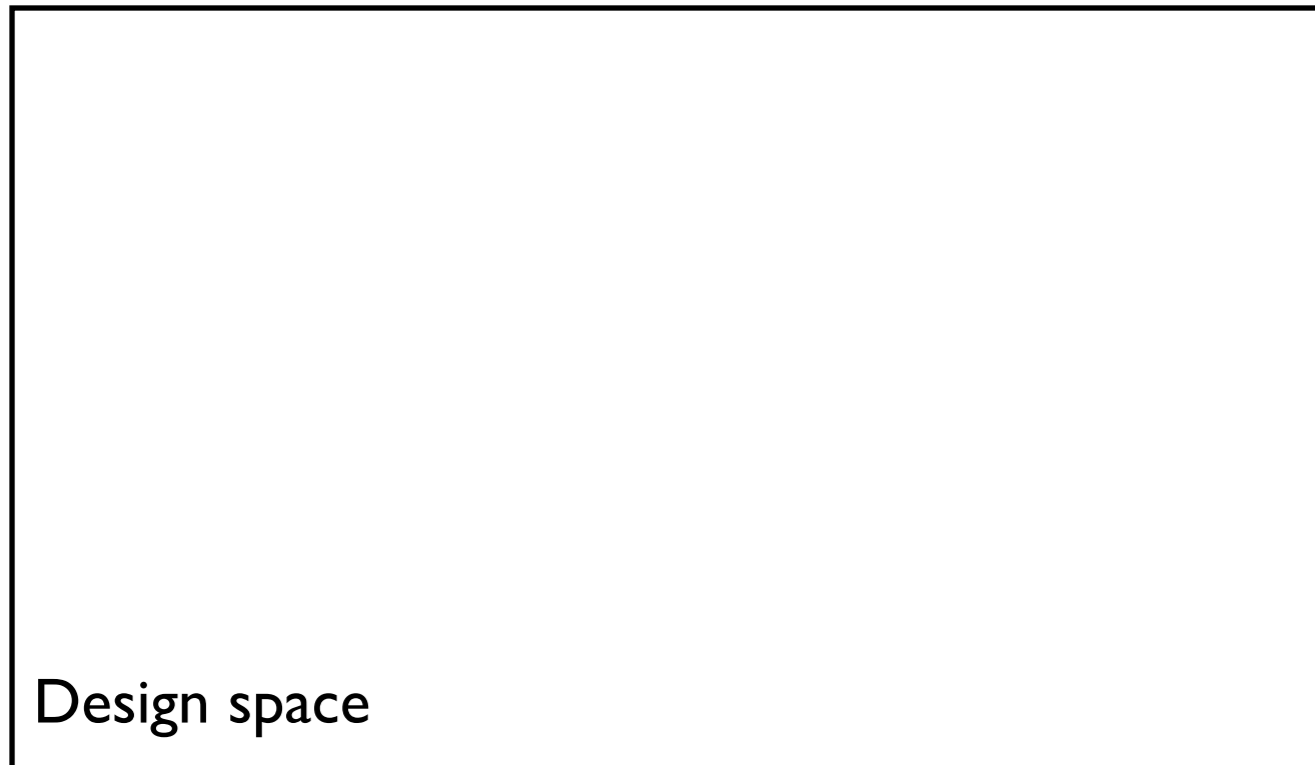
## Combinatorial problem

- Huge Design space
- Multiple objectives
- Diversity of user Population



Off-line  
Optimization

# Optimization Method





# Optimization Method



X

Design space

Generate

# Optimization Method

$$f(x) = ?$$

Design space

Generate



Estimate

# Optimization Method



Generate

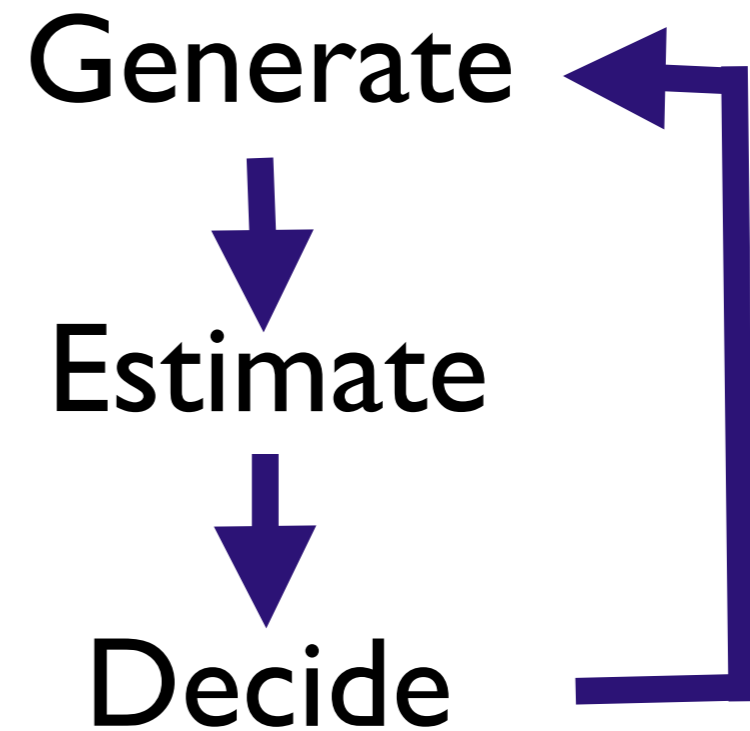
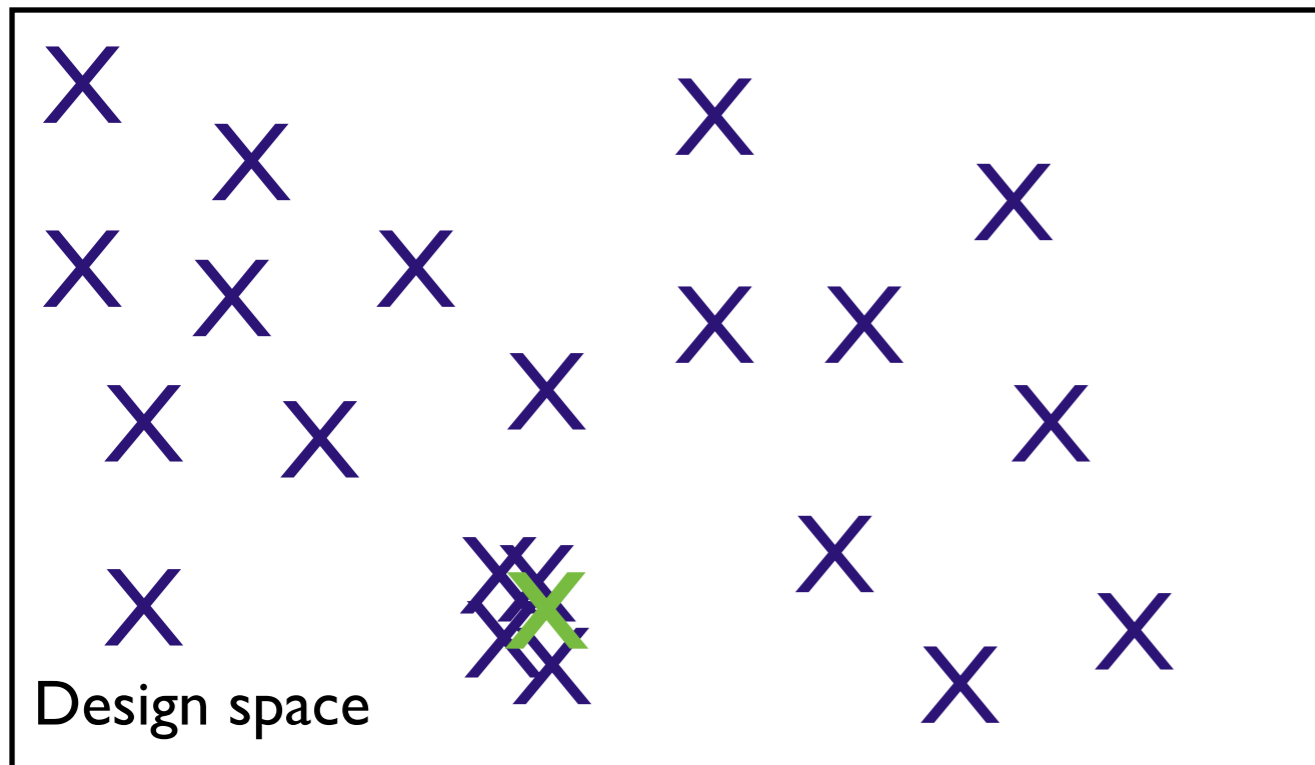


Estimate



Decide

# Optimization Method



# Optimization Methods

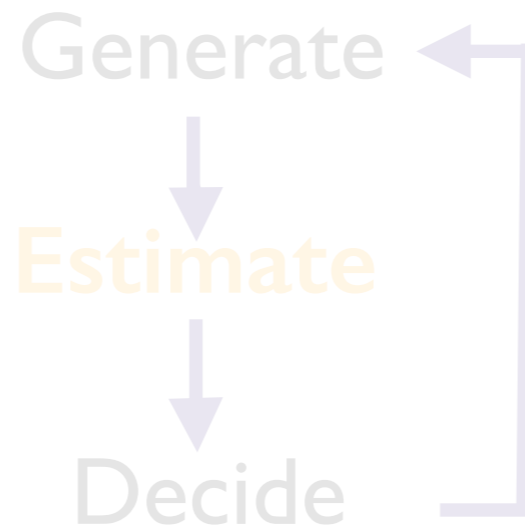
- **Text entry** [Light 93; Zhai 00; Oulasvirta 13; Eggers 03]
- **Menus** [Matsui 08; Goubko 10]
- **Accessibility** [Gajos 04; Gajos 07]
- **Dialog layout** [Fogarty 03]

# Optimization Methods

- Limitations

Open  
Save  
Save As  
Close  
...

1  
Problem  
definition



2  
Predictive  
model

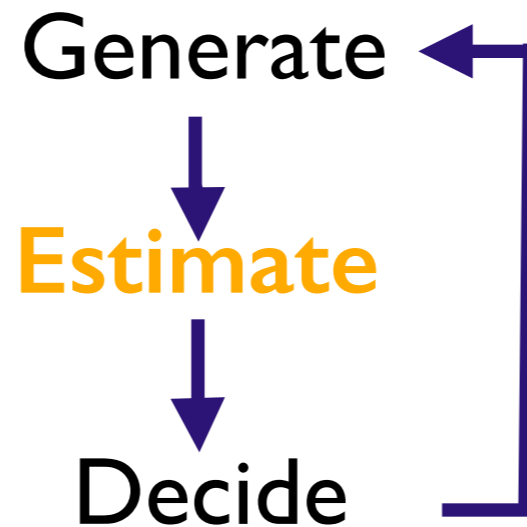


3  
Time  
constraint

# Optimization Methods

## ● Limitations

Open  
Save  
Save As  
Close  
...



1  
Problem  
definition

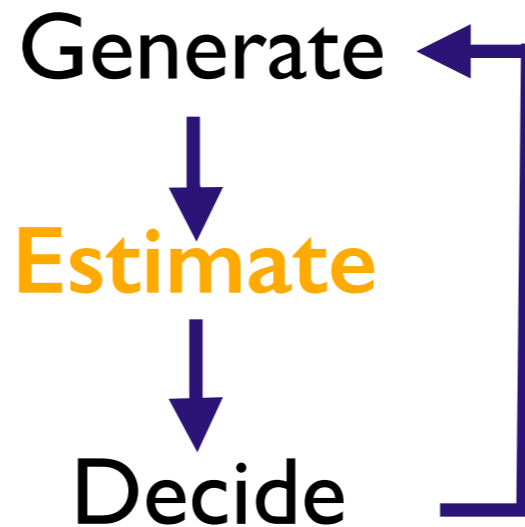
2  
Predictive  
model

3  
Time  
constraint

# Optimization Methods

- Limitations

Open  
Save  
Save As  
Close  
...



1  
Problem  
definition

2  
Predictive  
model

3  
Time  
constraint



# Design Process



Designer



Off-line  
Optimization

# Design Process



Designer

Human-Aided  
Optimization

Off-line  
Optimization

[Anderson 00;  
Quiroz 07;  
Scott 02]

# Design Process



Designer



**Interactive  
Optimization**

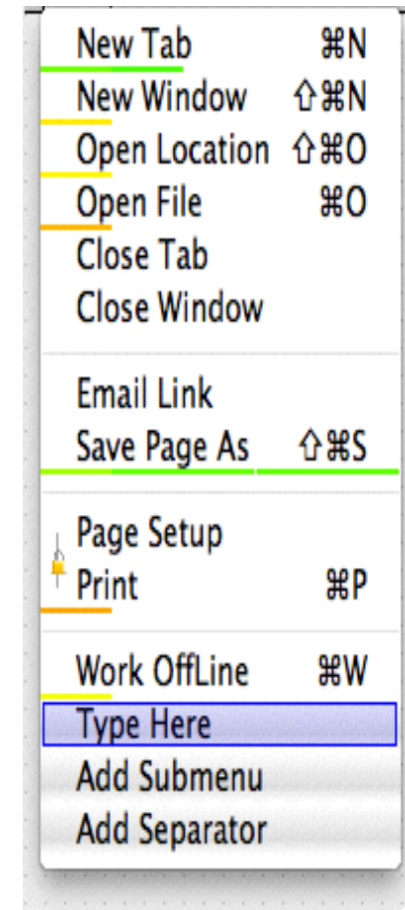
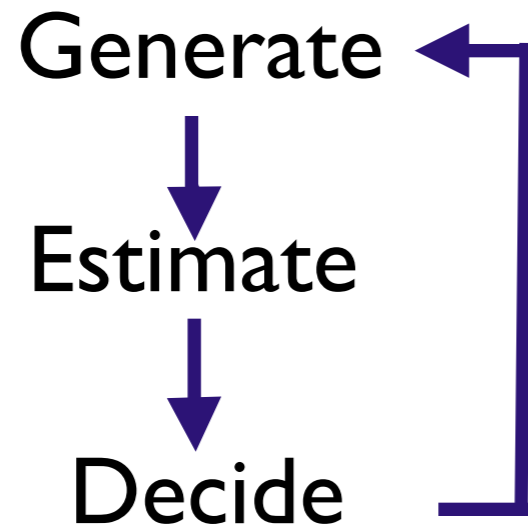


Human-Aided  
Optimization



Off-line  
Optimization

[Anderson 00;  
Quiroz 07;  
Scott 02]



## Optimizer



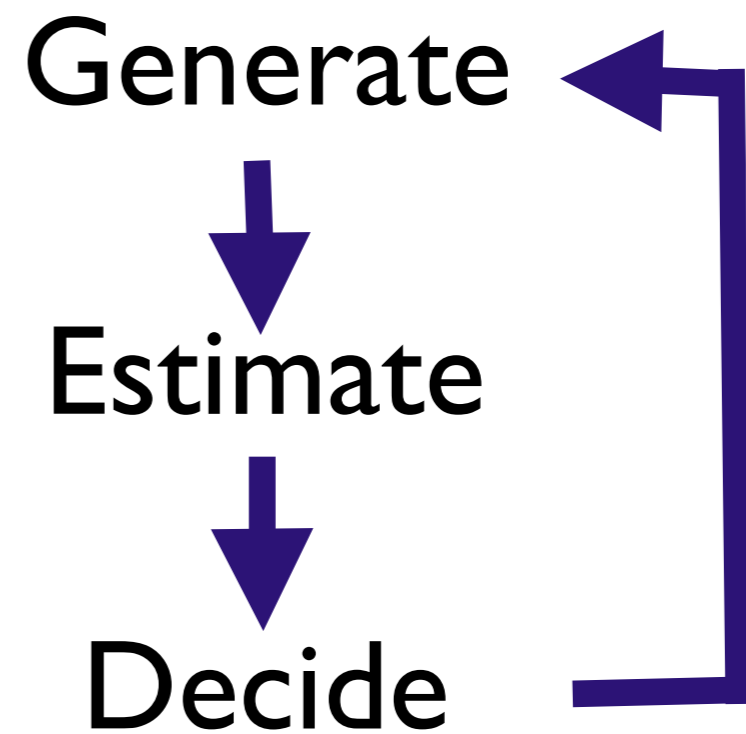
## Interactions



# Challenges

# Optimizer

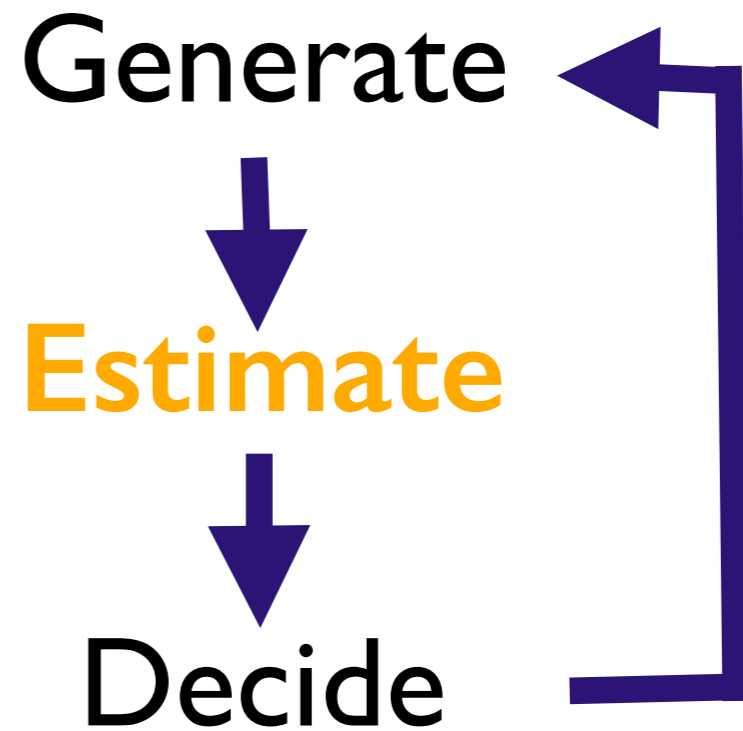
## Ant Colony Optimization



More details in the paper

# Optimizer

Which  
Predictive Model ?



# Search - Decision - Pointing Model (SDP)

[Cockburn 07]

$$T = f(L, T, H, P)$$

The model is based on Fitt's law and Hick-Hyman law

# Search - Decision - Pointing Model (SDP)

[Cockburn 07]

$$T = f(L, T, H, P)$$

Selection time ↑

The model is based on Fitt's law and Hick-Hyman law



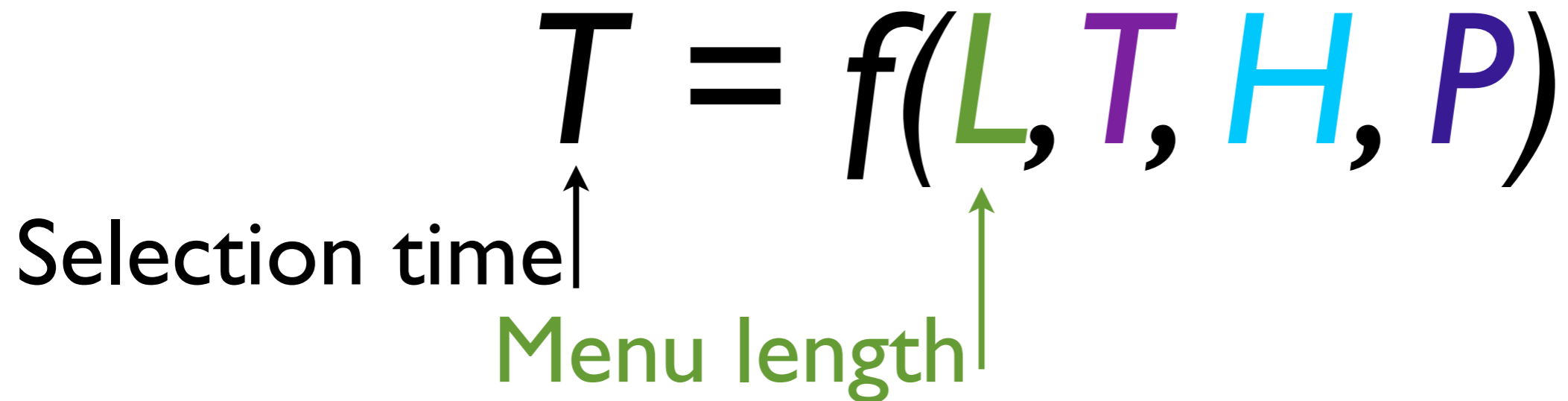
# Search - Decision - Pointing Model (SDP)

[Cockburn 07]

$$T = f(L, T, H, P)$$

Selection time ↑

Menu length ↑

The diagram shows the equation T = f(L, T, H, P). The variable T on the left is labeled 'Selection time' with an upward-pointing arrow. The variable L inside the function is labeled 'Menu length' with an upward-pointing arrow. The variables T, H, and P are also present inside the function but do not have external labels or arrows.

The model is based on Fitt's law and Hick-Hyman law

# Search - Decision - Pointing Model (SDP)

[Cockburn 07]

$$T = f(L, T, H, P)$$

Selection time ↑

Menu length ↑

Target Position ↑

The diagram shows the equation  $T = f(L, T, H, P)$  where the variables are color-coded:  $L$  is green,  $T$  is purple,  $H$  is cyan, and  $P$  is dark blue. Below the equation, four labels are positioned with arrows pointing upwards to their respective variables: 'Selection time' points to the  $T$  on the left, 'Menu length' points to the green  $L$ , 'Target Position' points to the purple  $T$ , and 'Hick-Hyman law' points to the cyan  $H$ .

The model is based on Fitt's law and Hick-Hyman law

# Search - Decision - Pointing Model (SDP)

[Cockburn 07]

$$T = f(L, T, H, P)$$

Selection time ↑

Menu length ↑

Target Position ↑

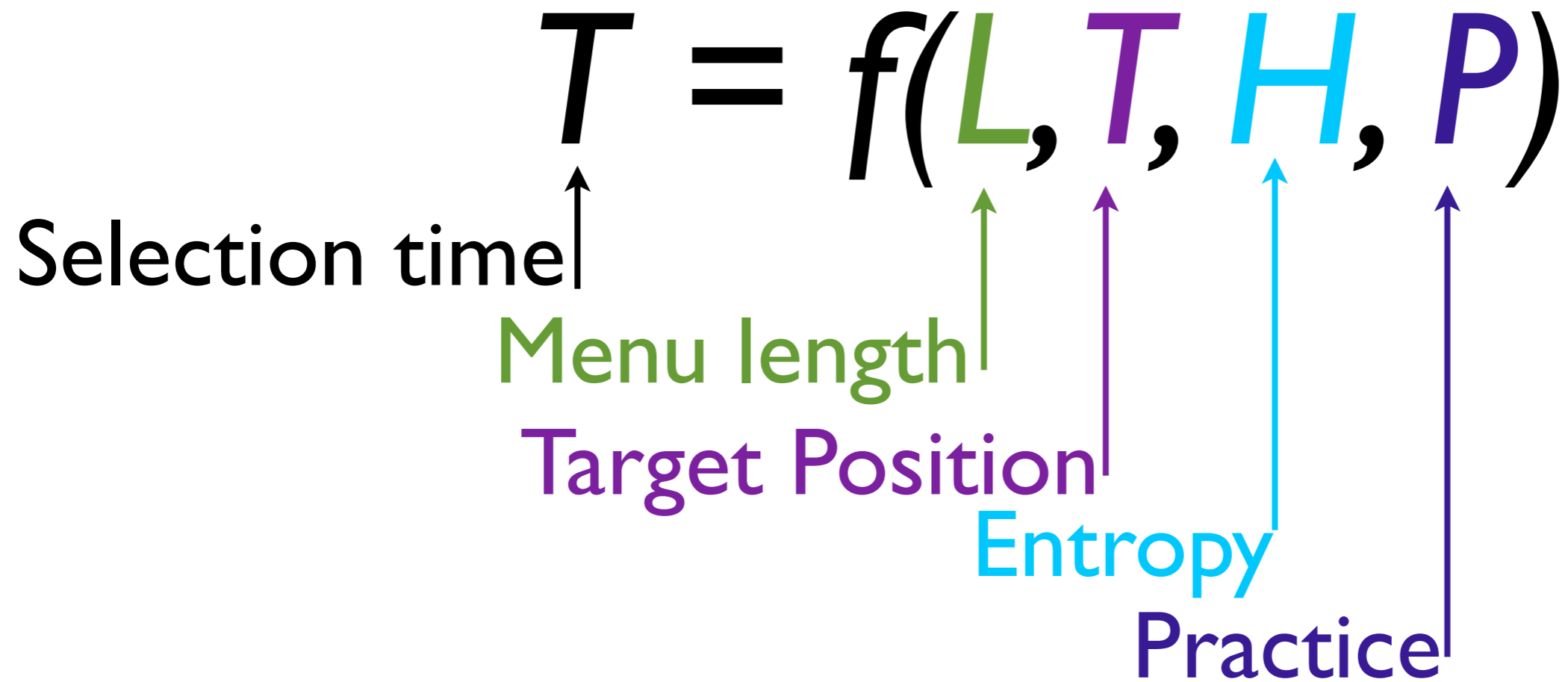
Entropy ↑

The diagram illustrates the Search-Decision-Pointing (SDP) model. At the top, the equation  $T = f(L, T, H, P)$  is shown, where  $T$  is the selection time, and  $L$ ,  $T$ ,  $H$ , and  $P$  are the input variables. Below the equation, four variables are listed with arrows pointing to their corresponding parameters in the function: 'Menu length' points to  $L$ , 'Target Position' points to  $T$ , 'Entropy' points to  $H$ , and 'Selection time' points to the output  $T$ . The arrows are color-coded to match the parameters: green for  $L$ , purple for  $T$ , cyan for  $H$ , and black for the output  $T$ .

The model is based on Fitt's law and Hick-Hyman law

# Search - Decision - Pointing Model (SDP)

[Cockburn 07]



The model is based on Fitt's law and Hick-Hyman law

*"Satisfy the immediate **expectations** of their clients"*

**From our Interviews**

- **Consistency with existing applications**
  - Convention
  - "Cut", "Copy" and "Paste" are frequently in the same group

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$$C = f(0)$$

- **Consistency with existing applications**
  - Convention
  - "Cut", "Copy" and "Paste" are frequently in the same group

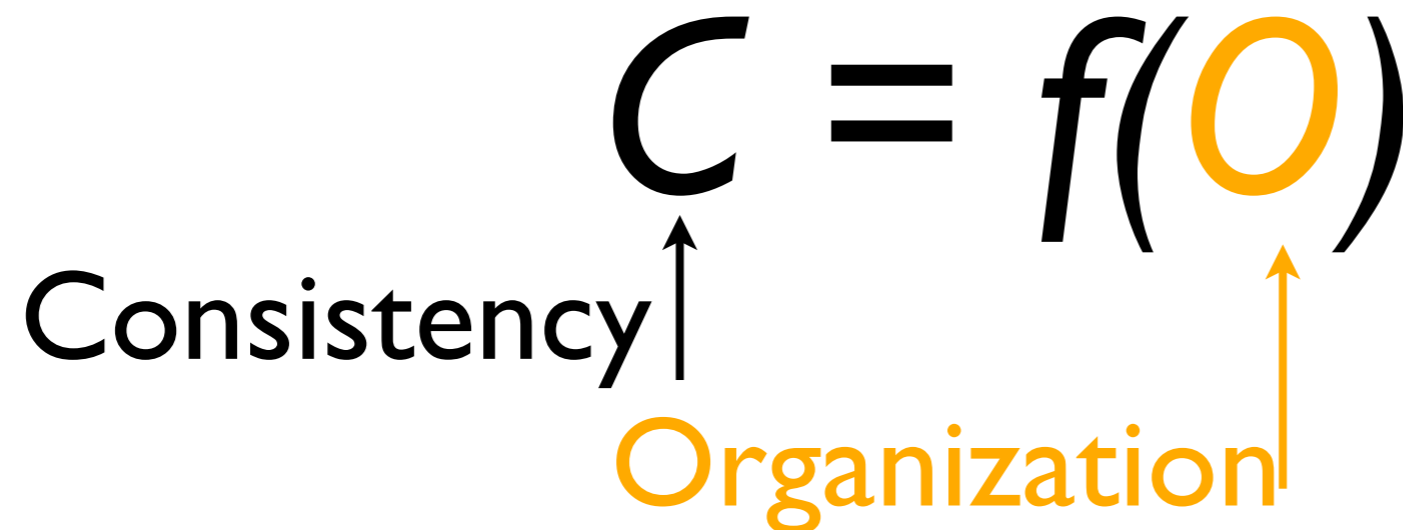
$$\text{Consistency} \uparrow C = f(O)$$

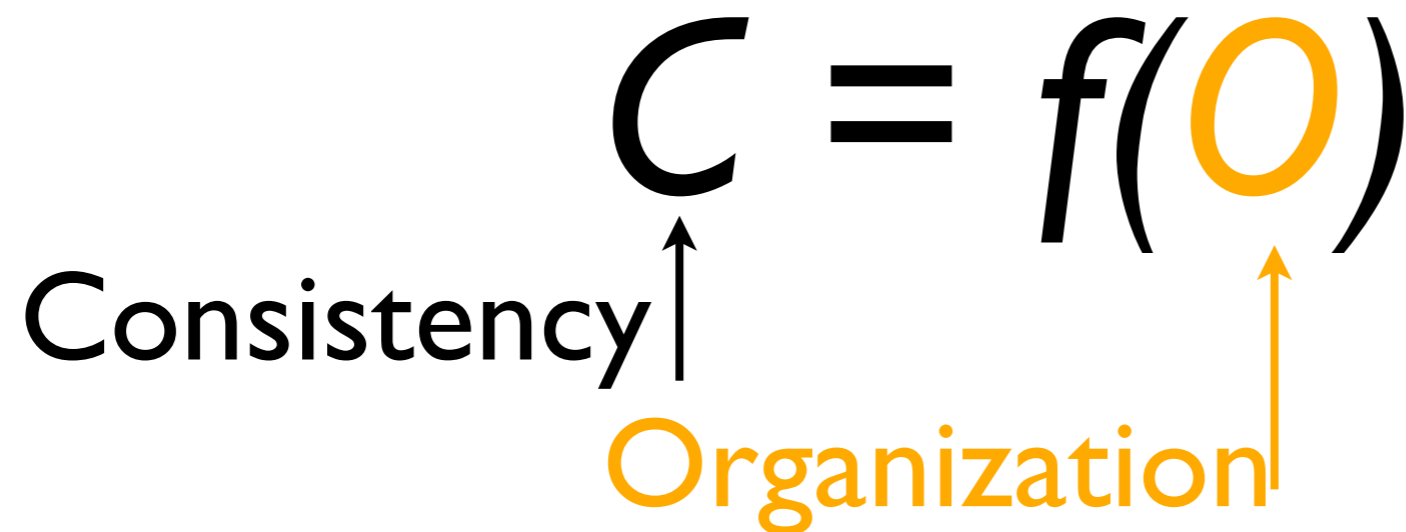
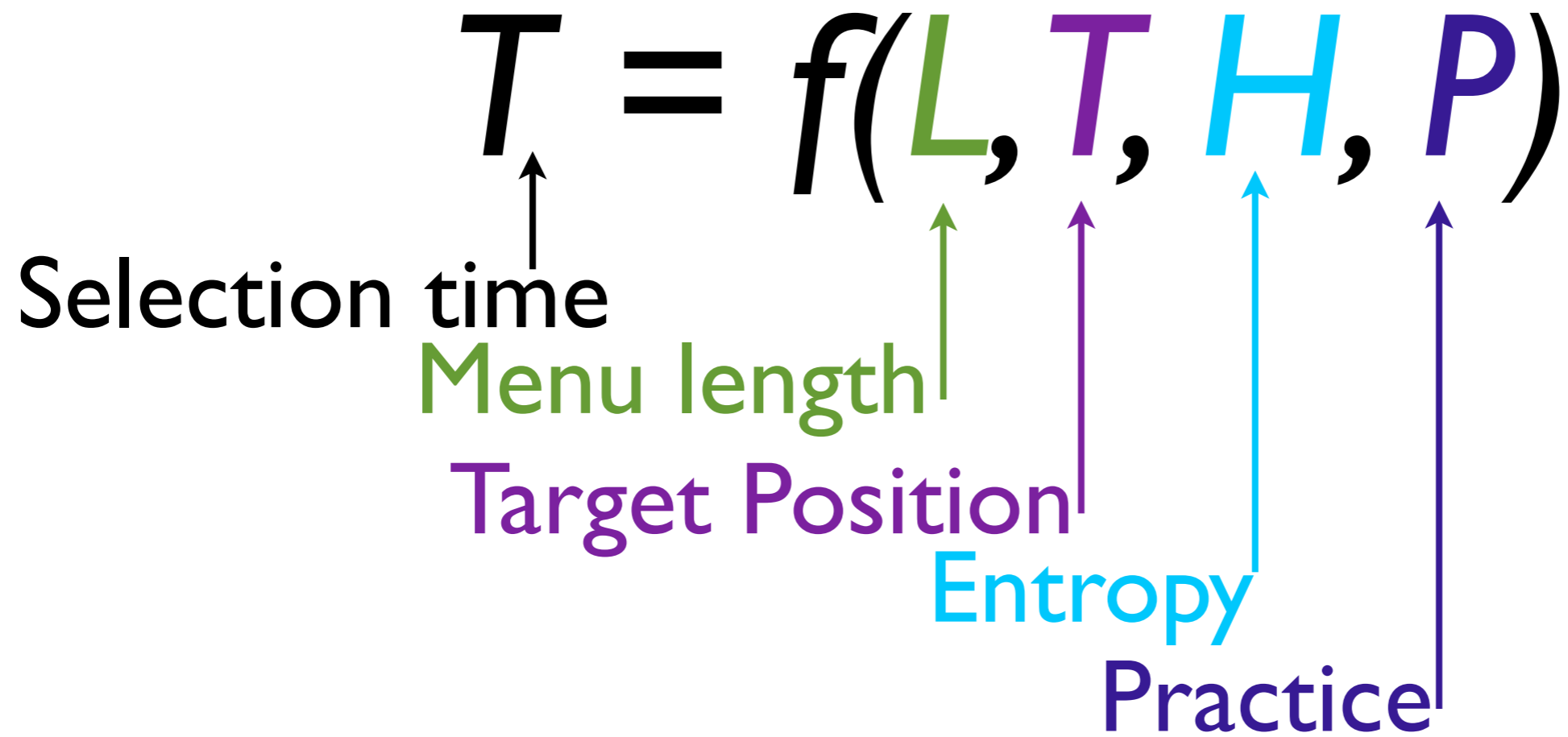


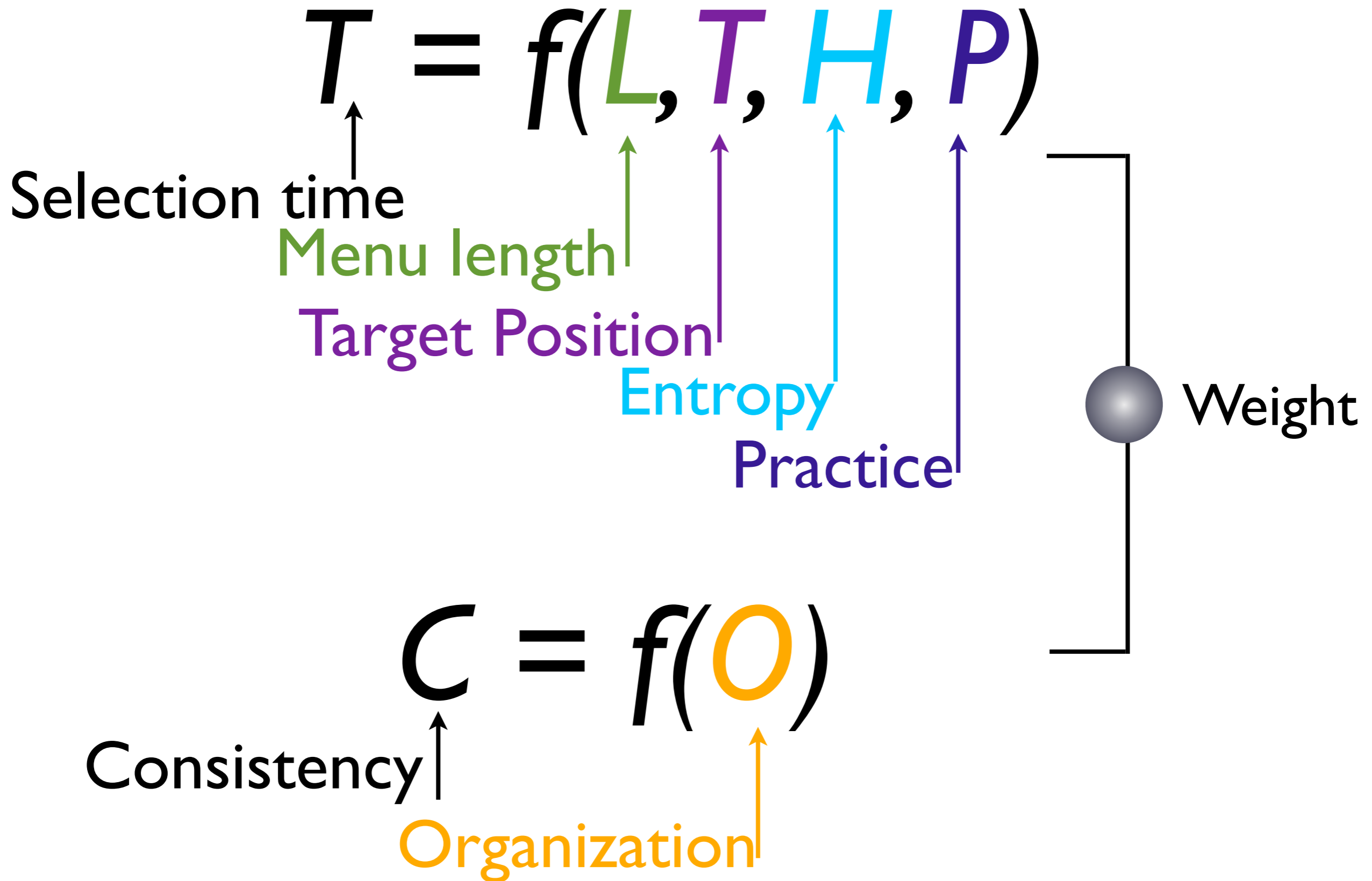
- **Consistency with existing applications**
  - Convention
  - "Cut", "Copy" and "Paste" are frequently in the same group

$$C = f(O)$$

Consistency ↑ Organization ↑







$$T = f(L, T, H, P)$$

Selection time

Menu length

Target Position

Entropy

Practice

Weight

$$C = f(O)$$

Consistency

Organization

$$T = f(L, T, H, P)$$

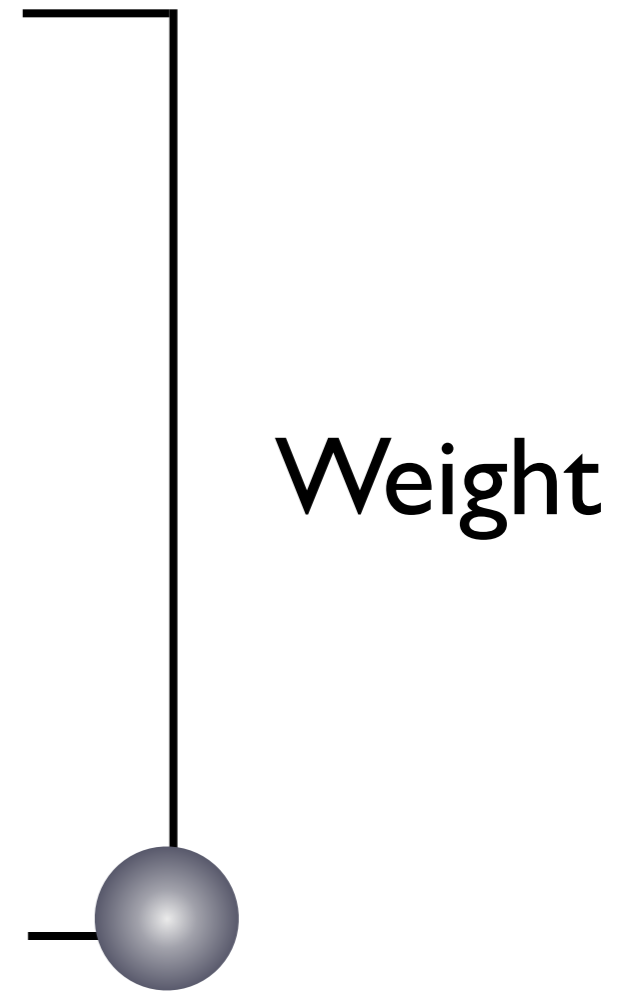
Selection time ↑

Menu length ↑

Target Position ↑

Entropy ↑

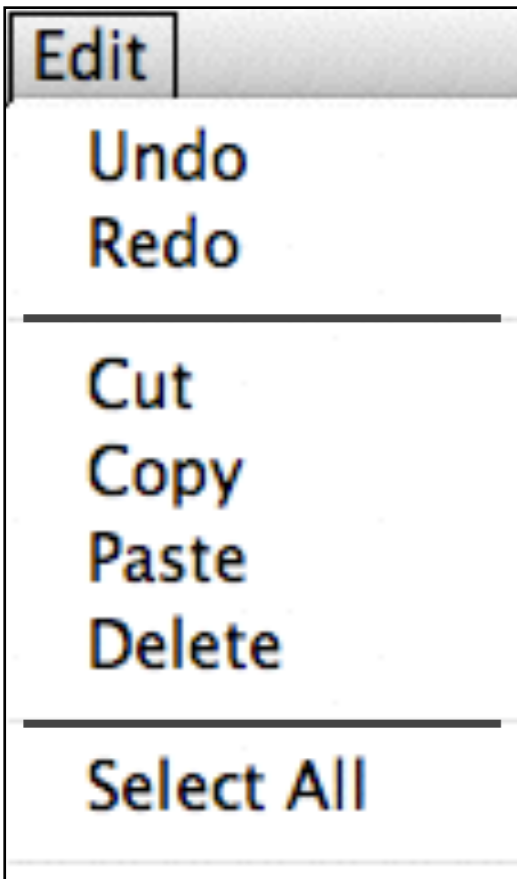
Practice ↑

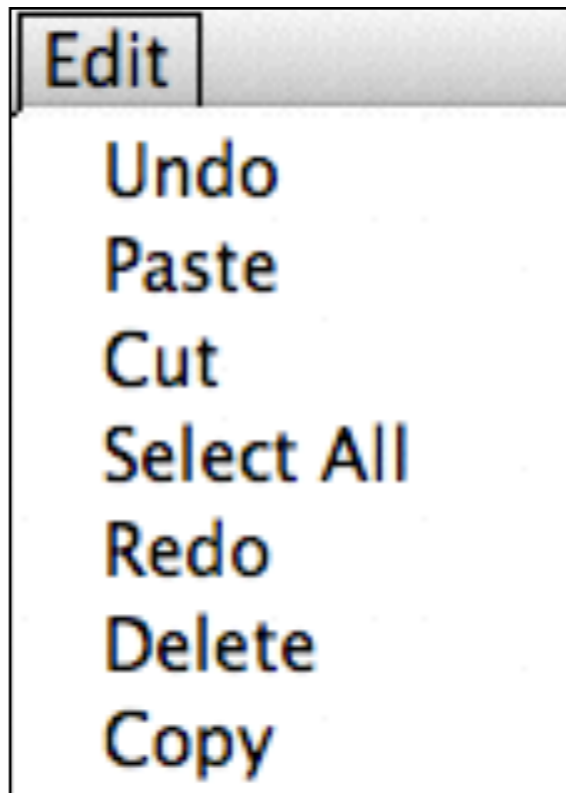
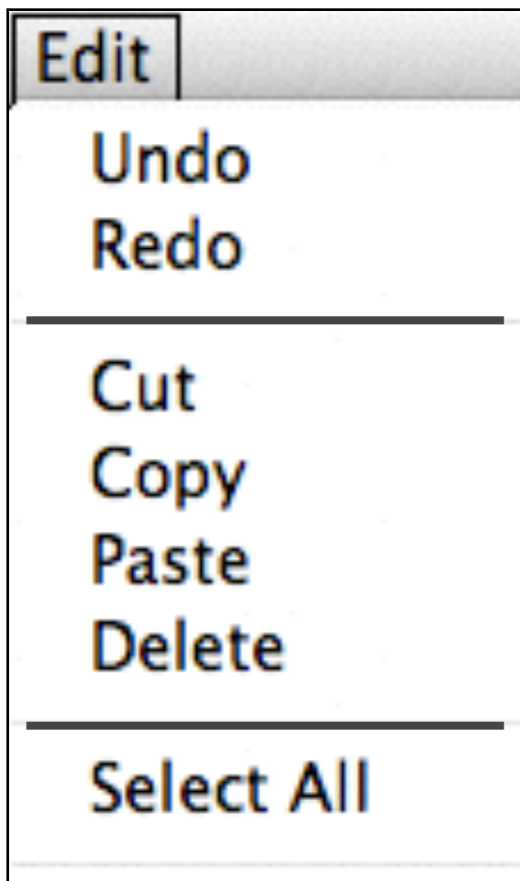


$$C = f(O)$$

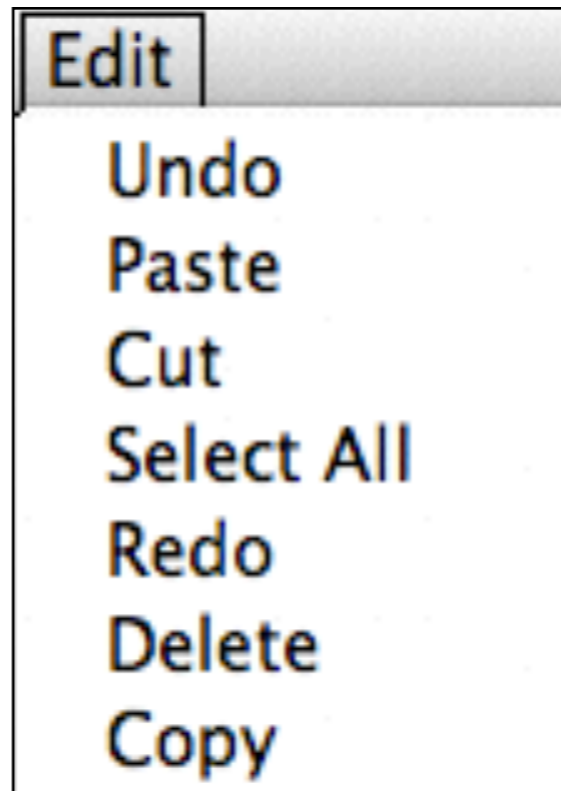
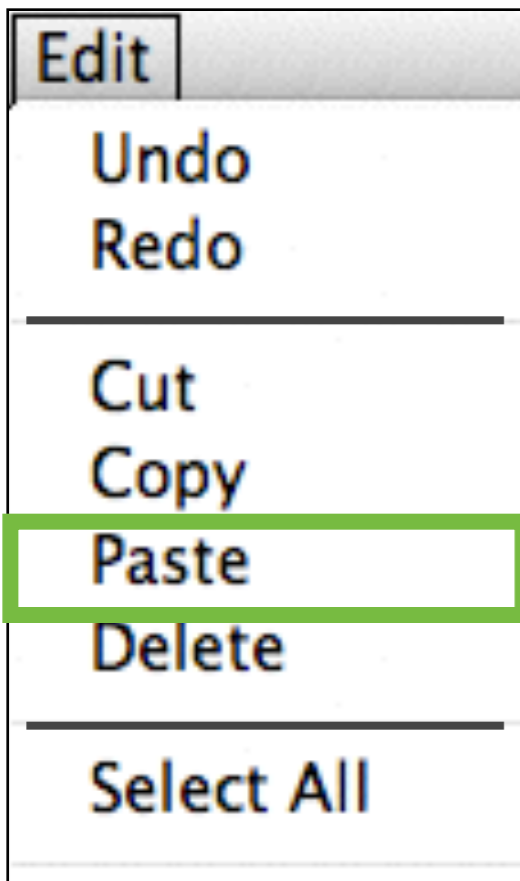
Consistency ↑

Organization ↑



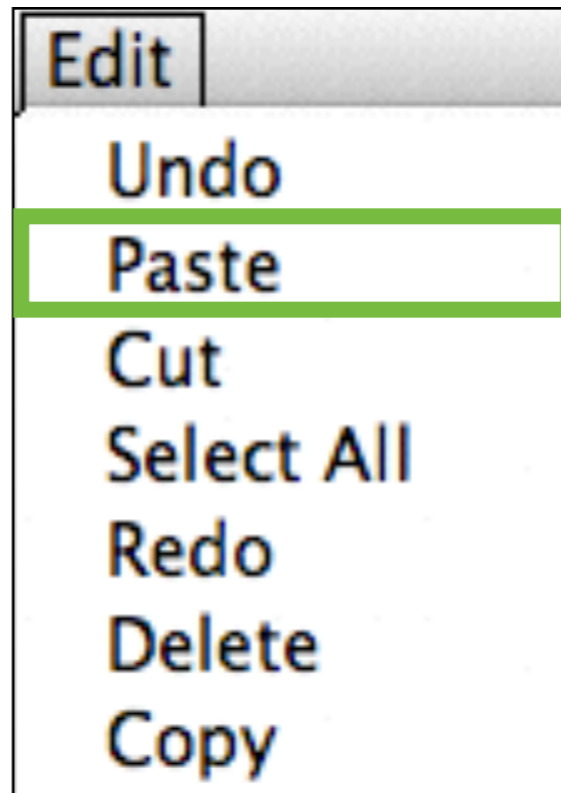
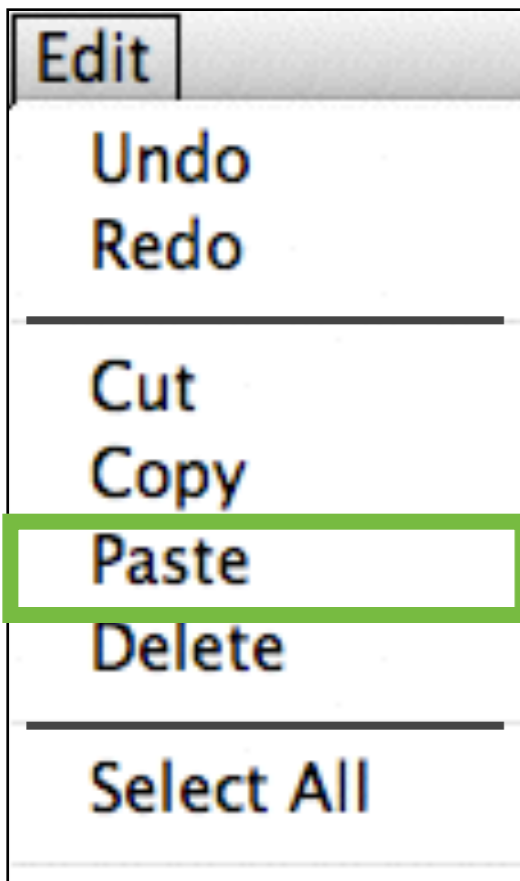


Selection Time  
**only**

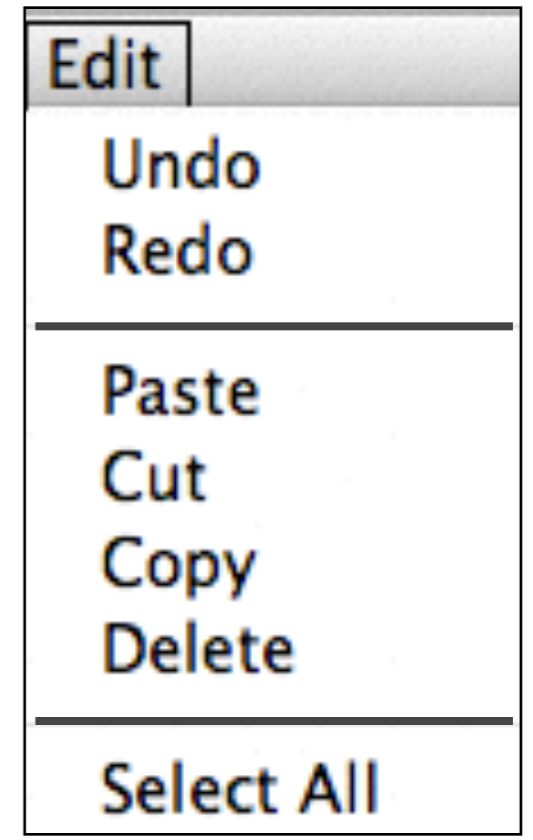
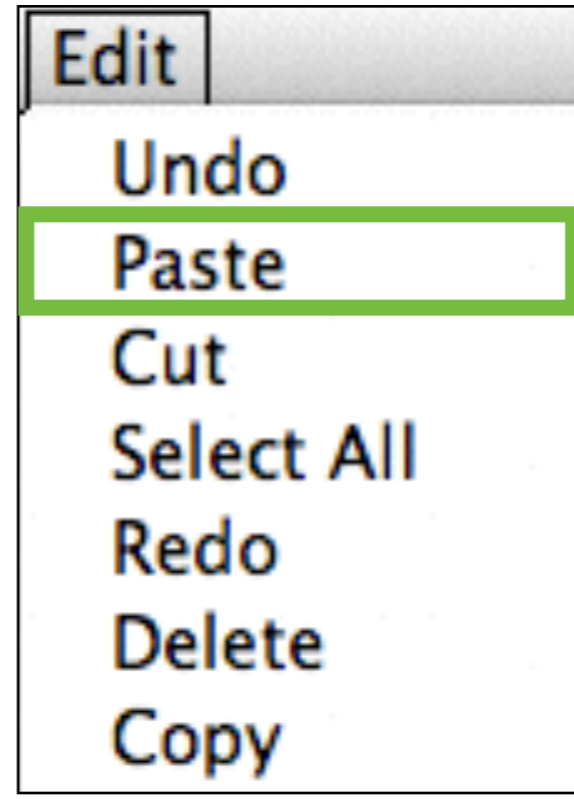
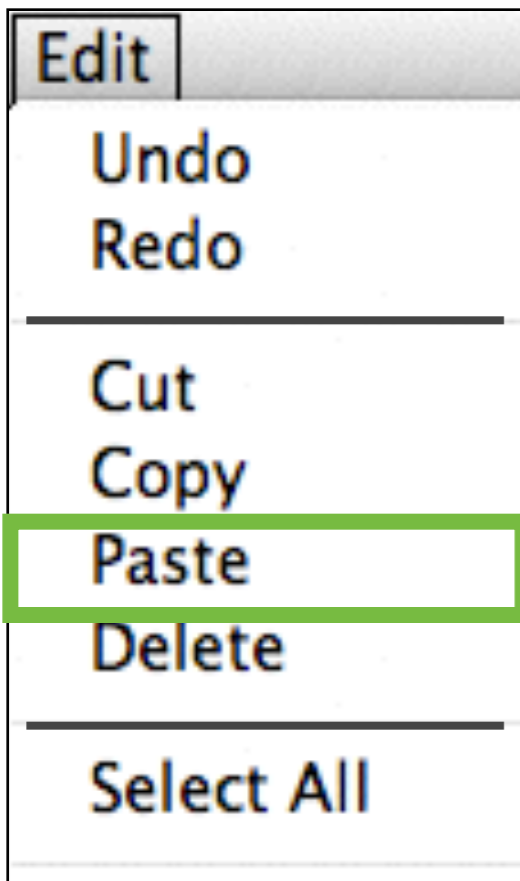


Selection Time  
**only**



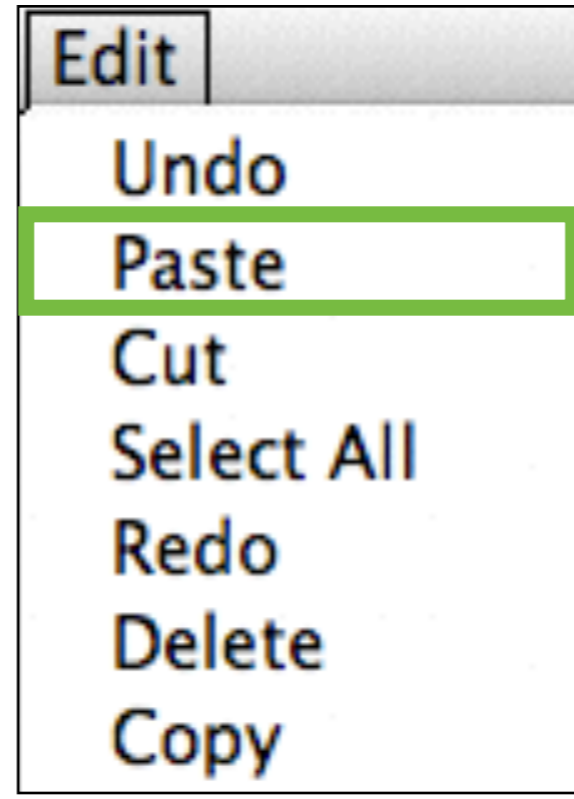
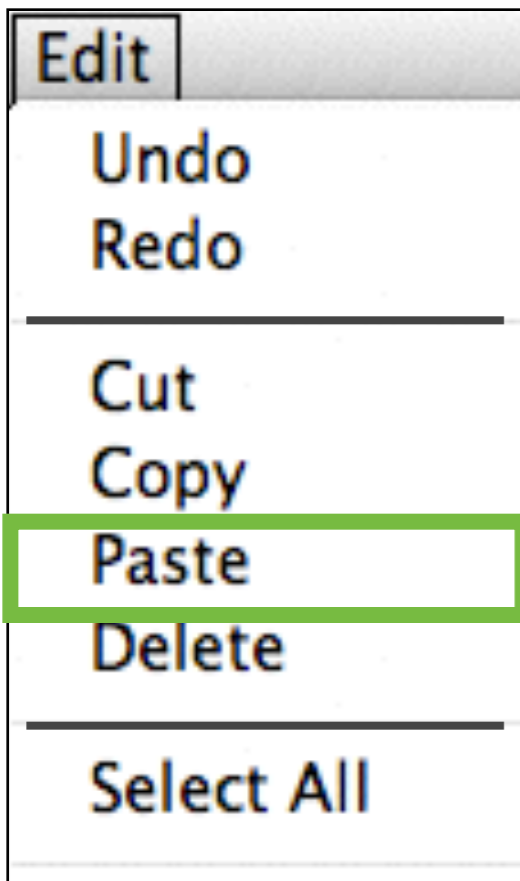


Selection Time  
**only**

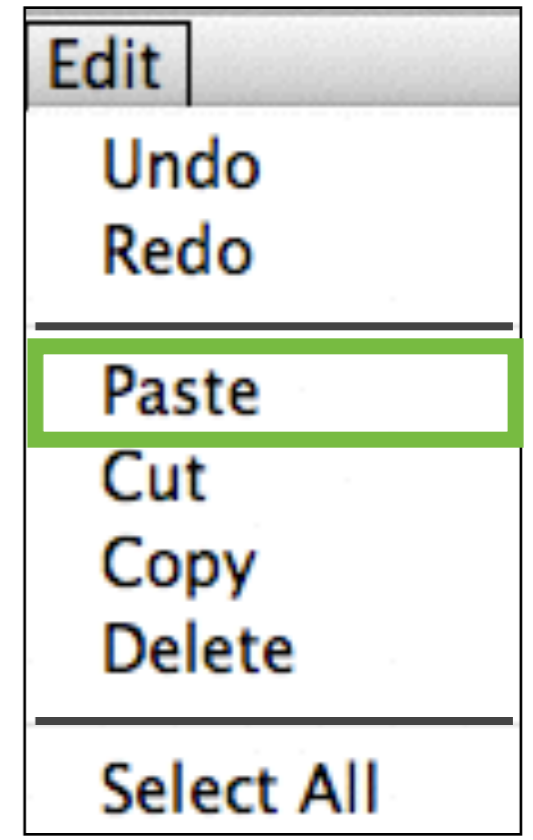


Selection Time  
**only**

Selection Time  
&  
Consistency

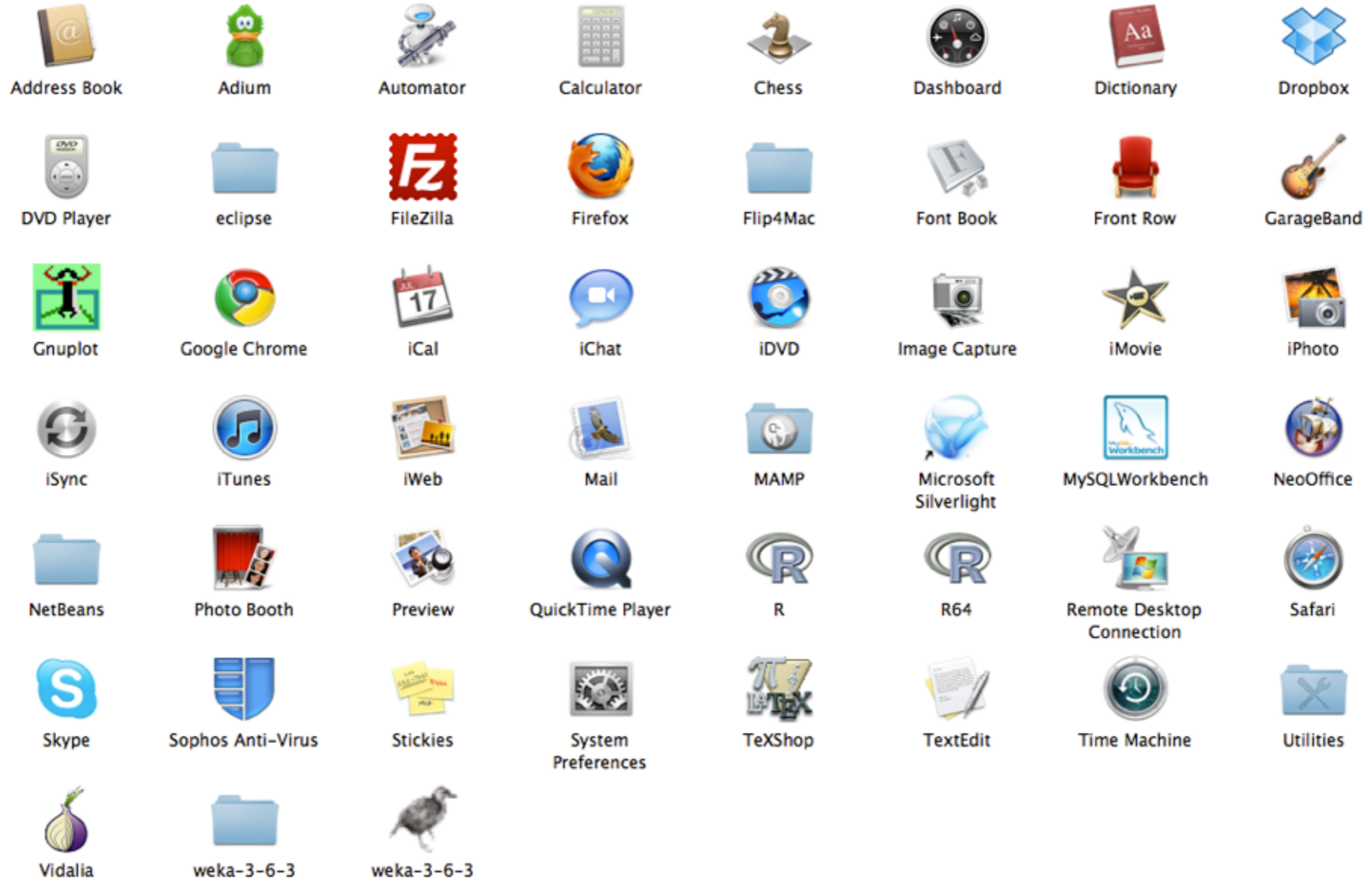


Selection Time  
**only**



Selection Time  
&  
Consistency

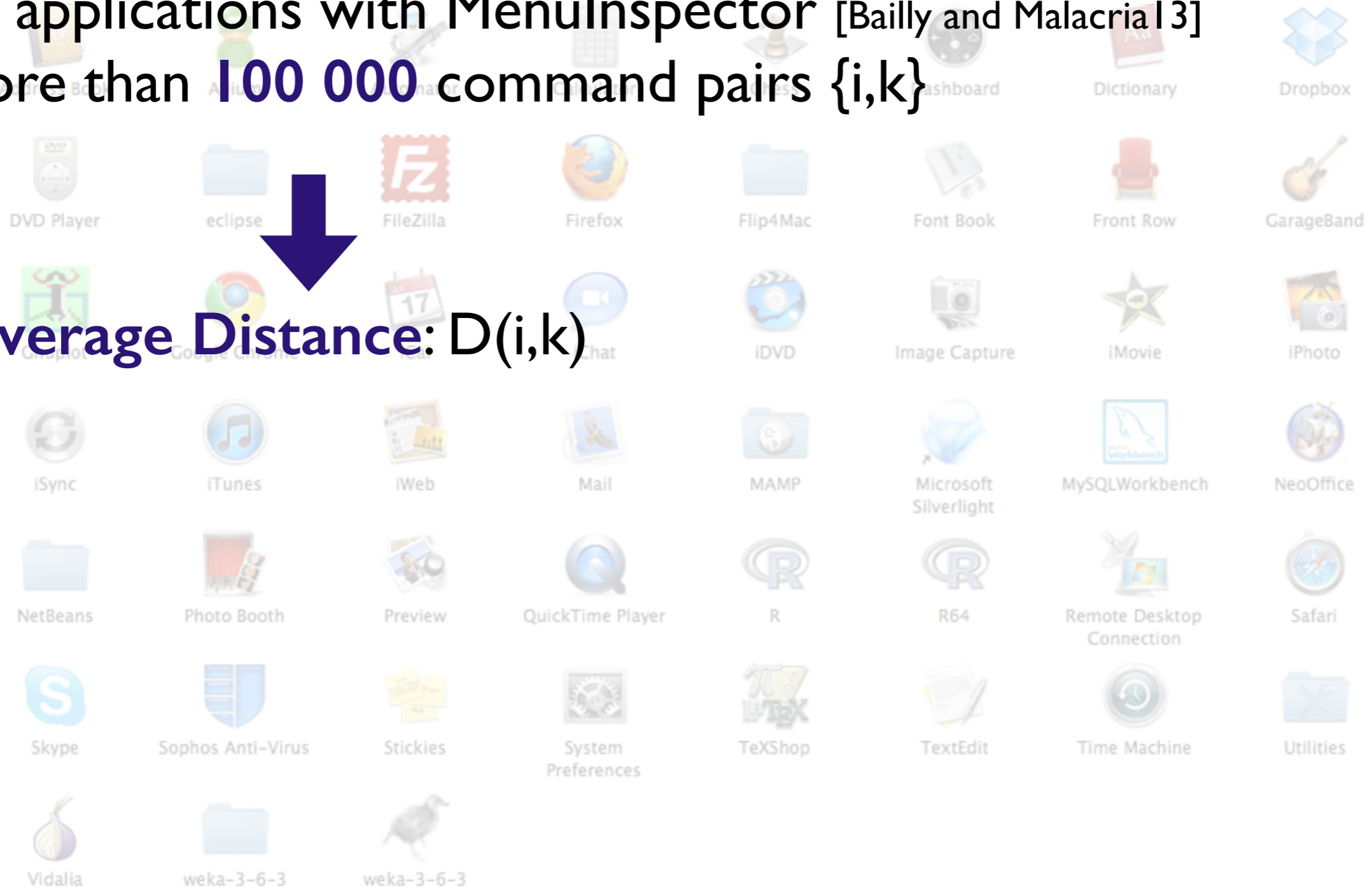
# Consistency



# Consistency

68 applications with MenuInspector [Bailly and Malacria 13]  
more than 100 000 command pairs  $\{i,k\}$

Average Distance:  $D(i,k)$

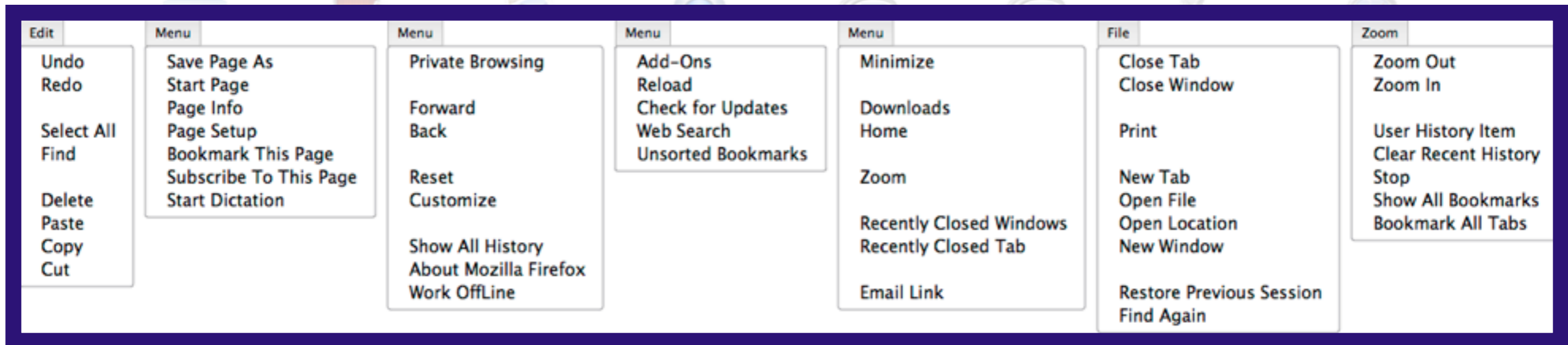


# Consistency

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Average Distance:  $D(i,k)$

Distance:  $D(i,k)$



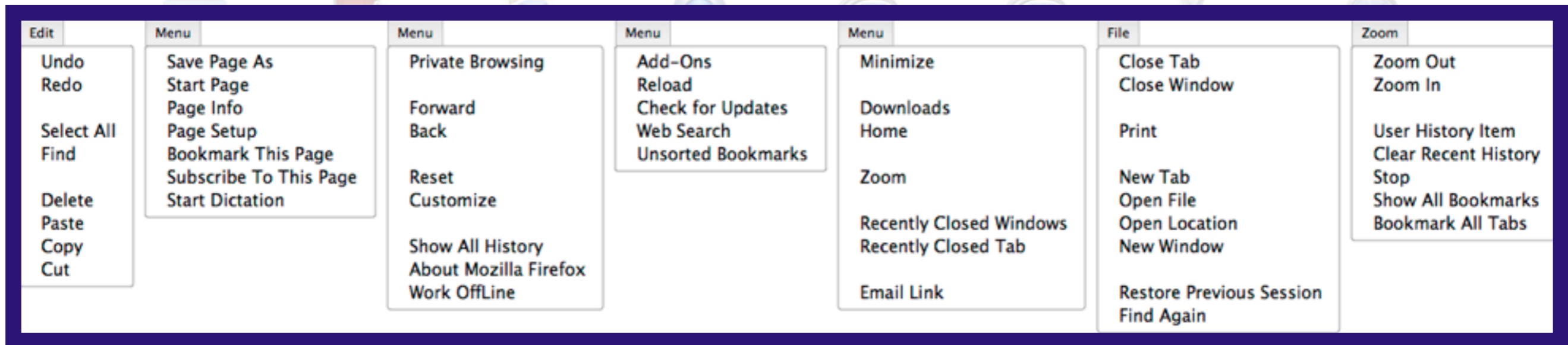
Current menu

# Consistency

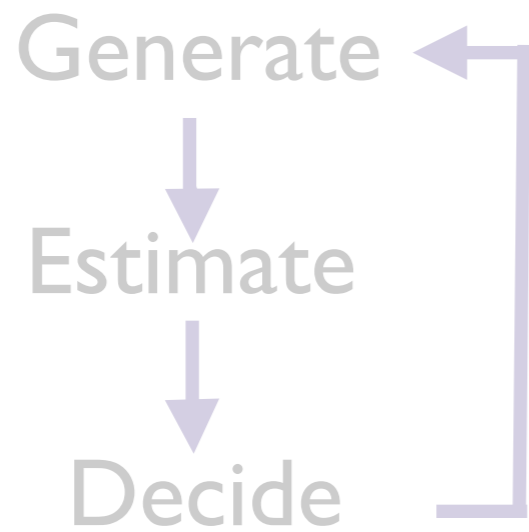
68 applications with MenuInspector [Bailly and Malacria 13]  
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Average Distance:  $D(i,k)$

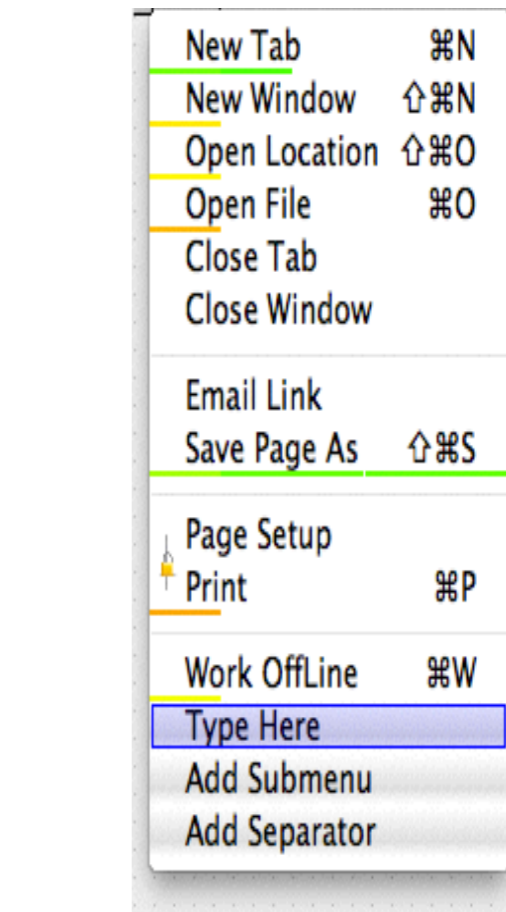
Distance:  $D(i,k)$



Current menu



Optimizer



Interactions



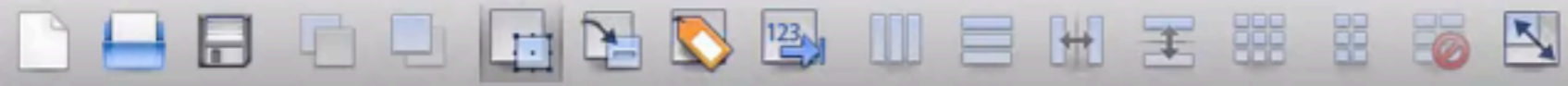
# Challenges



# Design Goals

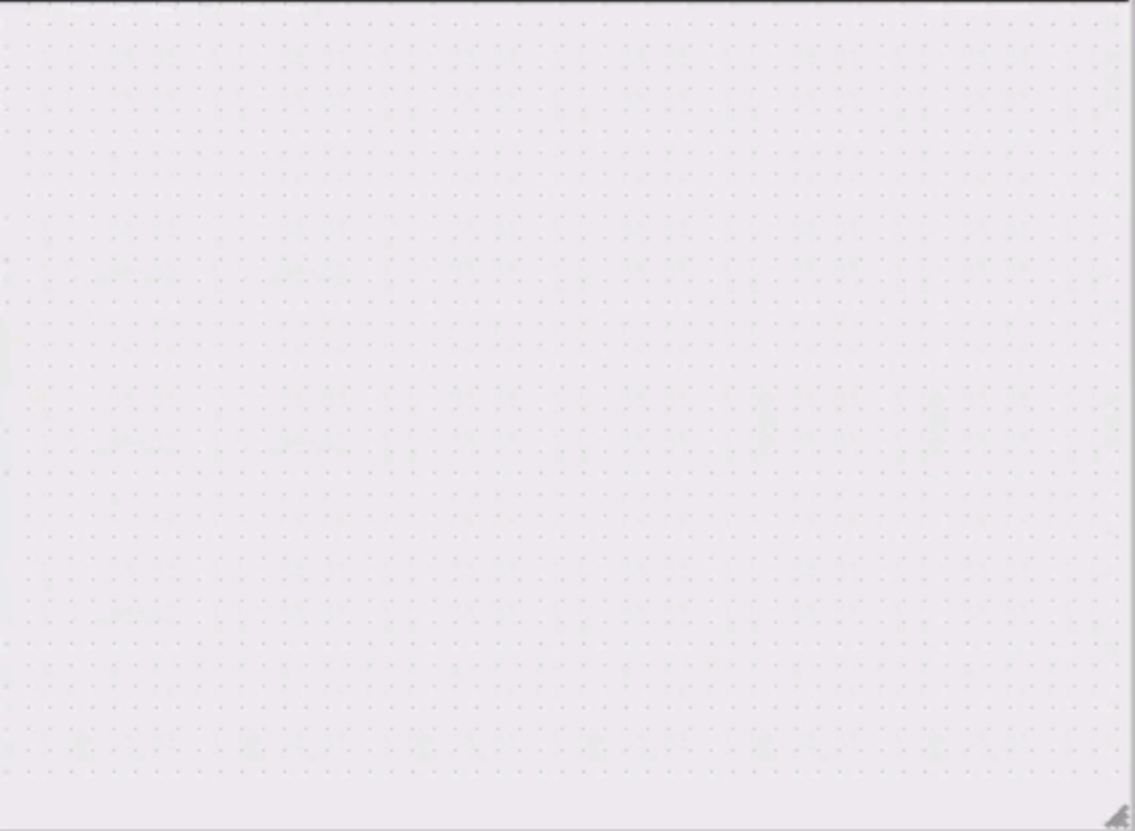
- Feedback for design choices
- Suggestions for improvement
- Editable Menus, objectives and assumptions

# MenuOptimizer

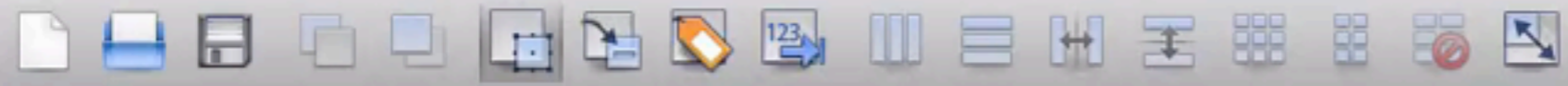


MainWindow - firefoxLight-single.ui

Firefox Type Here

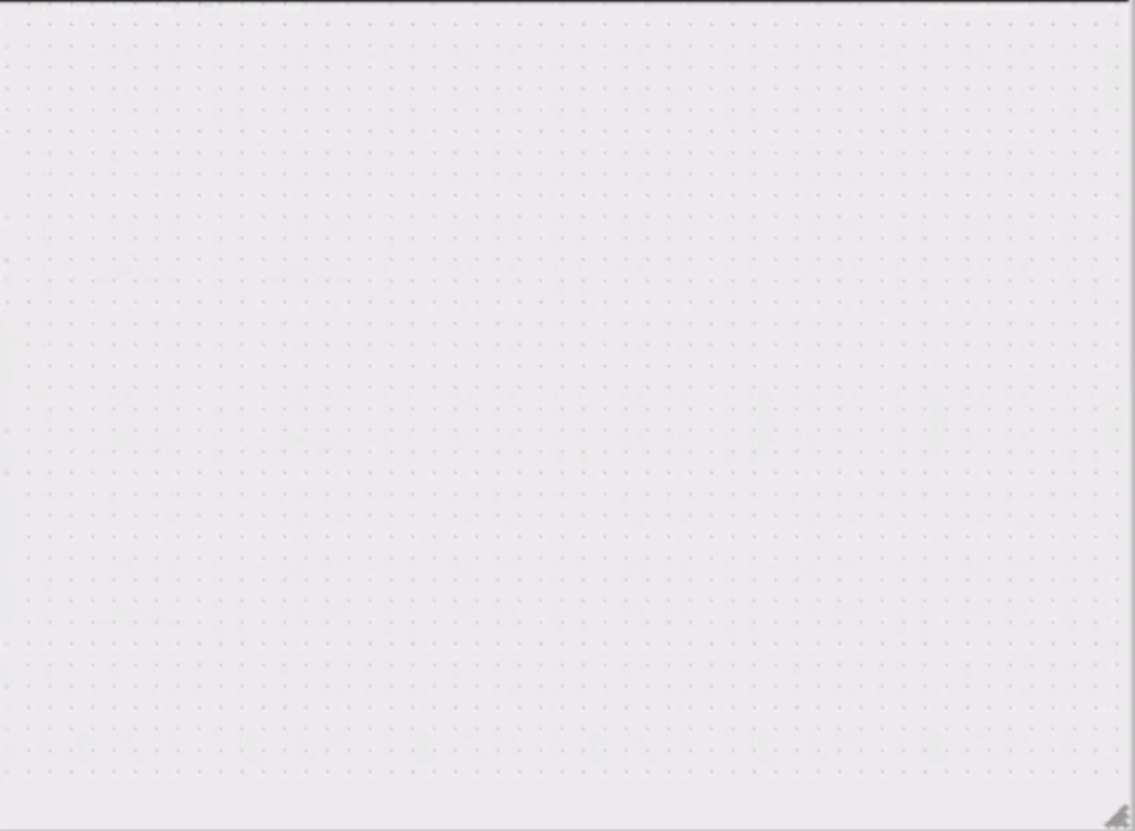


- Model
- Objective Panel
- Pareto
- User Behavior
- User Performance
- SemanticPanel
- Frequency Panel
- Assignment
- Evolution



MainWindow - firefoxLight-single.ui

Firefox Type Here



- Model
- Objective Panel
- Pareto
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- Assignment
- Evolution

# Evaluation

## ● FireFox case

- 52 commands
- Logs from 50 users
- Consistency: 85% - Selection time: 15%
- 5 minutes

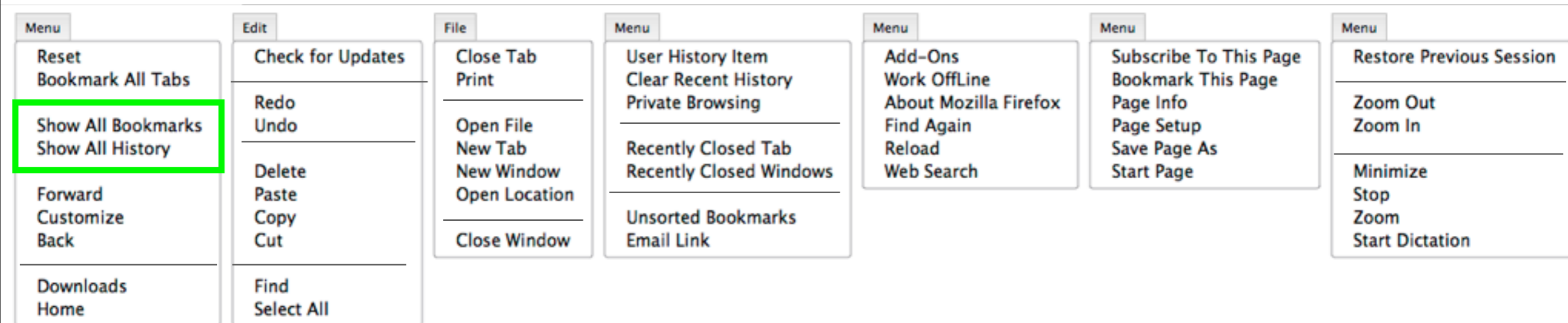
## ● Firefox case

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- Logs from 50 users
- Consistency: 85% - Selection time: 15%
- 5 minutes

Menu	Edit	File	Menu	Menu	Menu	Menu
Reset Bookmark All Tabs	Check for Updates	Close Tab Print	User History Item Clear Recent History Private Browsing	Add-Ons Work OffLine About Mozilla Firefox Find Again Reload Web Search	Subscribe To This Page Bookmark This Page Page Info Page Setup Save Page As Start Page	Restore Previous Session
Show All Bookmarks Show All History	Redo Undo	Open File New Tab New Window Open Location	Recently Closed Tab Recently Closed Windows			Zoom Out Zoom In
Forward Customize Back	Delete Paste Copy Cut	Close Window	Unsorted Bookmarks Email Link			Minimize Stop Zoom Start Dictation
Downloads Home	Find Select All					

## ● Firefox case

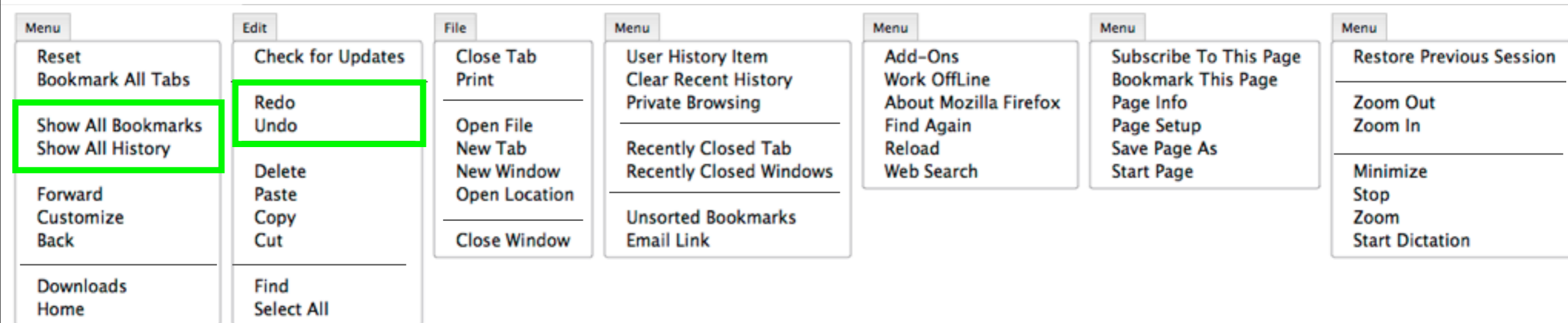
- 52 commands
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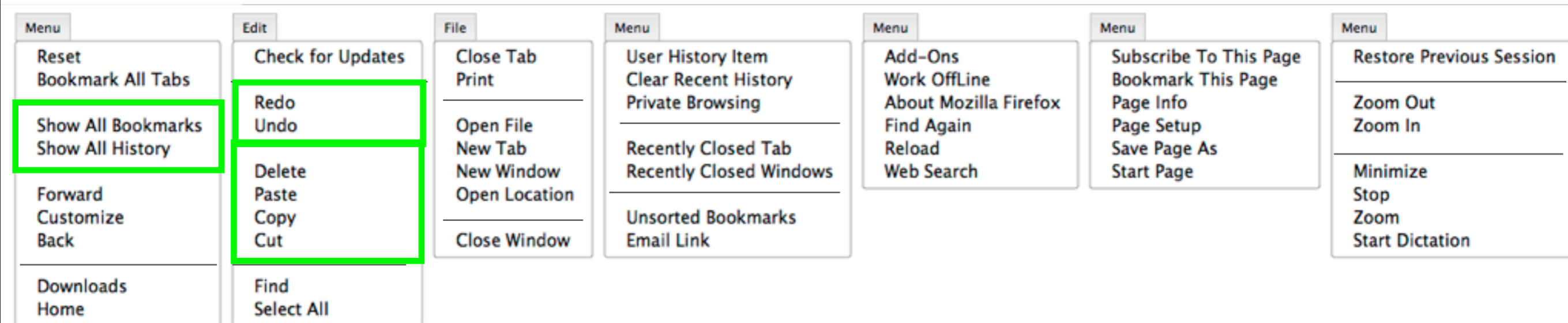
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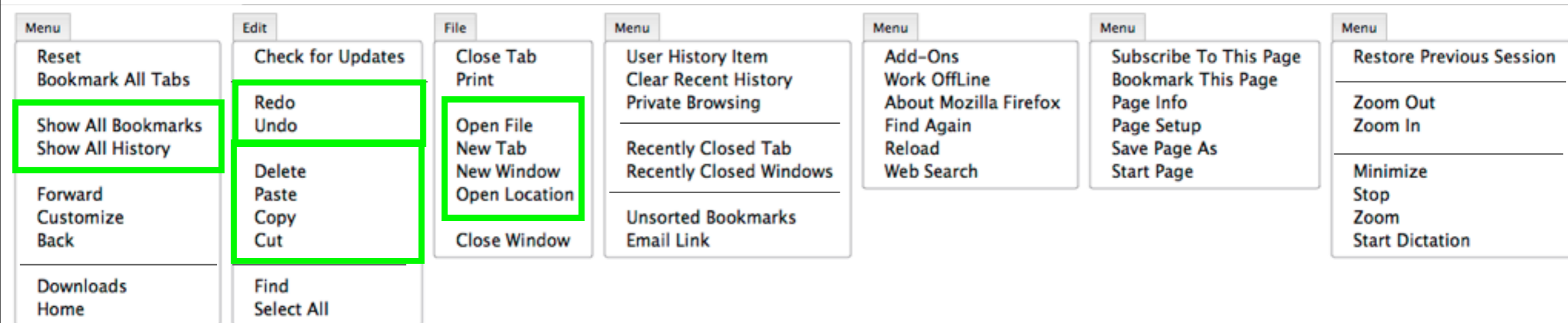
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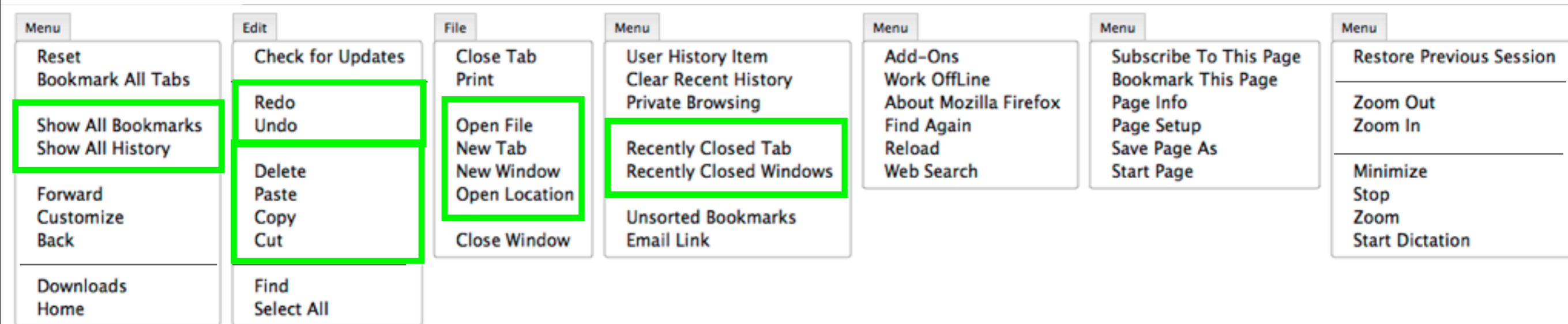
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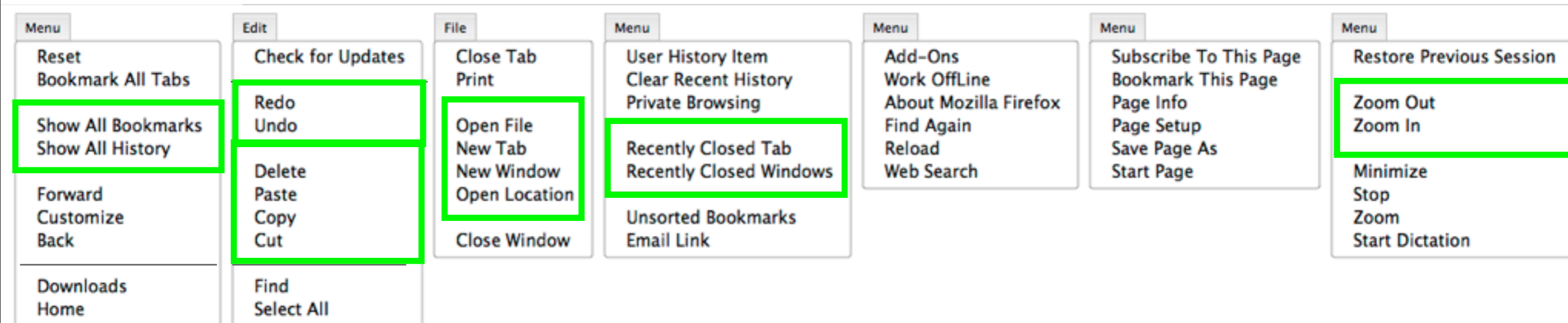
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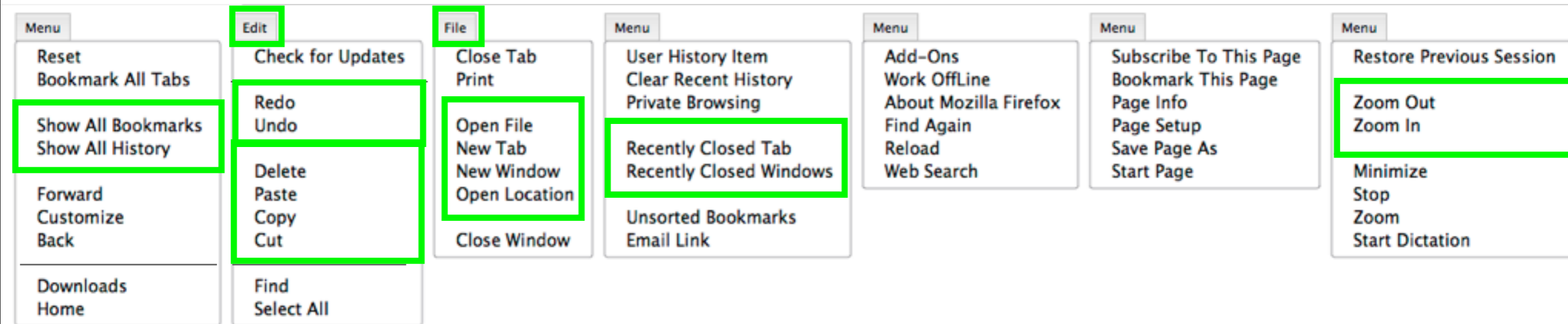
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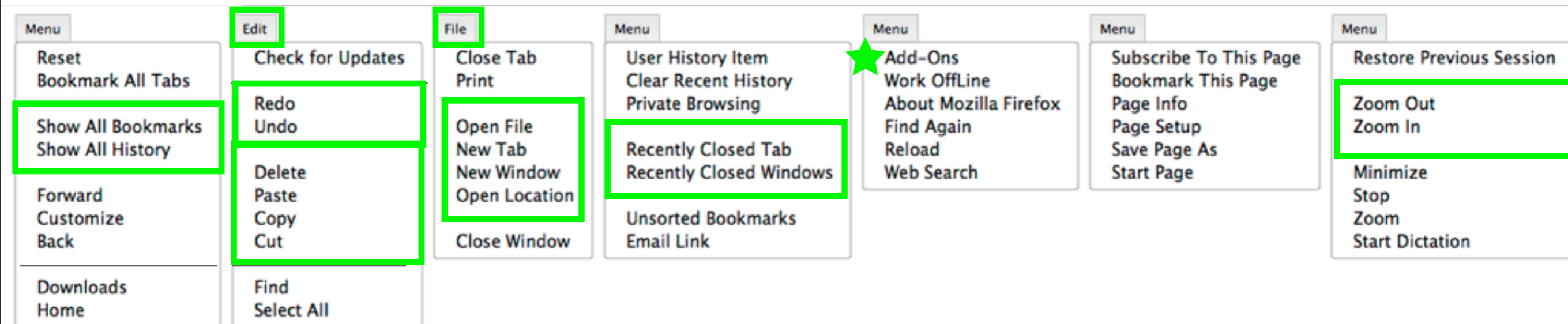
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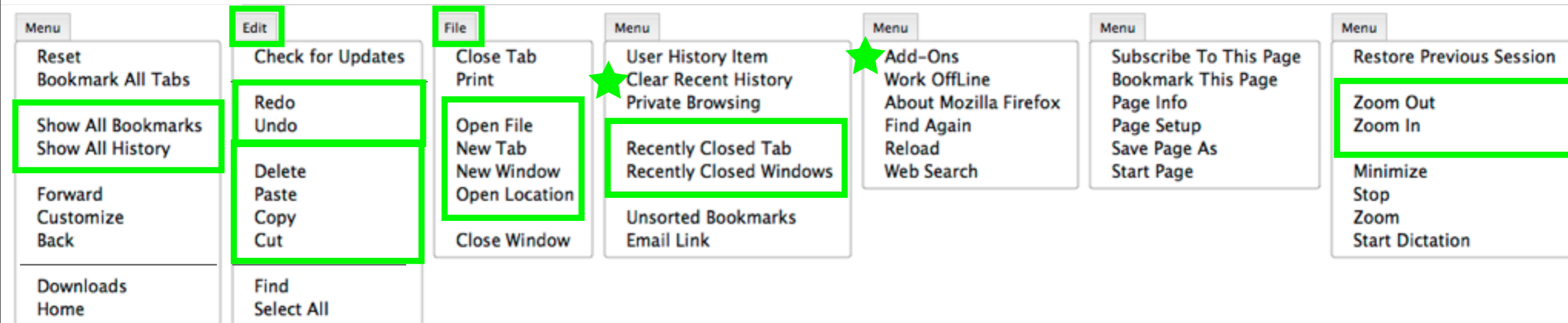
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## ● Firefox case

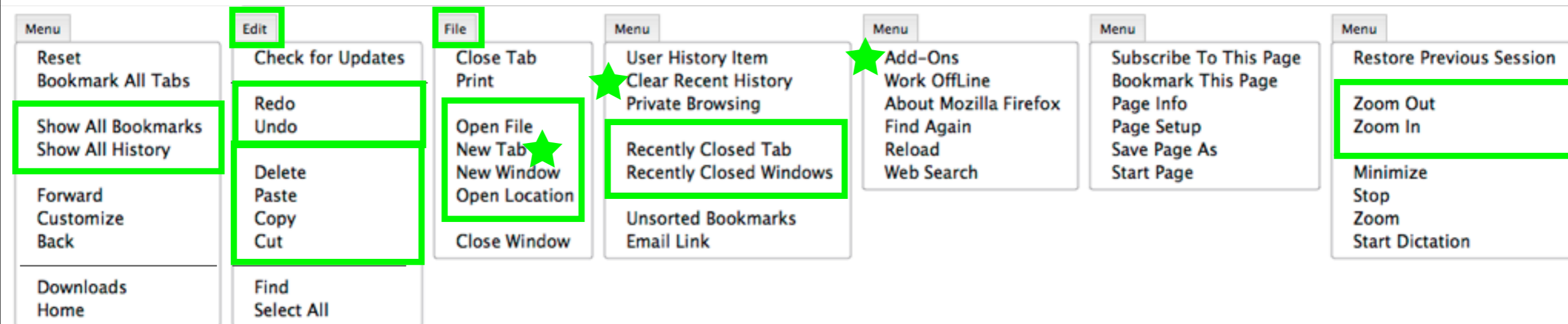
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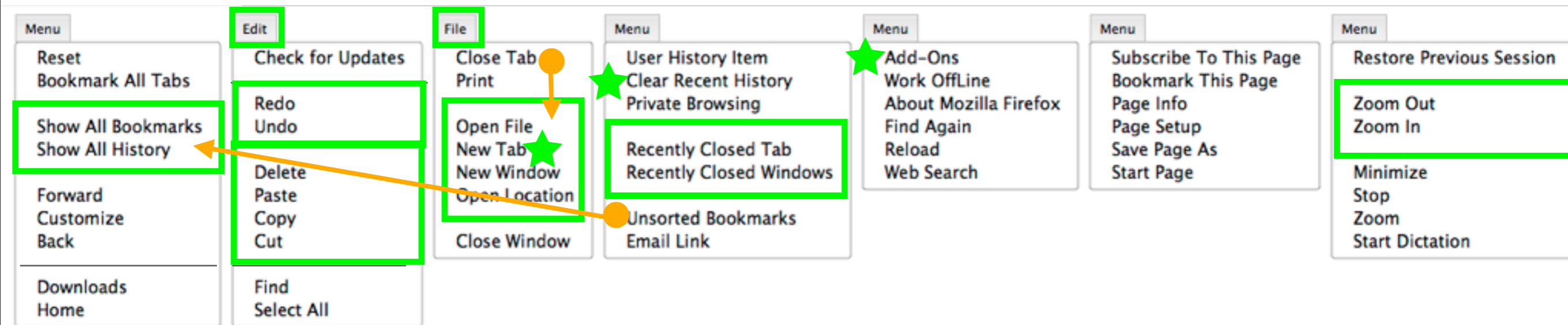
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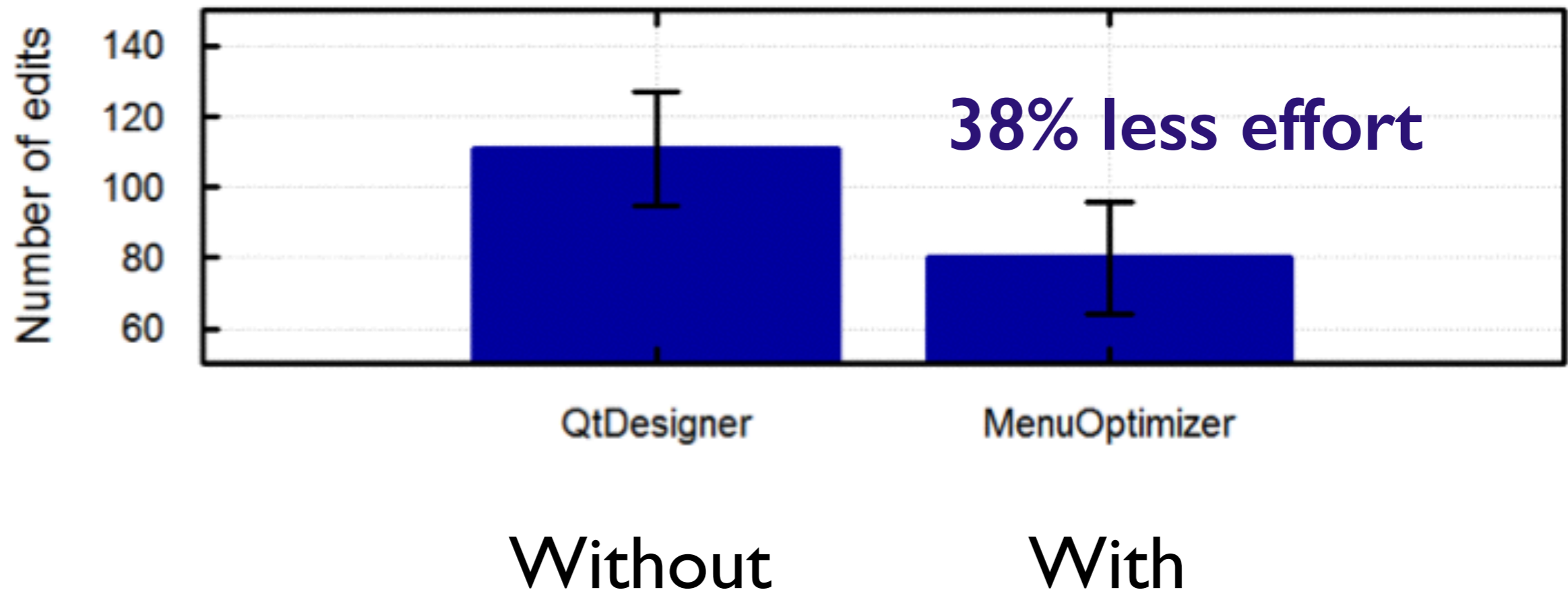
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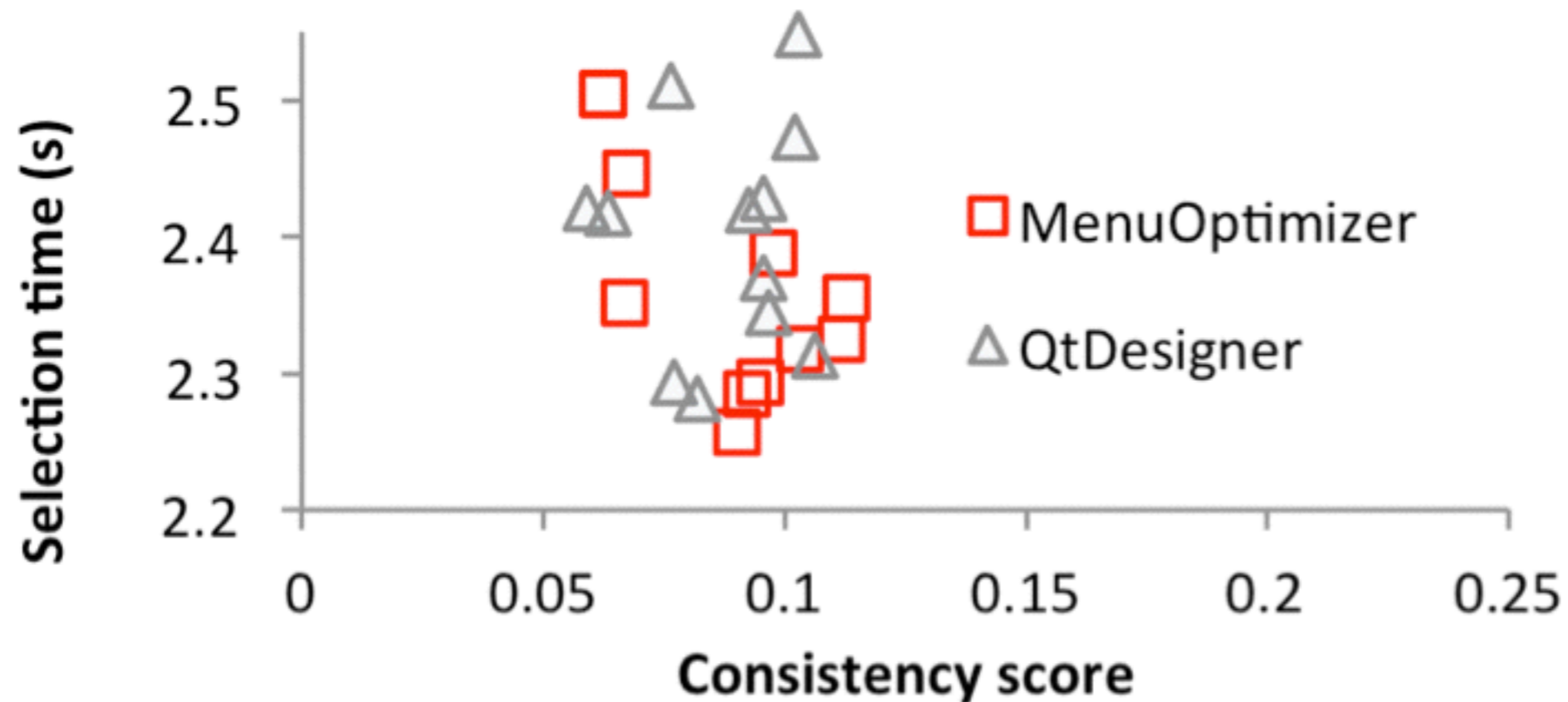
# User study

- Task: Designing a menu system
  - With Optimizer (MenuOptimizer)
  - Without Optimizer (Qt Designer): Baseline



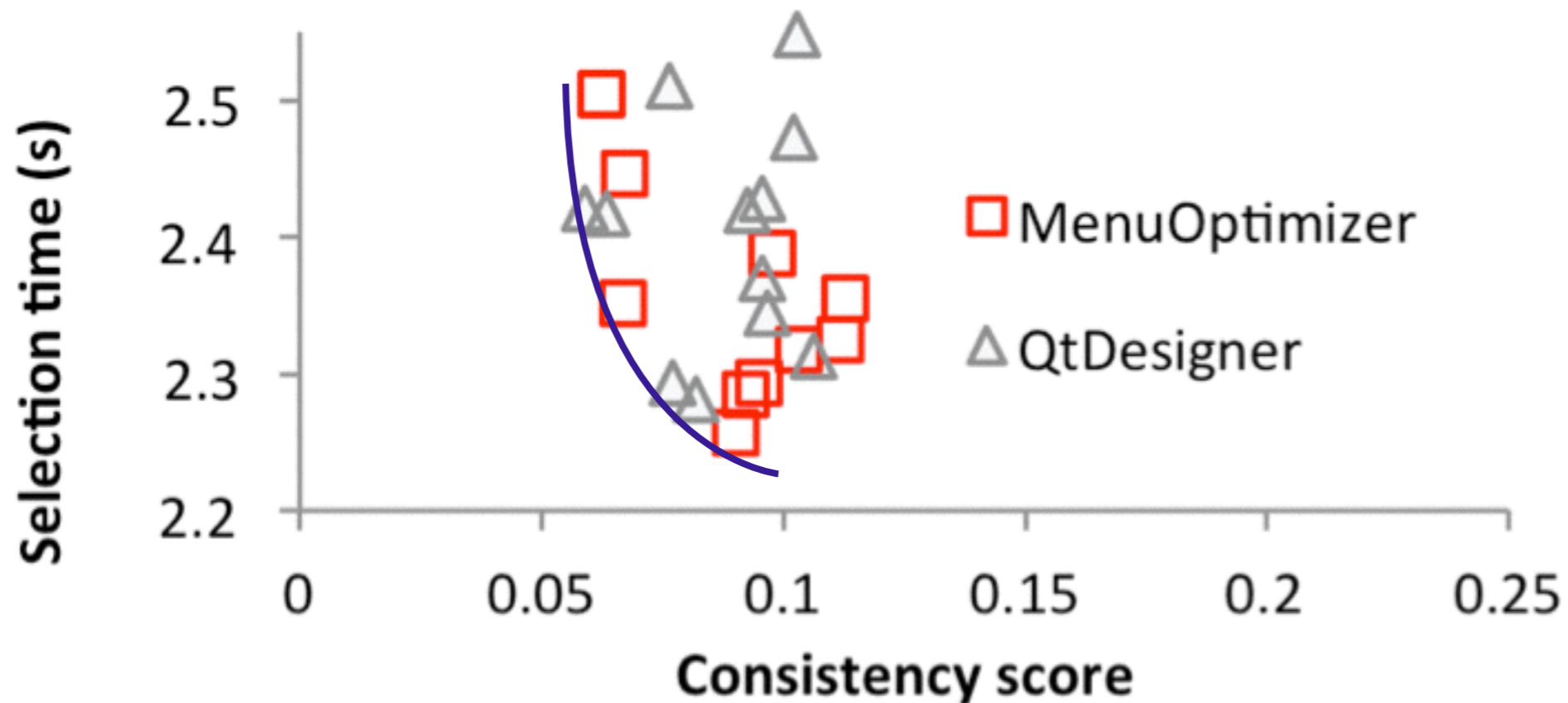
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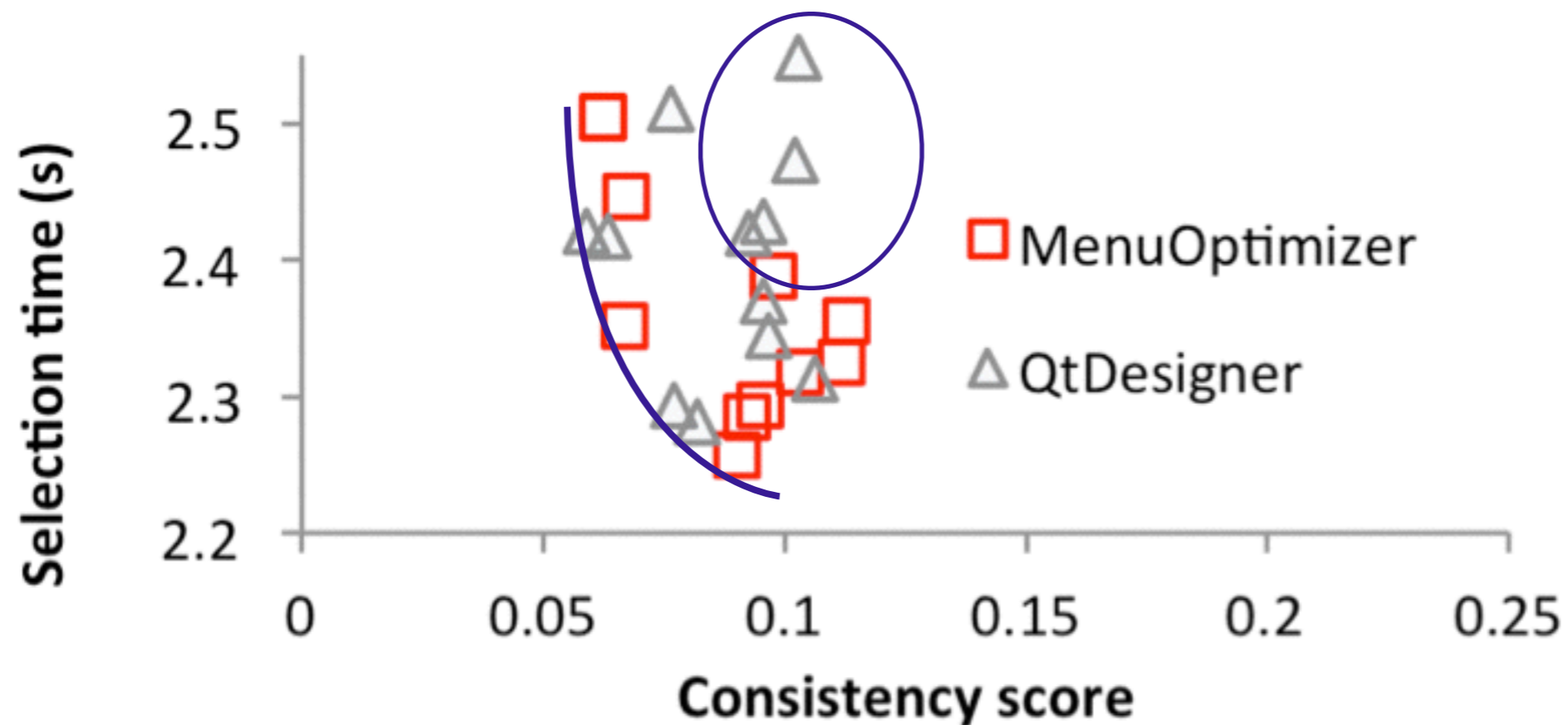
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# User study

- Task: Designing a menu system
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How to help **designers**

to design **usable** menu Systems?

**Research question**

# Conclusion

**Menu design** can be formulated as an **optimization problem**

## Interactive Optimization

- Assisting menu designers with an optimizer in the loop

## MenuOptimizer

- Express constraints
- Deal with several objectives
- Refine automatically generated solutions
- etc.



# MenuOptimizer

Gilles Bailly

with Antti Oulasvirta, Timo Kötzing, Sabrina Hoppe



File Edit View Bookmarks History Windows Tools Help

**New Tab** ⌘N  
⌘⇧N  
Open Location ⌘⇧O  
Open File ⌘O  
Close Tab  
Close Window  
Email Link  
Save Page As ⌘⇧S  
Page Setup  
Print ⌘P  
Work OffLine ⌘W

Show All Bookmarks  
Bookmark This Page  
Subscribe To This Page  
Bookmark All Tabs  
Unsorted Bookmarks

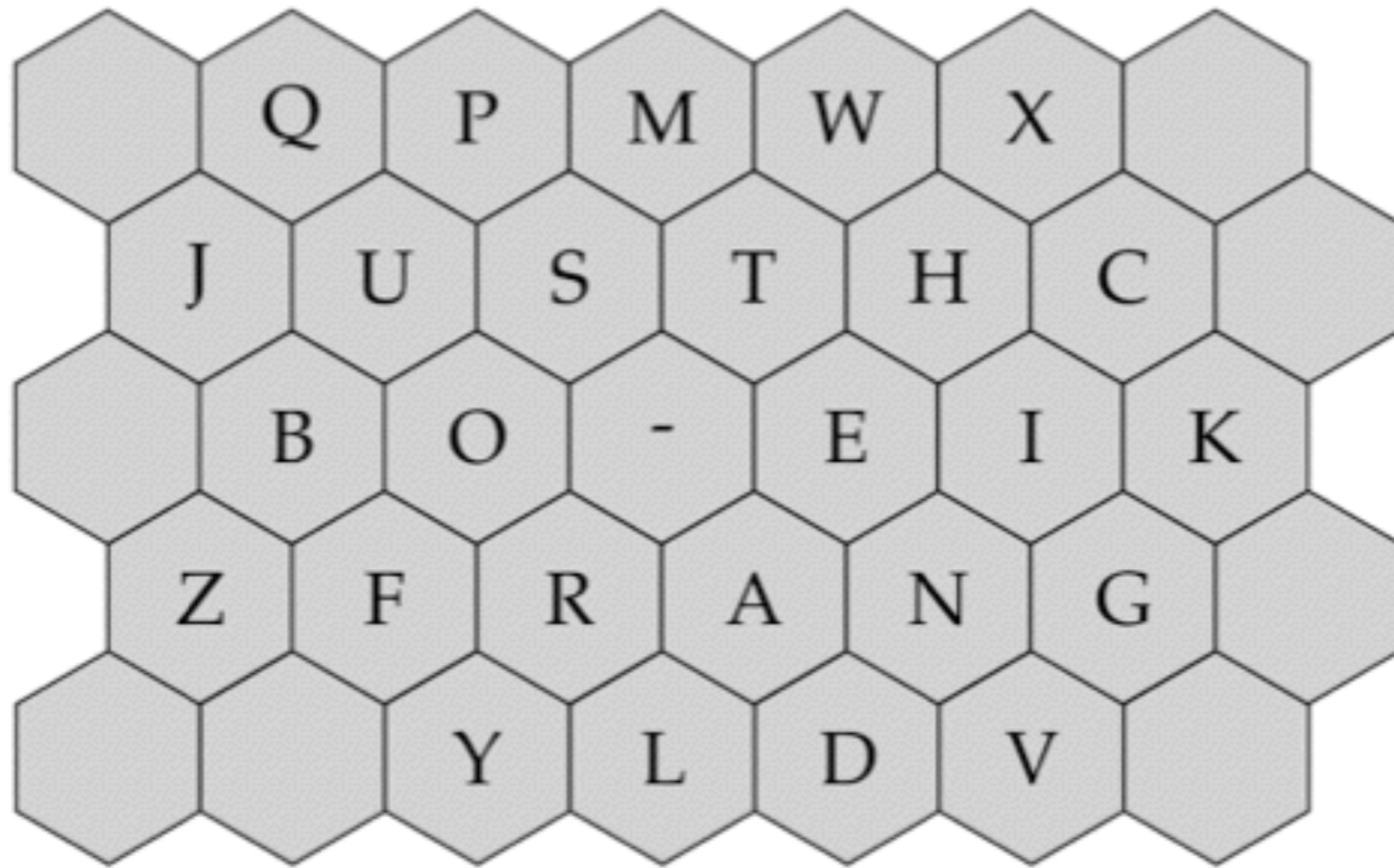
Web Search  
Downloads ⌘D  
Add-Ons ⌘A  
Check for Updates ⌘⇧⇧C  
Page Info ⌘⇧P  
Private Browsing ⌘⇧P  
Clear Recent History ⌘⇧C

Page Info

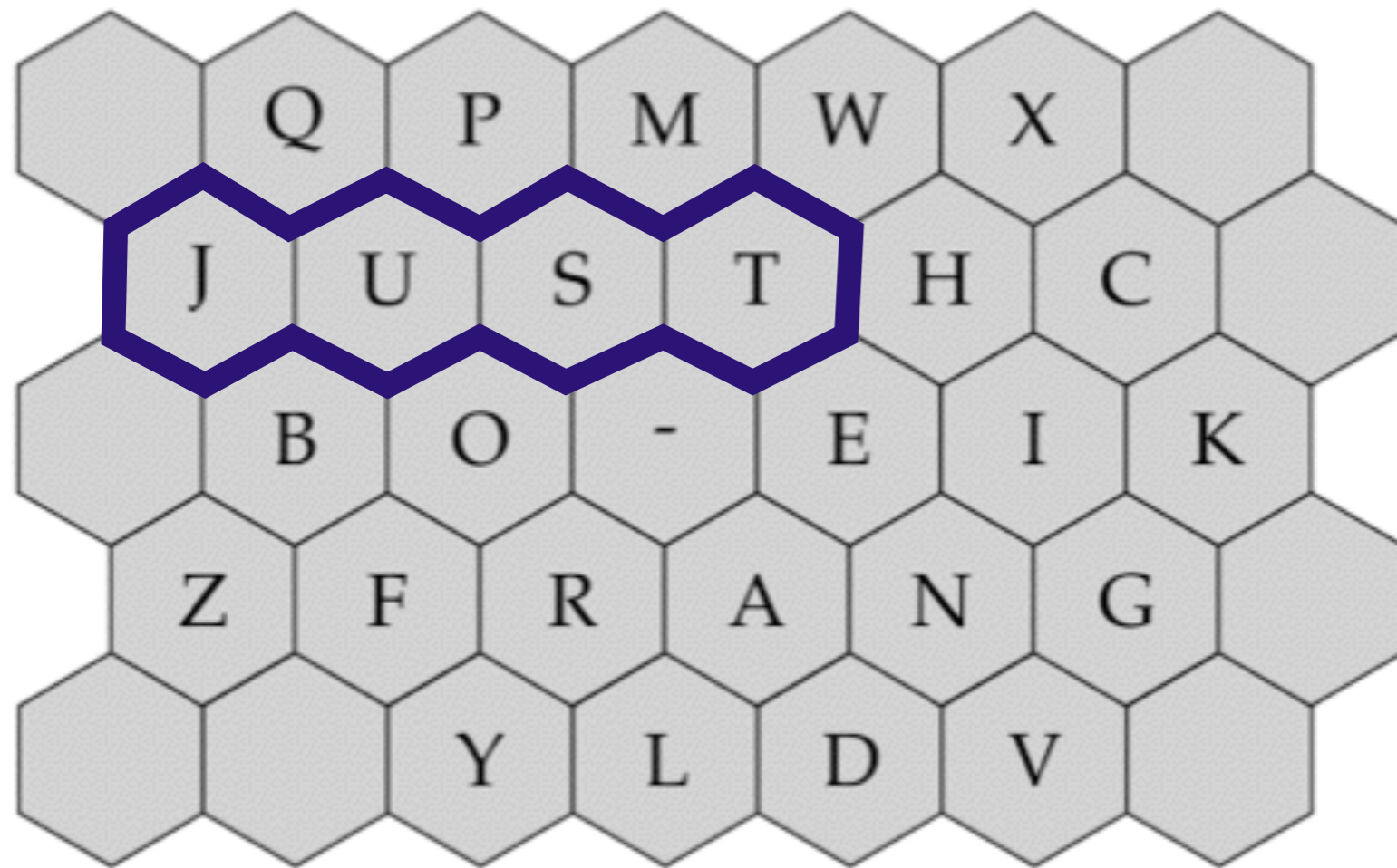
Designer Optimizer

# Virtual Keyboard

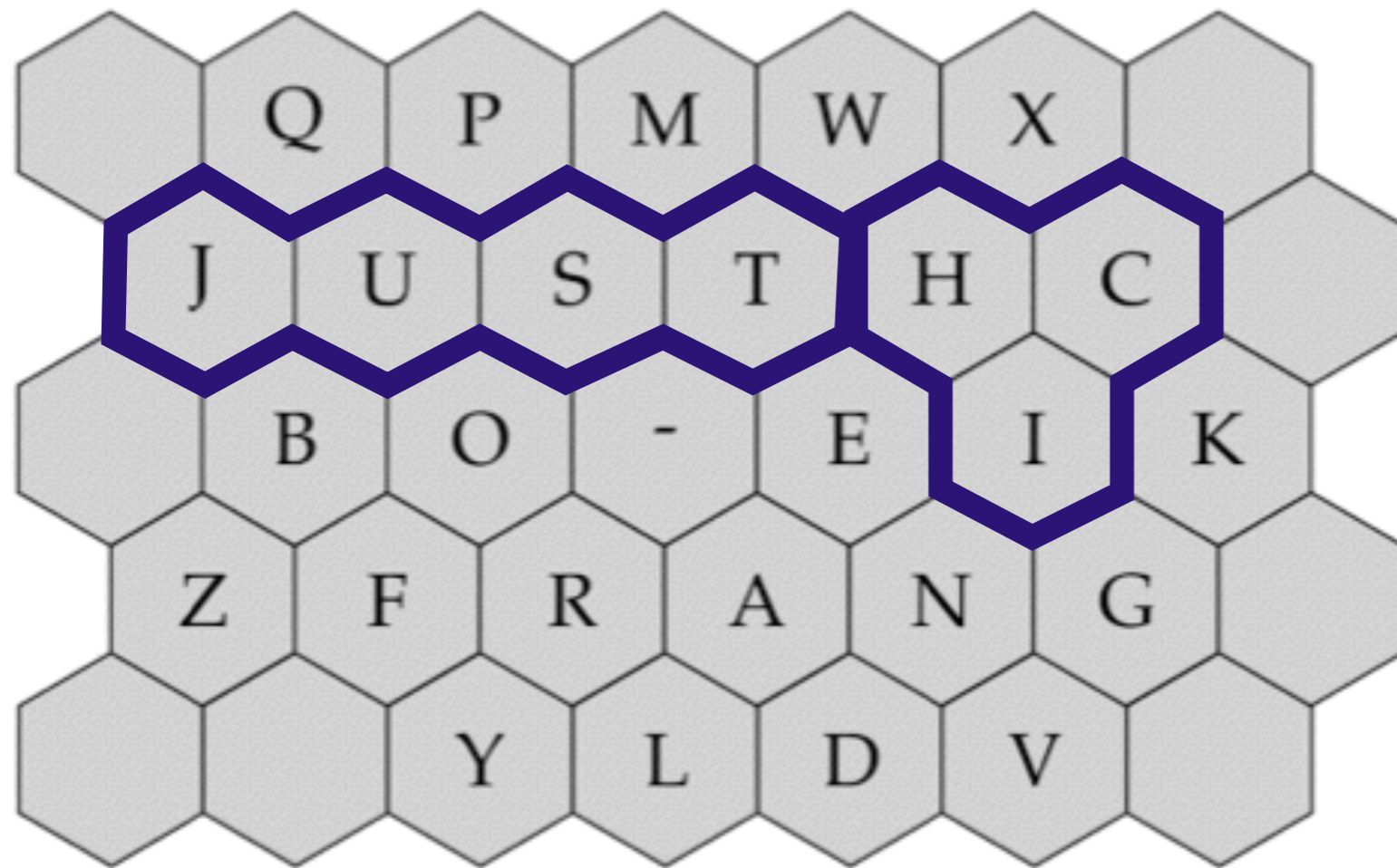
# Virtual Keyboard



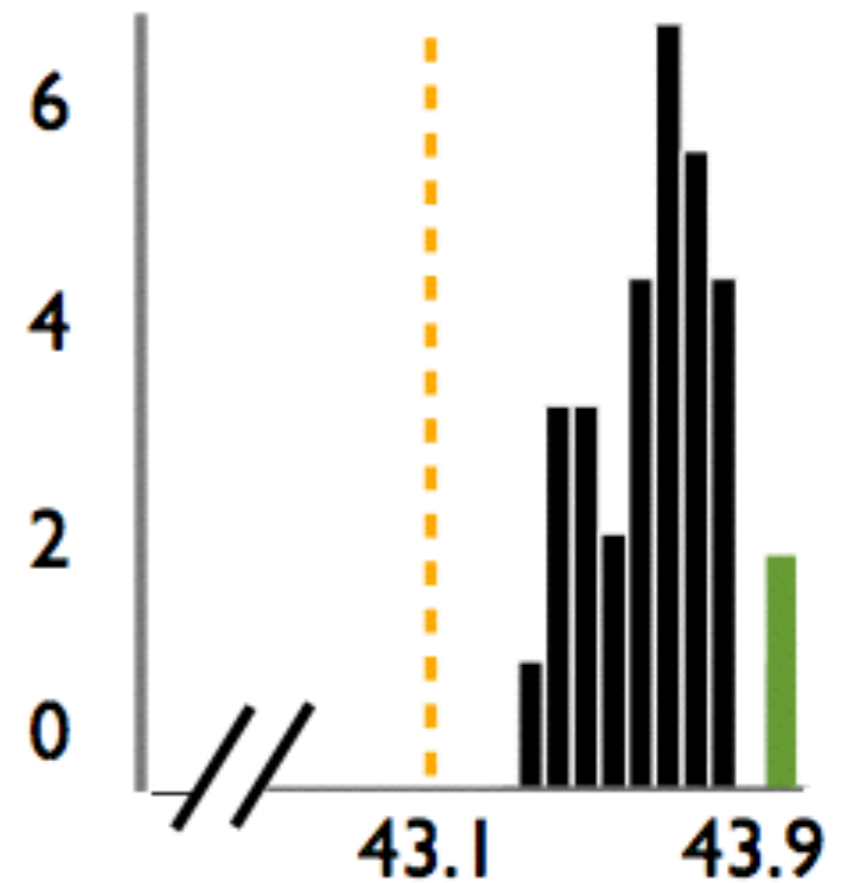
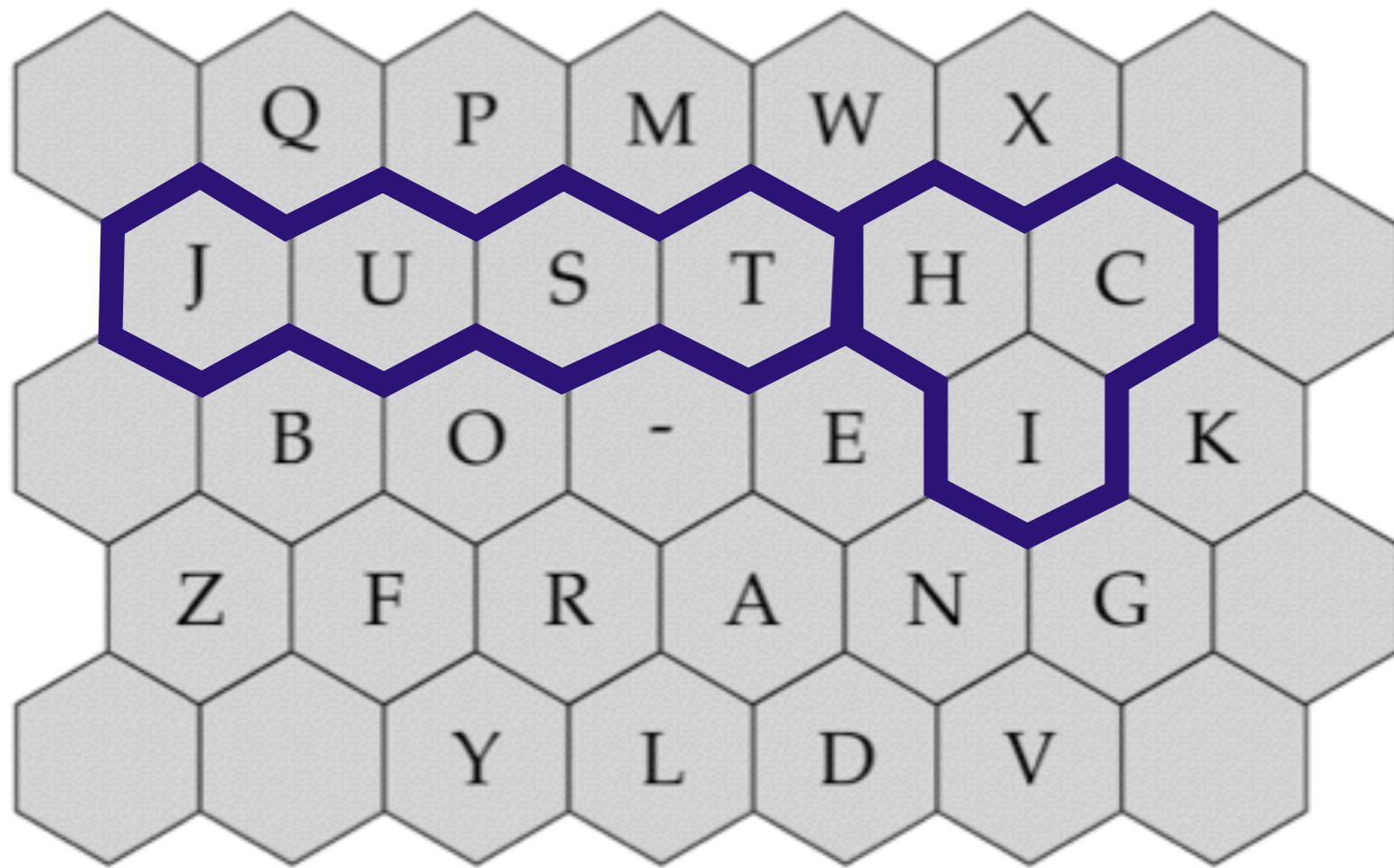
# Virtual Keyboard



# Virtual Keyboard



# Virtual Keyboard



Metropolis

JustHCl