# Direct Manipulation

## and Instrumental Interaction

## Review: Interaction vs. Interface

- What's the difference between user interaction and user interface?

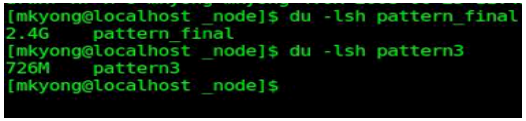
- Interface refers to what the system presents to the user
  - it's what you can manipulate and what the system uses to present feedback

- Interaction refers to the sequence of actions a person expresses and the corresponding system responses
  - it unfolds over time

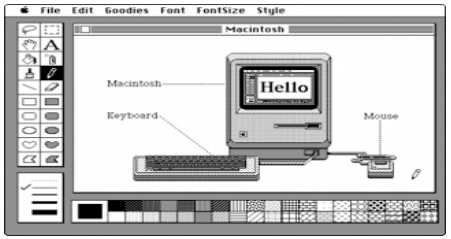
# Recall: Interaction Paradigms

- Batch interfaces
  - Knobs and Switches
  - Punch Cards

- Conversational interfaces
  - Command Line
  - Speech
  - Gestures



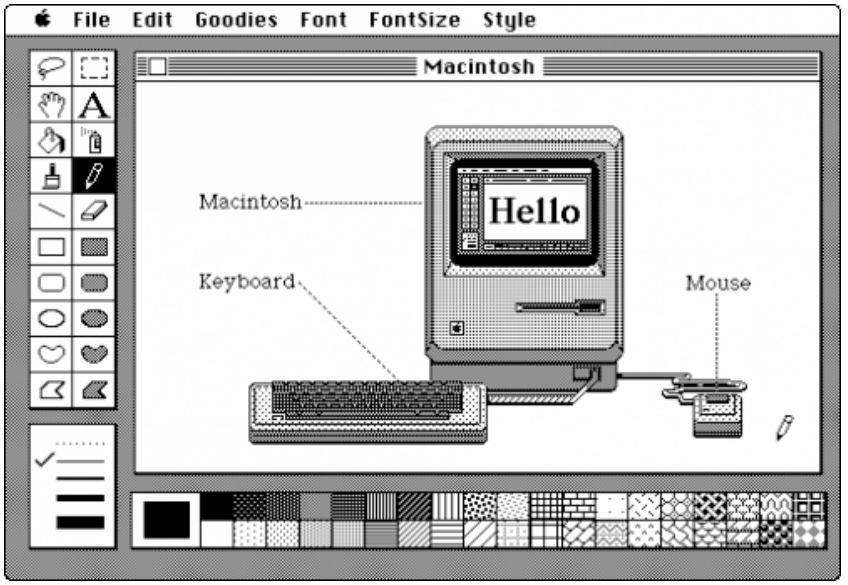

- Graphical interfaces
  - Direct Manipulation
  - …



## Recall: Graphical User Interface

- Hardware interface
  - High resolution, high refresh graphics display
  - Keyboard
  - Pointing device (e.g., mouse)

- WIMP interface
  - Windows, Icons, Menus, and Pointer
  - Desktop, files and folders



## What is Direct Manipulation?

Graphical User Interfaces often use *metaphor* to suggest how a system should be used.

- e.g. file folders on a desktop suggest specific actions: you can open a folder to reveal files, which you can read.

  Affordance:
  - a quality of an object or of an environment which allows one to perform an action
  - Don Norman: an affordance should suggest its uses; uses should be "discoverable"

**Direct Manipulation** is an attempt to make build affordances into the interface that resemble affordances for real world objects.

## What is Direct Manipulation?

By Example:

- Dragging a document to the trash, or to the printer
- Opening a file folder to reveal files that can be read
- Changing the size of a shape by dragging a “handle”
- Inserting characters in a document by pointing to where they should go (with a mouse/cursor/insertion point) and then typing
- “Dialing” a phone number using a virtual keypad
- Playing a song using controls like a physical CD/DVD player (which were like tape decks, which were like some reel-to-reel tape recorders, …)

## What is Direct Manipulation?

By Contrast: It's one of several interaction styles

- Menu selection
- Fill-in forms
- Command language
- Natural language
- Direct manipulation
- …

- Used on desktop systems, touch-based and mobile systems.

## What is Direct Manipulation?

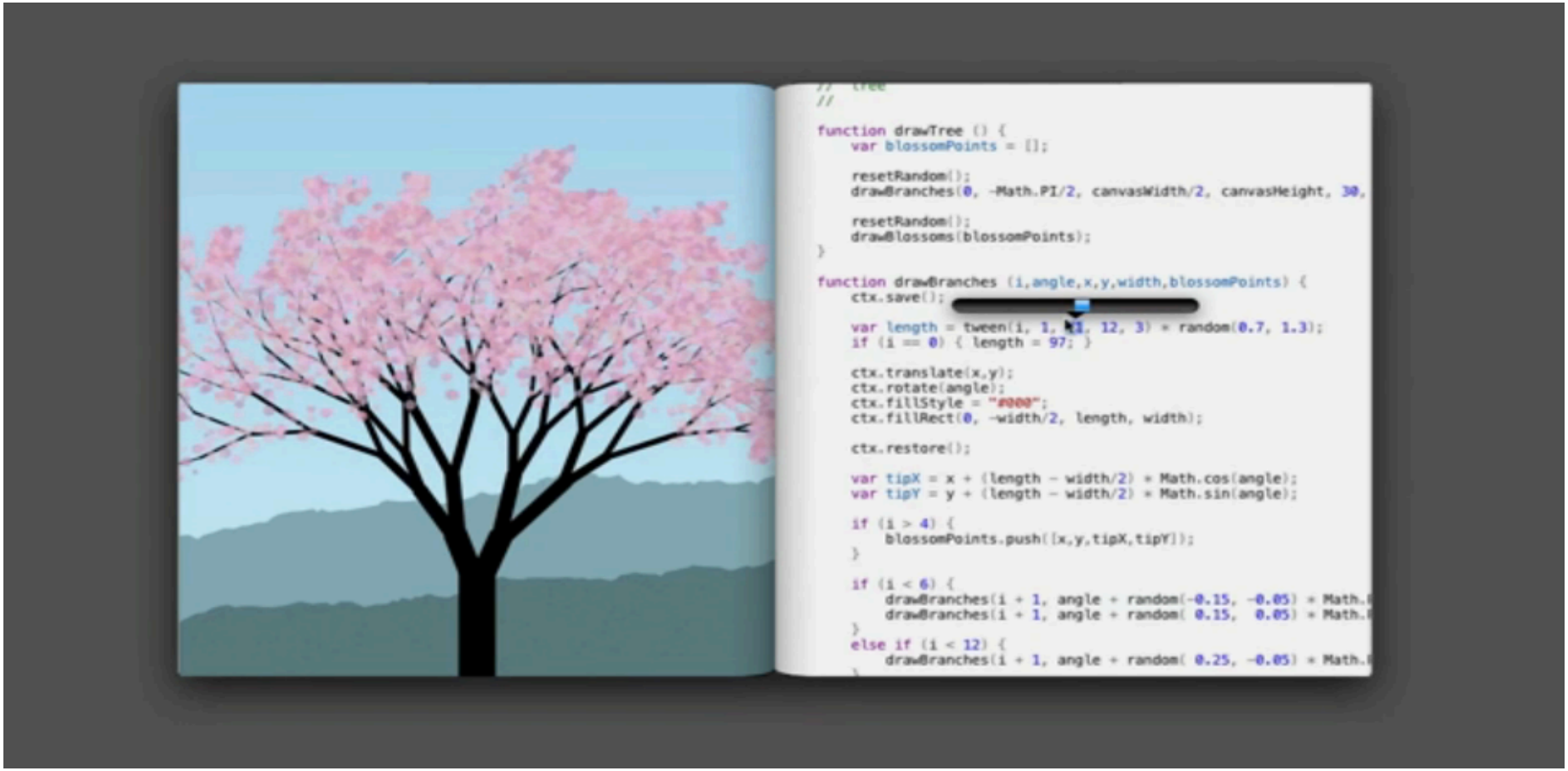
By Characteristics:

- There is a visible and continuous representation of the task objects and their actions. Consequently, there is little syntax to remember.
- The task objects are manipulated by physical actions, such as clicking or dragging, rather than by entering complex syntax.
- Every operation is syntactically legal
- Operations are rapid and incremental
- The effect of operations on task objects are immediately visible
- (Almost) all actions are reversible
- Users can explore without severe consequences

## What is Direct Manipulation?

By Benefits:

- While interacting with DM interfaces, users feel as if they are interacting with the task object rather than with the interface, so they focus on the task rather than on the technology. There is a feeling of direct involvement with a world of task objects rather than communication with an intermediary.




Bret Victor, Inventing on Principle (talk from CUSEC 2012)

- http://vimeo.com/36579366 2:33 – 4:30 (2:30 – 5:25 for animation)

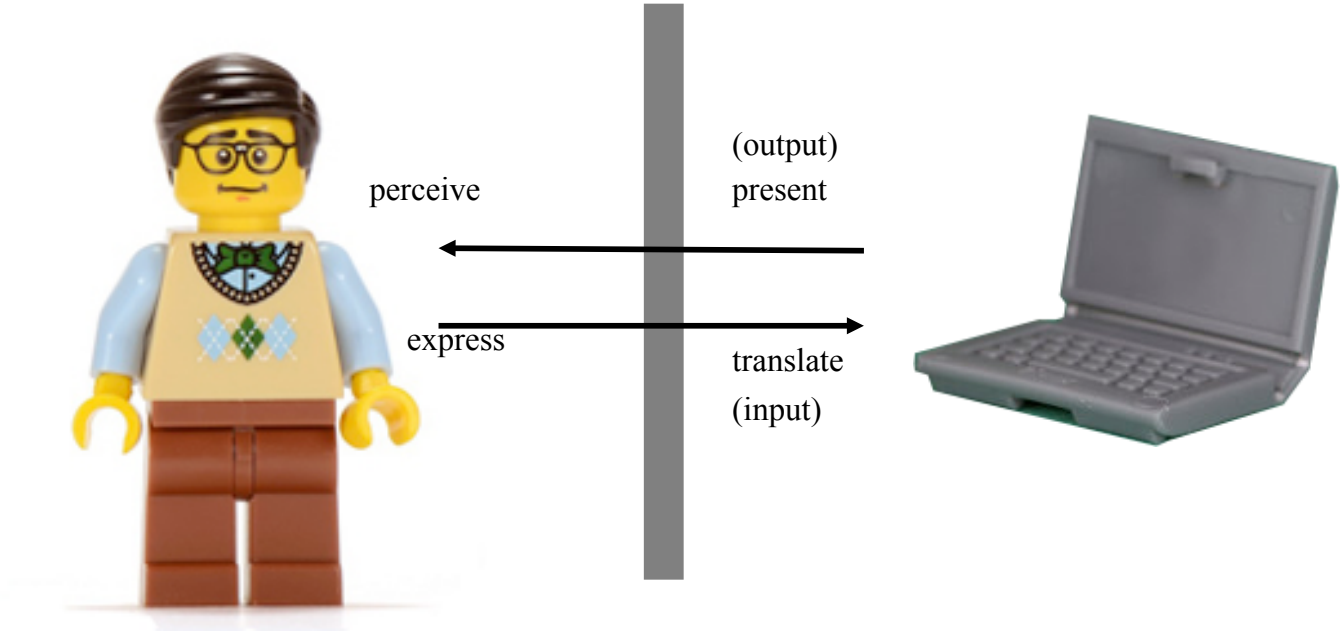
# Evaluating Graphical Interfaces

## Instrumental Interaction

## Look and Feel

Look = How manipulatable objects are **presented** in the interface

Feel = How user expression of these objects is **translated** into commands to manipulate underlying data



## Interaction Model

"An interaction model is a set of principles, rules, and properties that guide the design of an interface. It describes how to combine interaction techniques in a meaningful and consistent way and defines the *look and feel* of the interaction from the user's perspective. Properties of the interaction model can be used to evaluate specific interaction designs." (Lafon, 2000)

- We have talked about execution-evaluation cycle and interaction framework in this course, but these are at the user-action level, not at the level of describing UI objects

Beaudouin-Lafon, M. 2000. Instrumental interaction: an interaction model for designing post-WIMP user interfaces. Proceedings of CHI '00, 446-453. http://doi.acm.org/10.1145/332040.332473

## Instrumental Interaction

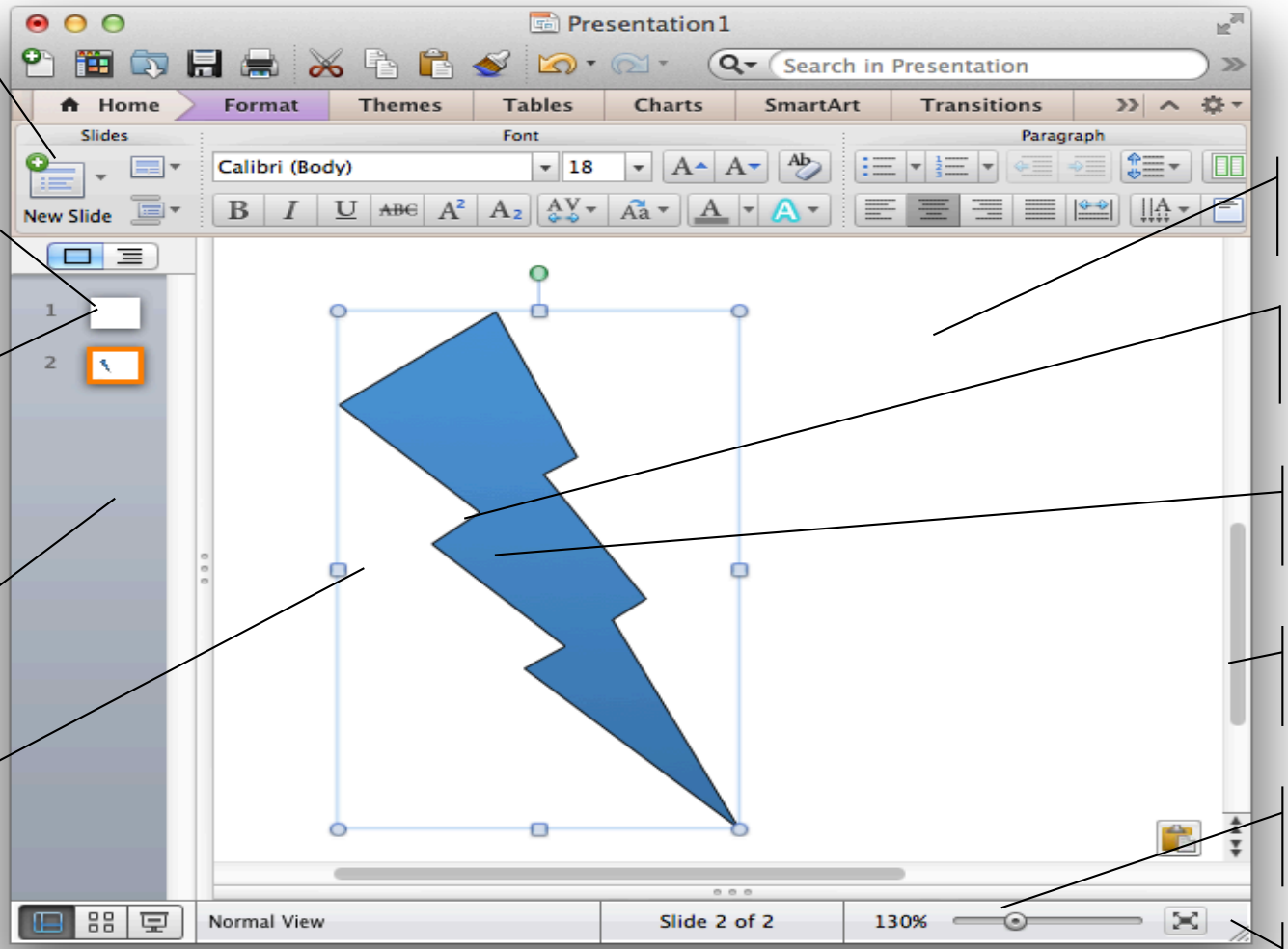
"A model of interaction based on how we naturally use tools (or instruments) to manipulate objects of interest in the physical world."

An interface is composed of

- **Domain objects:** the thing of interest, e.g., data and associated attributes
- **Interaction instrument**: a necessary mediator between the user and domain objects

Domain objects are manipulated using interaction instruments.

# Instruments vs. Domain Objects




new slide instrument

slide selection instrument

slide reordering instrument

presentation object

resize instrument

slide object

drawing object

translate instrument

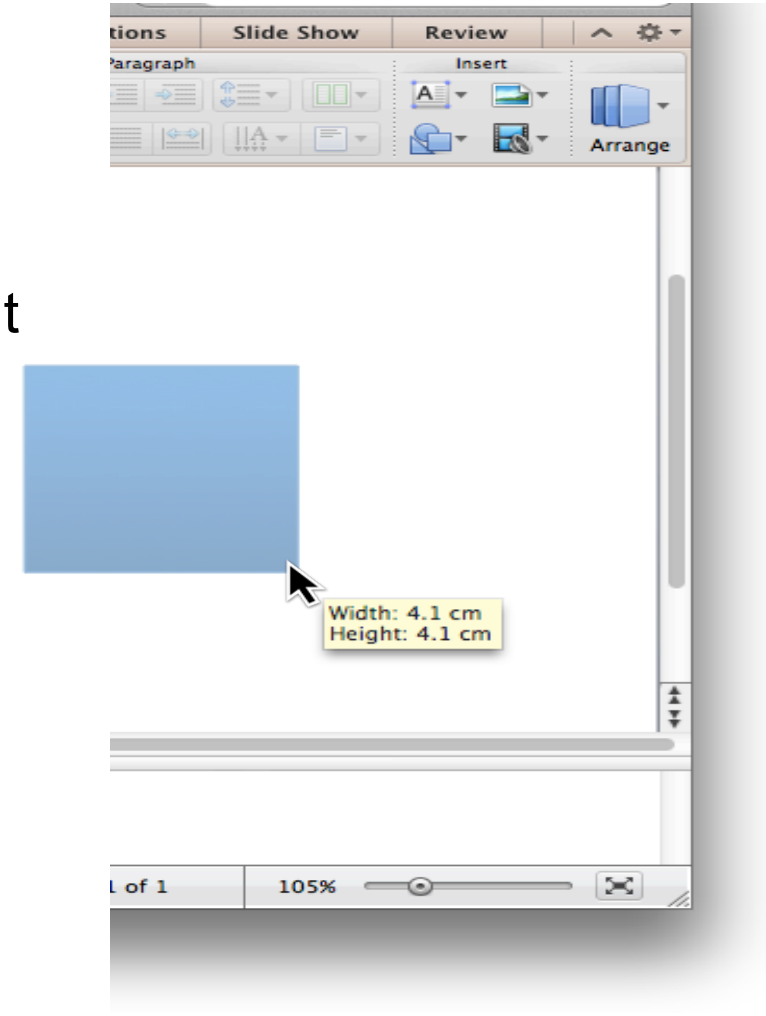
scroll instrument

magnification instrument

resize instrument

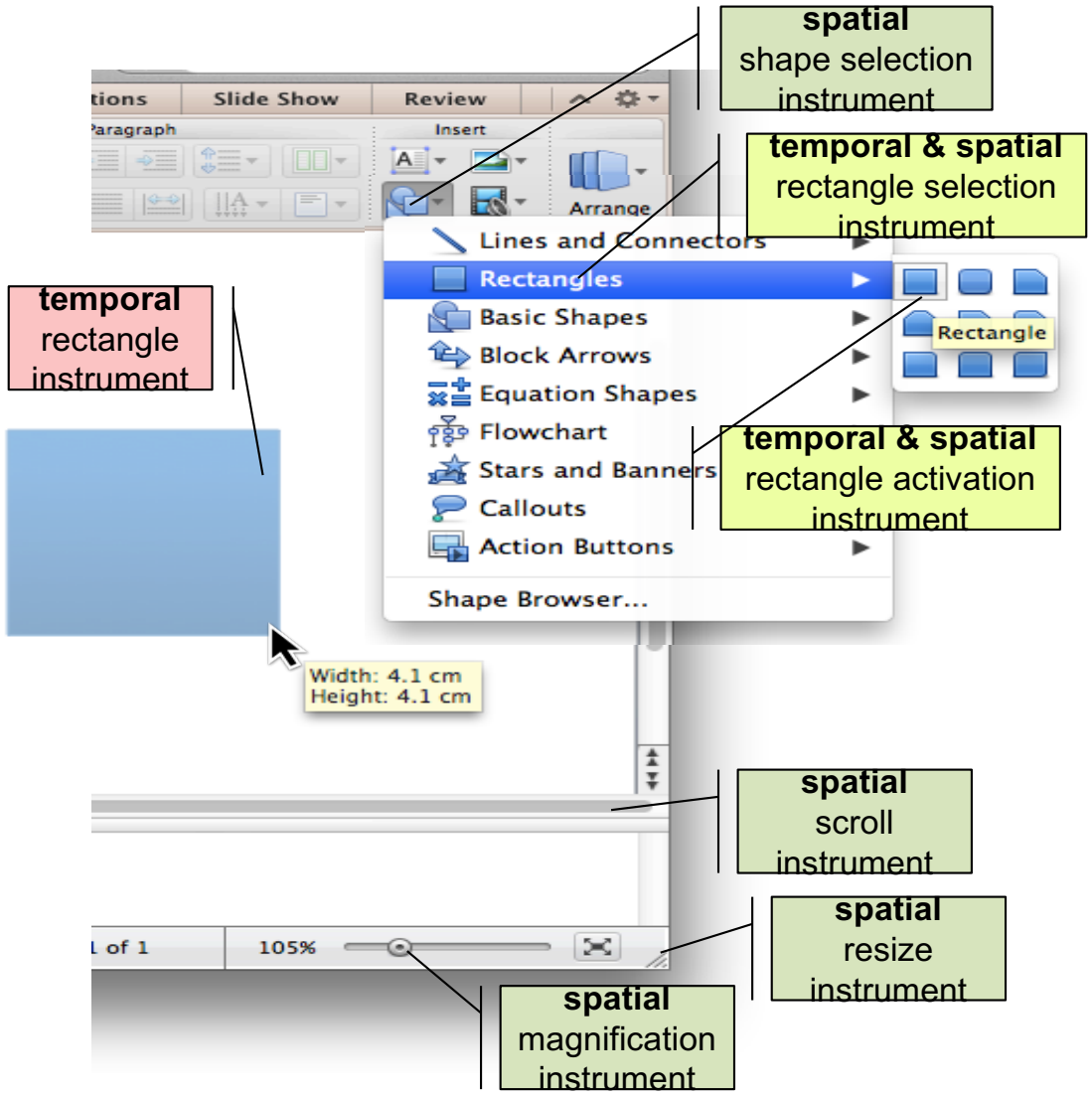
# Instrument Activation

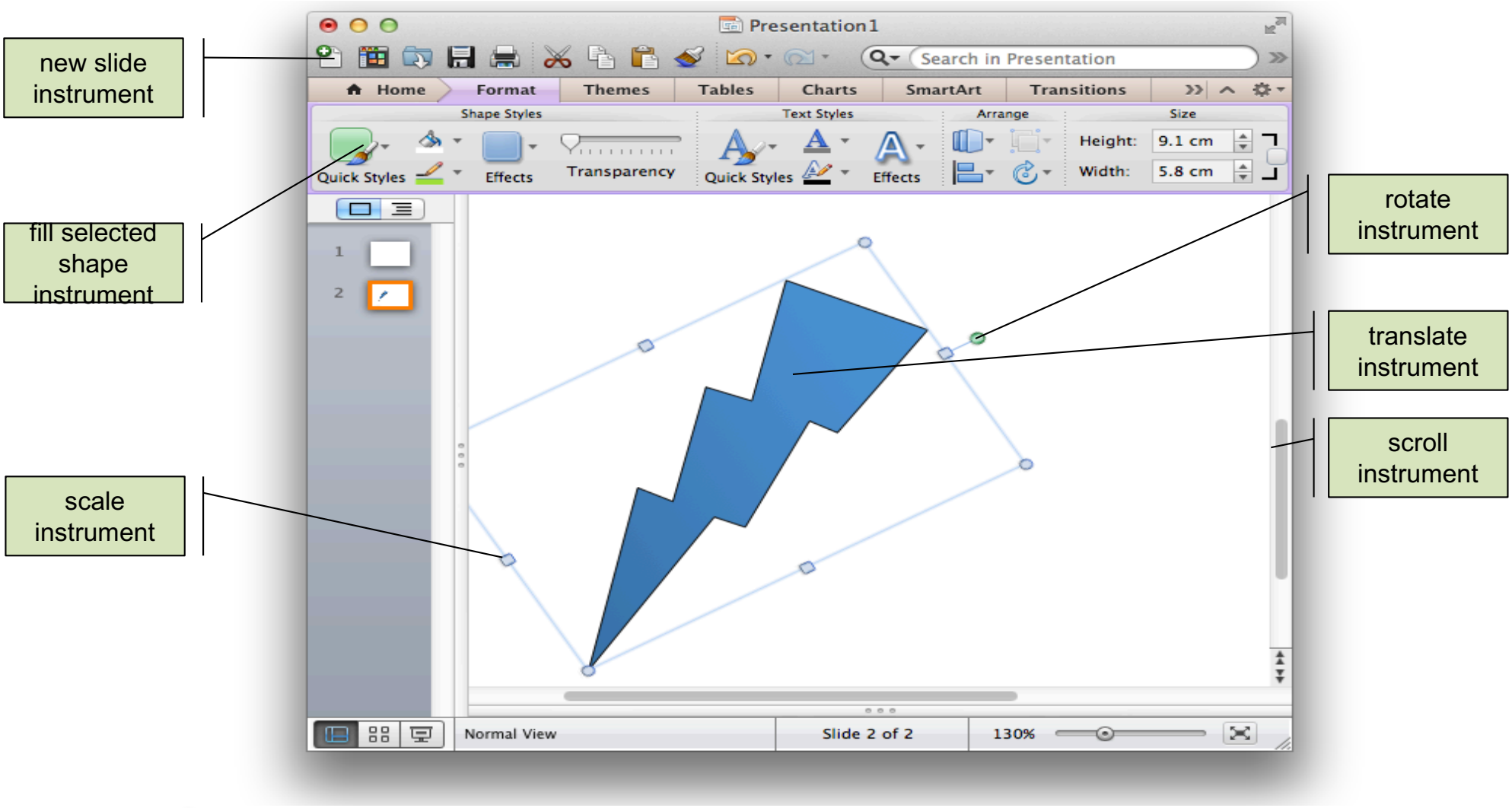
- **Activation**: When instrument (logical part) is under user's control (via physical part – mouse or keyboard)
  - Using the scrollbar instrument – how did it get activated?
  - Using the rectangle creation instrument – how did it get activated?
- WIMP instruments activated spatially or temporally or by a combination
  - **Spatial**: caused by moving mouse/cursor into a control area
  - **Temporal**: caused by a former action; remains in effect until the activation of another instrument; enters a "mode".



# Instrument Activation

- WIMP instruments activated spatially or temporally
  - **Spatial**: caused by moving mouse/cursor into a control area
  - **Temporal**: caused by a former action; remains in effect until the activation of another instrument.
- Spatial activation requires an on-screen representation.
- Temporal activation could be via on-screen or keyboard.




new slide instrument
fill selected shape instrument
scale instrument
rotate instrument
translate instrument
scroll instrument
Presentation1
Search in Presentation
Home
Format
Themes
Tables
Charts
SmartArt
Transitions
Shape Styles
Quick Styles
Effects
Transparency
Text Styles
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Effects
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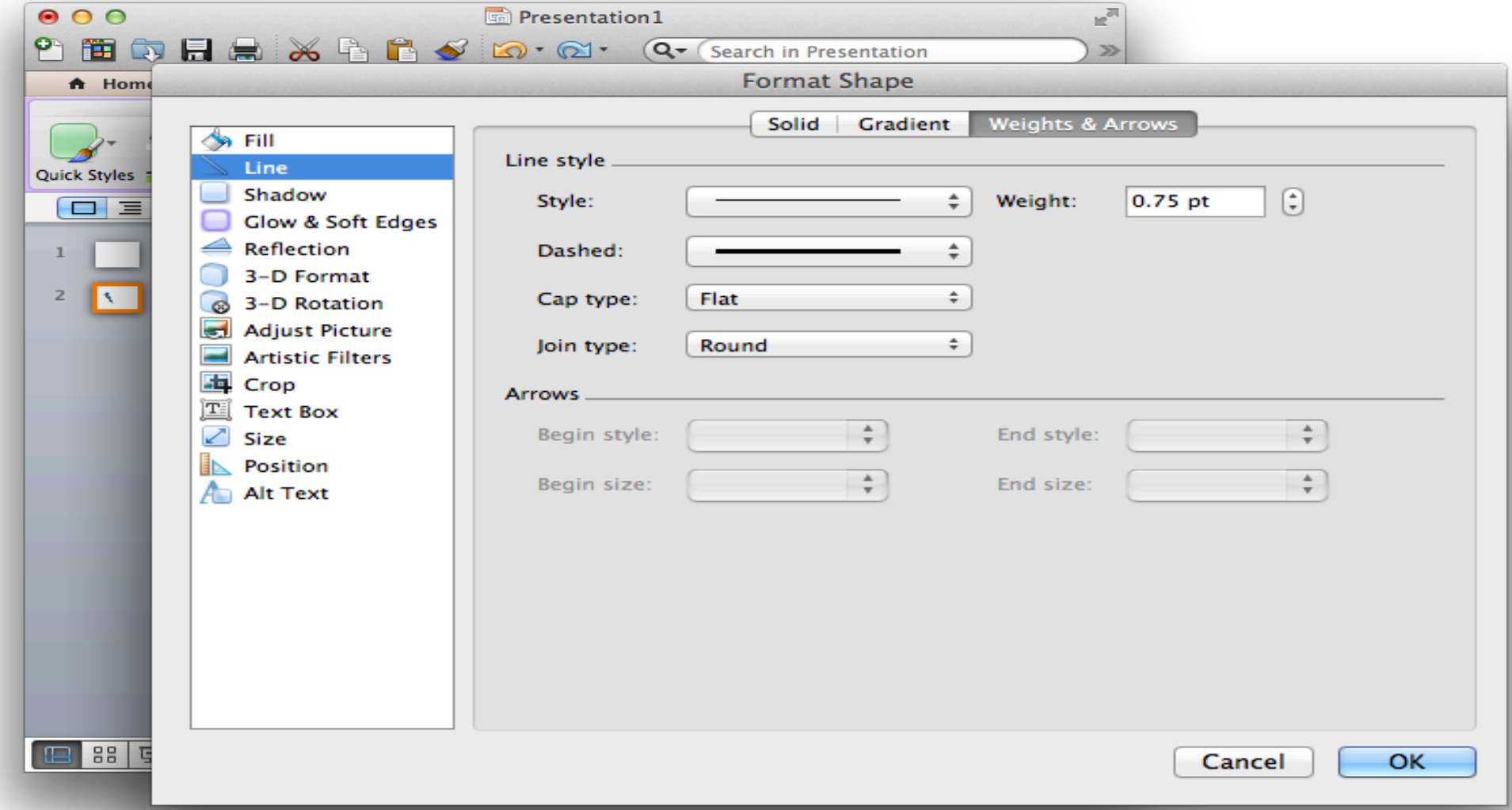
Size
Height:
9.1 cm
Width:
5.8 cm
Normal View
Slide 2 of 2
130%


Presentation1
Search in Presentation
Home
Quick Styles
Format Shape
Fill
Line
Shadow
Glow & Soft Edges
Reflection
3-D Format
3-D Rotation
Adjust Picture
Artistic Filters
Crop
Text Box
Size
Position
Alt Text
Solid
Gradient
Weights & Arrows
Line style
Style:
Weight:
0.75 pt
Dashed:
Cap type:
Flat
Join type:
Round
Arrows
Begin style:
End style:
Begin size:
End size:
Cancel
OK

## Activation Costs

- Spatial and Temporal activations have different costs
  - Spatial: cost to move the cursor to the area of interest.
  - Temporal: cost to activate a widget through a sequence of actions or steps.

- Interface designers face tradeoffs because costs can become significant when users must frequently change instruments.
  - Option:  Add more input devices

http://palettegear.com

## Evaluating Instruments

Degree of indirection

- Spatial/ temporal offset between instrument and action on object

Degree of integration

- Ratio of degrees of freedom of instrument to degrees of freedom of input device

Degree of compatibility

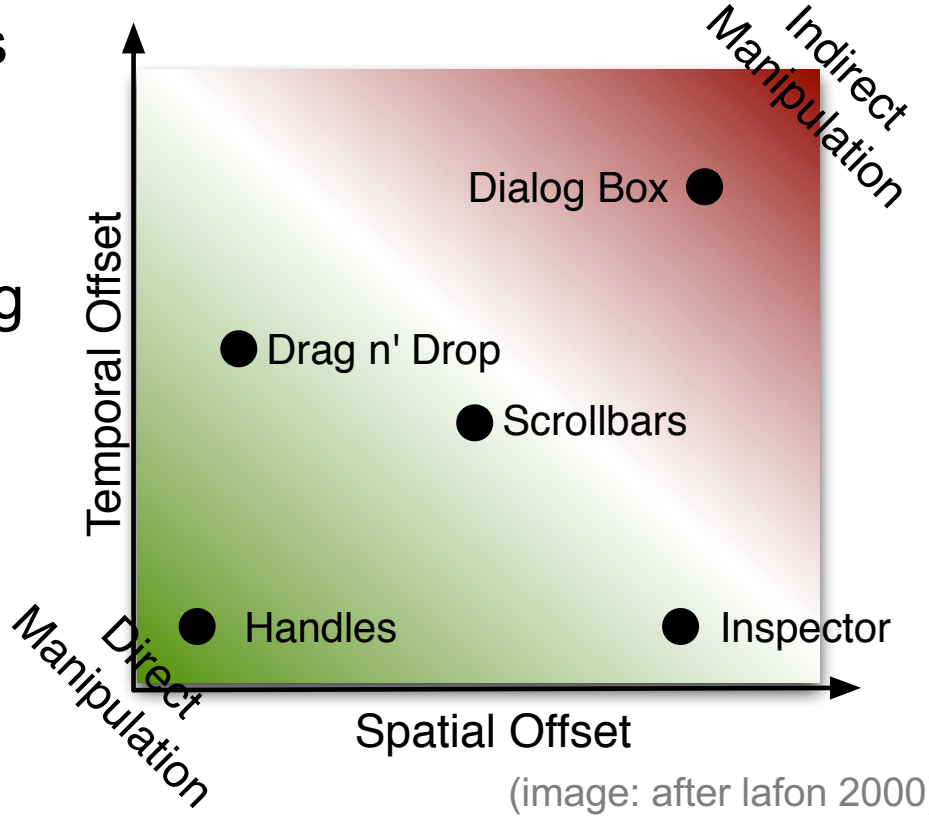
- Similarity of action on control device/instrument to action on object

## Degree of Indirection

2D measure of spatial and temporal offsets of instrument

- Spatial
  - Close: drag to translate, handles on rectangle to resize
  - Far: scrollbar, dialog boxes
- Temporal
  - direct dragging response vs. waiting until after exiting dialog

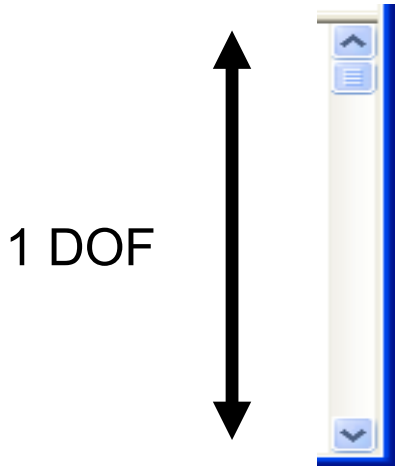
Continuum between direct manipulation and indirect manipulation



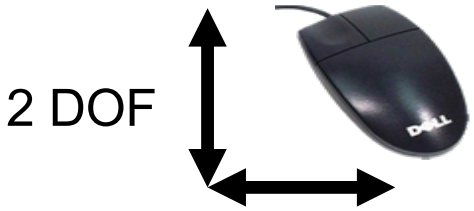

(image: after lafon 2000)

## Degree of Integration

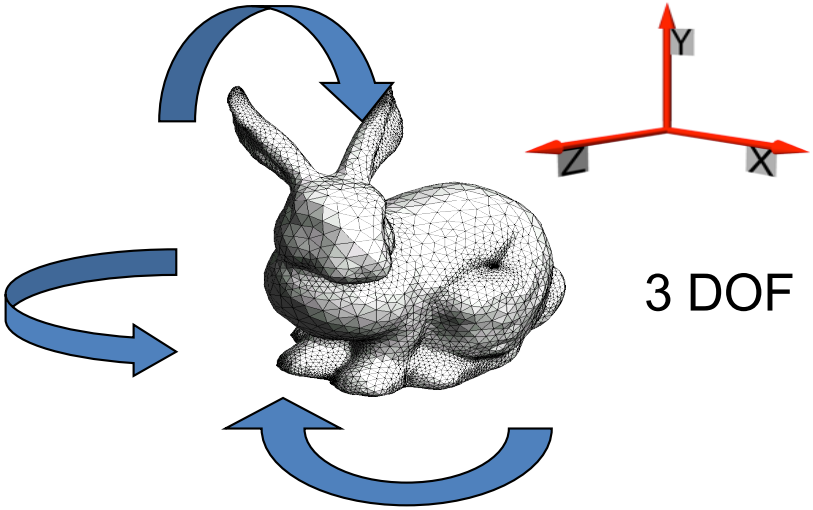
The ratio between the number of degrees of freedom (DOF) of the instrument and the DOF captured by input device



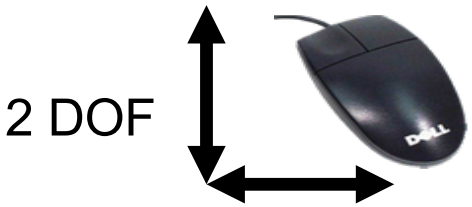
1 DOF



2 DOF




3 DOF

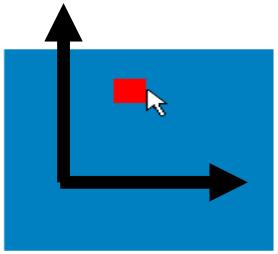


2 DOF

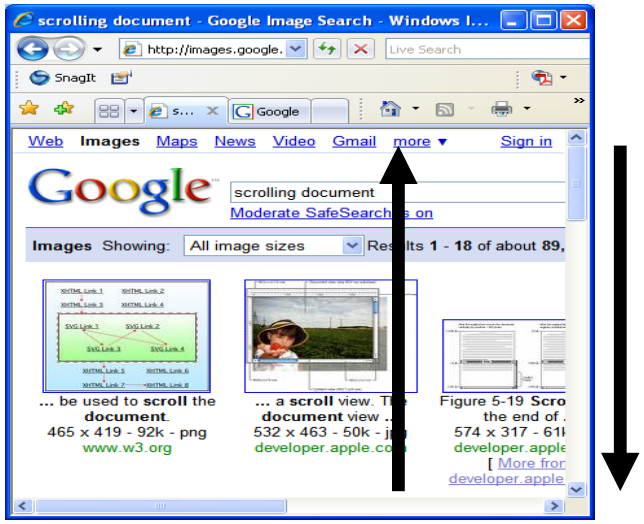
**Degree of Compatibility**

The similarity between the physical actions on the instrument and the response of the object.

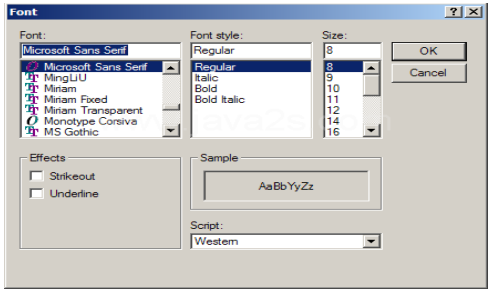
Dragging = high



Scrolling = medium




Dialog = low



# Direct Manipulation Reprise

## Direct Manipulation Principles

- There is a visible and continuous representation of the domain objects and their actions. Consequently, there is little syntax to remember.
- The instruments are manipulated by physical actions, such as clicking or dragging, rather than by entering complex syntax.
- Operations are rapid and incremental
- Their effects on domain objects are immediately visible.
- Reversibility of (almost) all actions
- Users can explore without severe consequences
- Operations are self-revealing
- Syntactic correctness – every operation is legal

(from User Interface Design & Evaluation, p. 213-214)

## GUI != Direct Manipulation

- Many commands are invoked indirectly
  - Menus, dialog boxes, toolbars
    - Not direct manipulation
    - They are mediators that pull users away from objects of interest
- Many objects of interest are hidden
  - Style sheets
  - Alignment constraints are often fleeting
- Lots of objects in the interface are not objects of interest
  - Toolbar pallets

(From Beaudoin-Lafon [2000])

## Direct Manipulation Issues

- Visually impaired users can't see the graphics; no linear flow for screen readers; physically impaired may have difficulty with required movements
- Often consume significant screen space, forcing valuable information off-screen.
- Switching between keyboard & pointer is time consuming
- Analogies may not be clear
  - Users need to learn meaning of visual representations
  - Visual representations may be misleading