

# Discovering Natural Language Commands in Multimodal Interfaces



Arjun Srinivasan



Mira Dontcheva



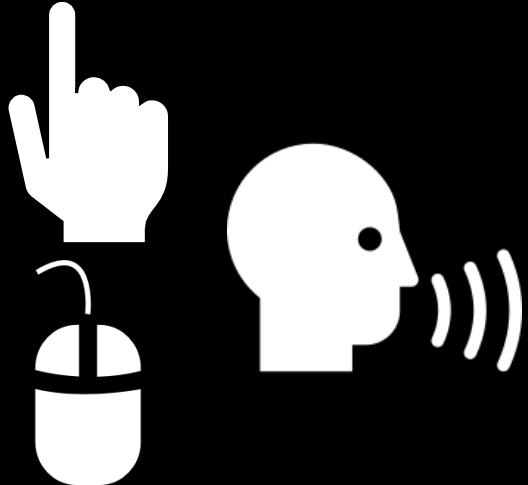
Eytan Adar



Seth Walker



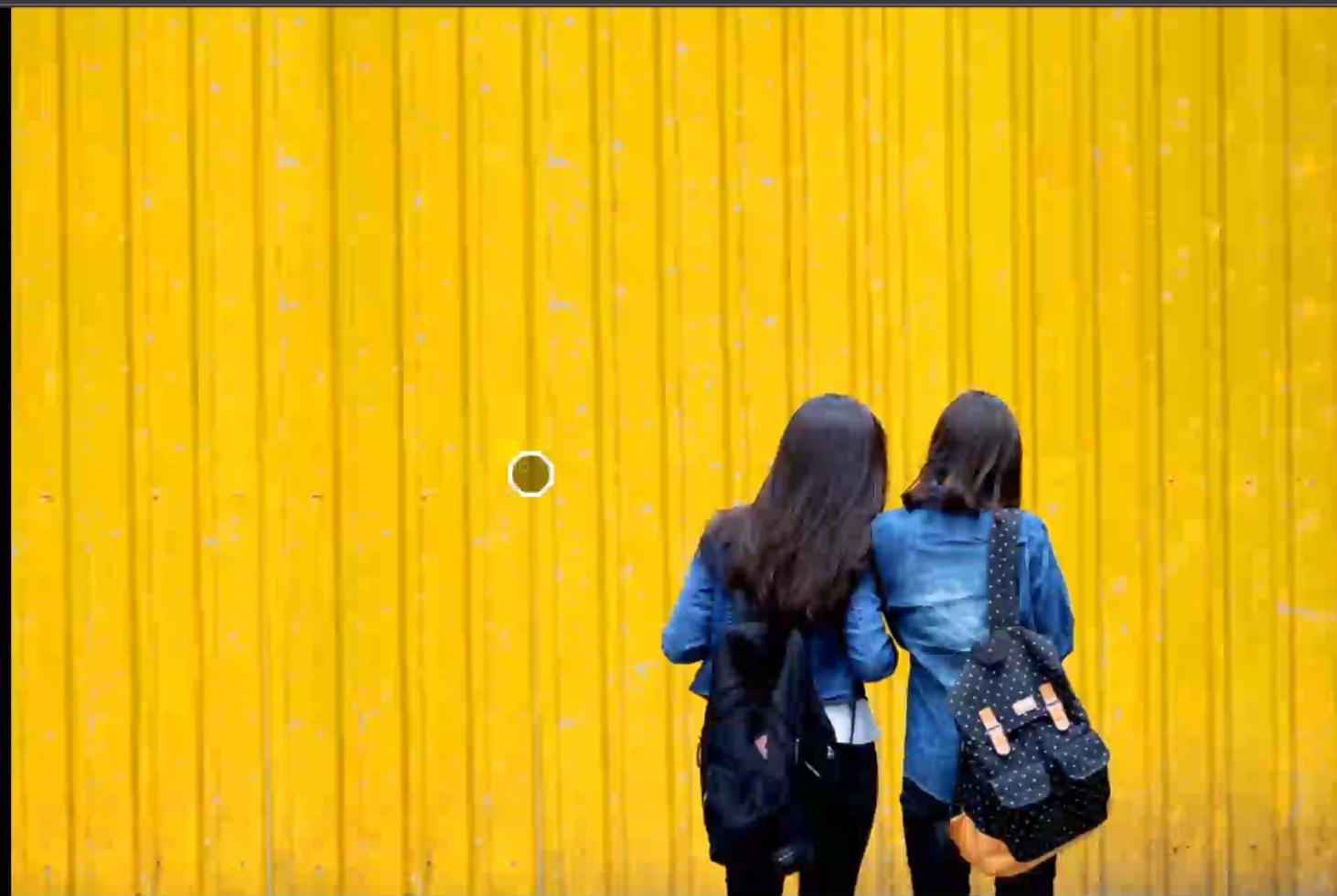
Speech-enabled multimodal interfaces are becoming popular...



Tap & Hold to Start Speaking



System feedback for your commands will appear here.



Label:  
Canvas

Effect:

Applied effects:

apply a sepia filter on the canvas



Added a medium sepia filter.



Label:  
Canvas

Effect:  
Choose an Effect...

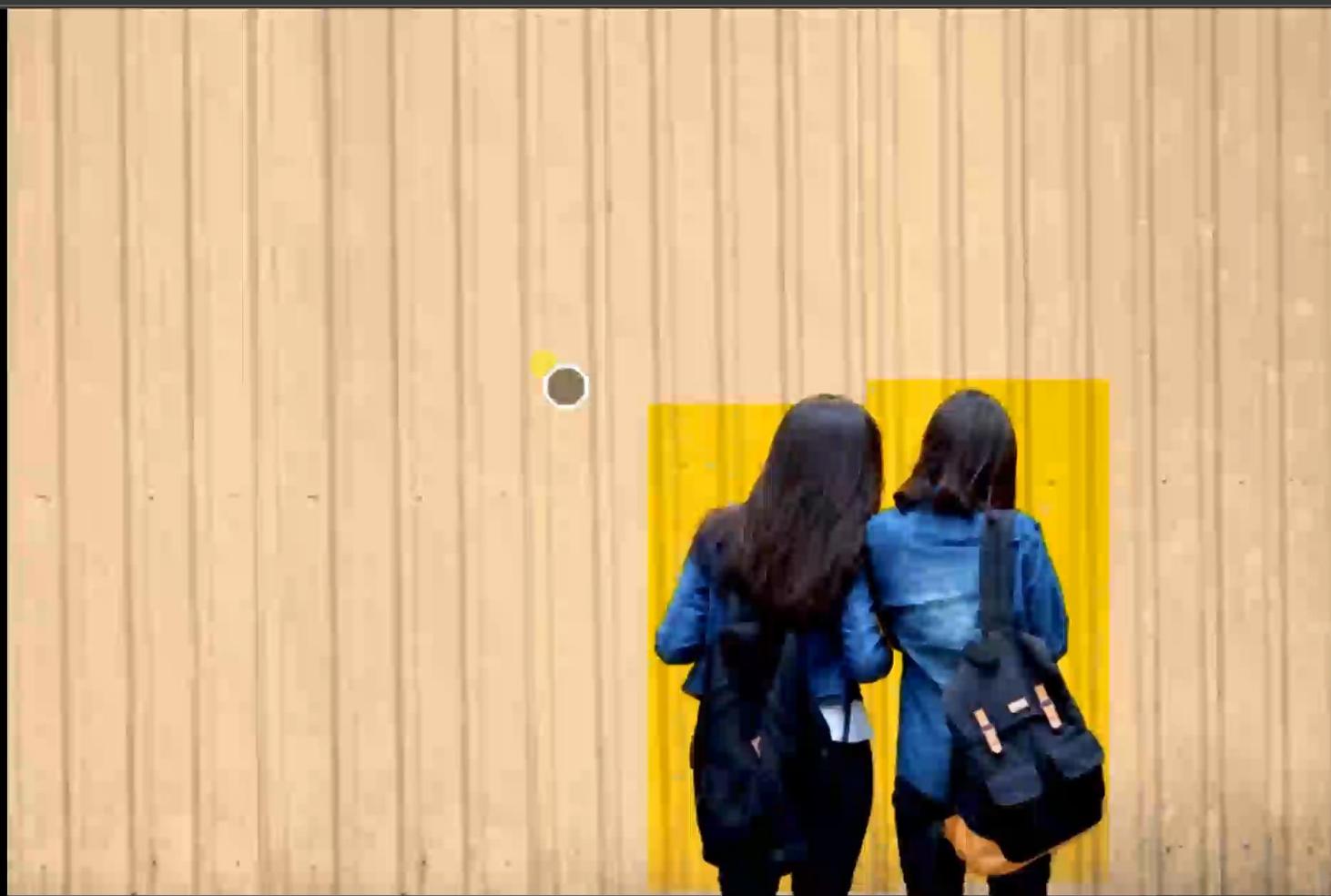
Applied effects:  
sepia



apply or light morph filter on both people



Added a light morph filter.



Label:

Canvas

Effect:

Choose an Effect...

Applied effects:

sepia



add an image to the cameras



Image added to canvas.



Label:

IMAGE\_0



Stroke color:

Black

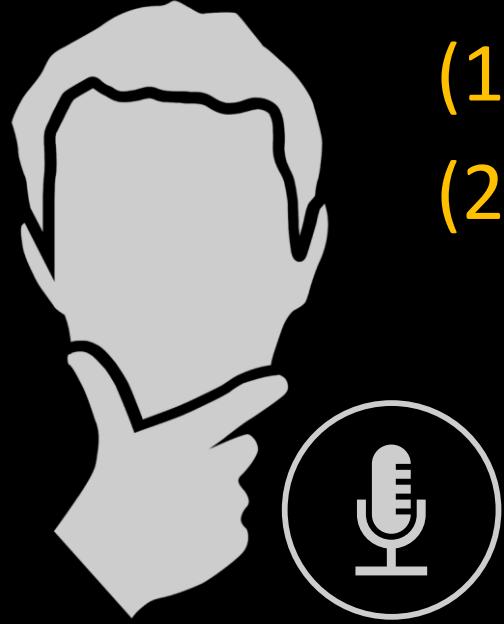
Stroke width:

1  10

Effect:

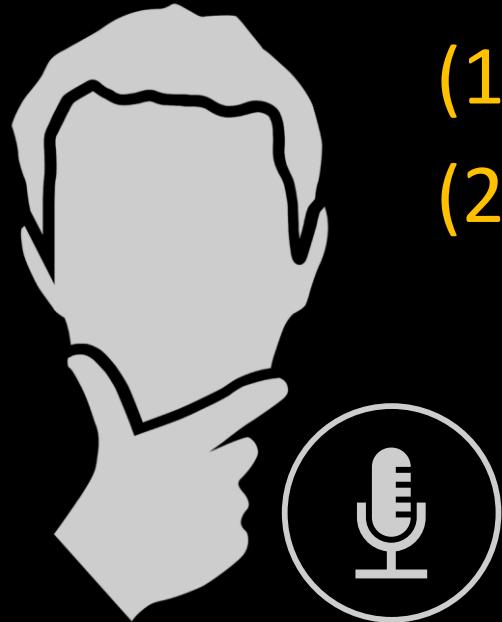
Choose an Effect...

Applied effects:



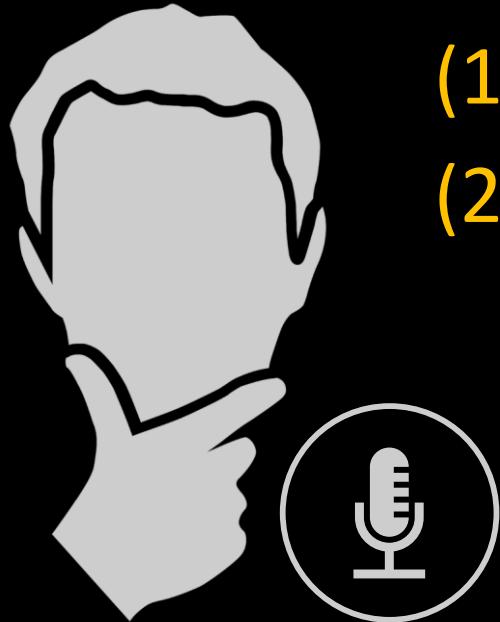
- (1) What operations can I perform?
- (2) How do I ask the system to perform them?

# Discoverability



- (1) What operations can I perform?
- (2) How do I ask the system to perform them?

# Discoverability



- (1) What operations can I perform?
- (2) How do I ask the system to perform them?

**2<sup>nd</sup> most common challenge with Voice User Interfaces**  
*Patterns for How Users Overcome Obstacles in Voice User Interfaces*, Myers et al.  
CHI 2018



"Hey Siri what can you do"

tap to edit

You can ask me to get directions,  
make phone calls, and send new  
texts and emails. I can show you  
lots more when you can look at  
your iPhone.



Phone

"Call Brian"



FaceTime



Mail



Reminders

Can we leverage multimodal input to enhance discoverability by suggesting contextually-relevant natural language commands?



Messages

"Tell Susan I'll be right there"



Calendar

"Set up a meeting at 9"



Sports

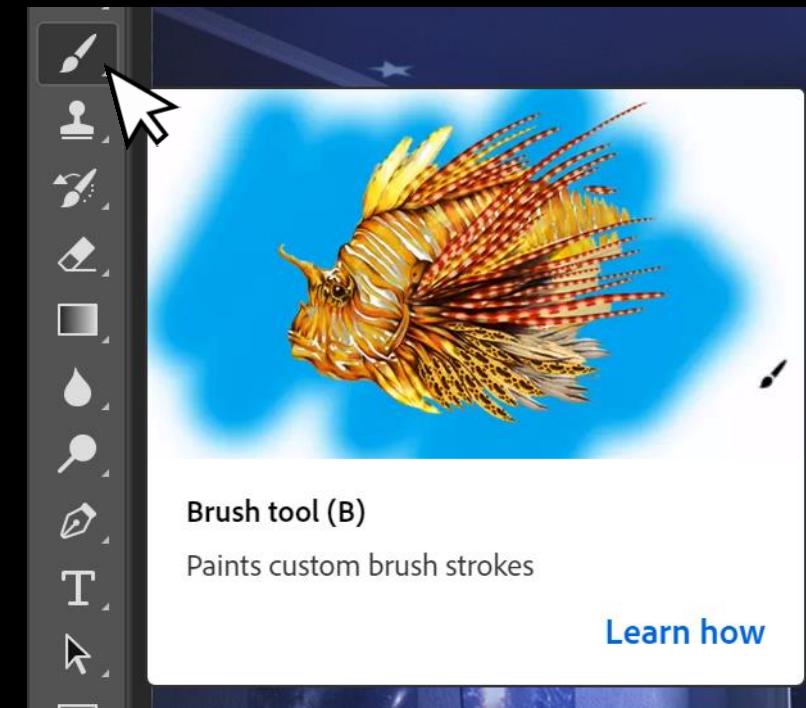
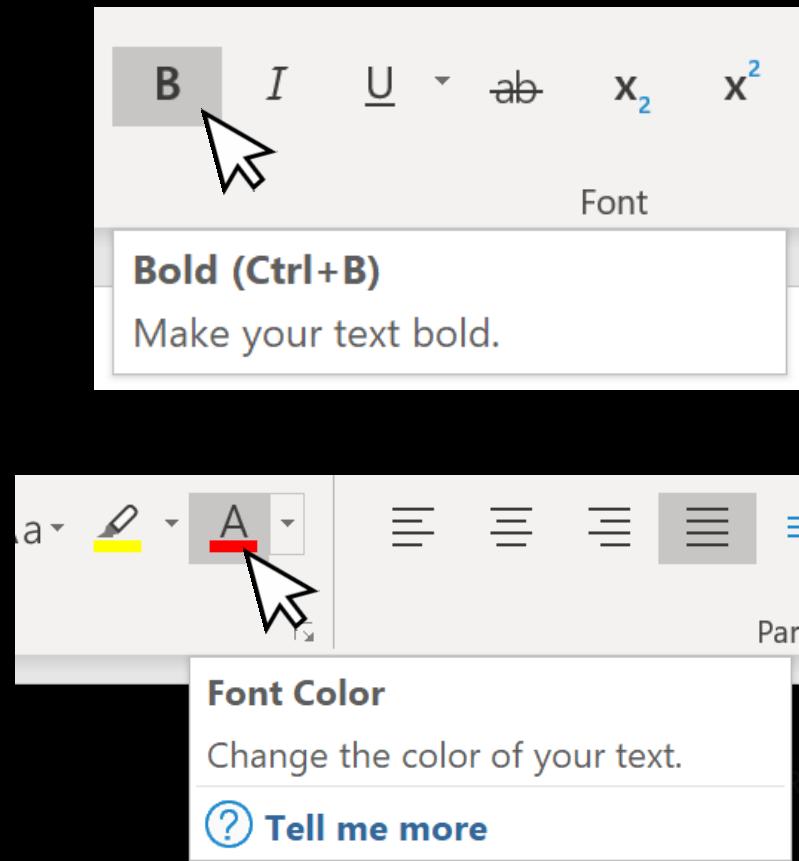
"Hockey scores from last night"



Photos



# 💡 Tooltips



Tap & Hold to Start Speaking



System feedback for your commands will appear here.



Label:  
Canvas

Effect:  
Choose an Effect...

Applied effects:

Tap & Hold to Start Speaking



System feedback for your commands will appear here.



Label:  
Canvas

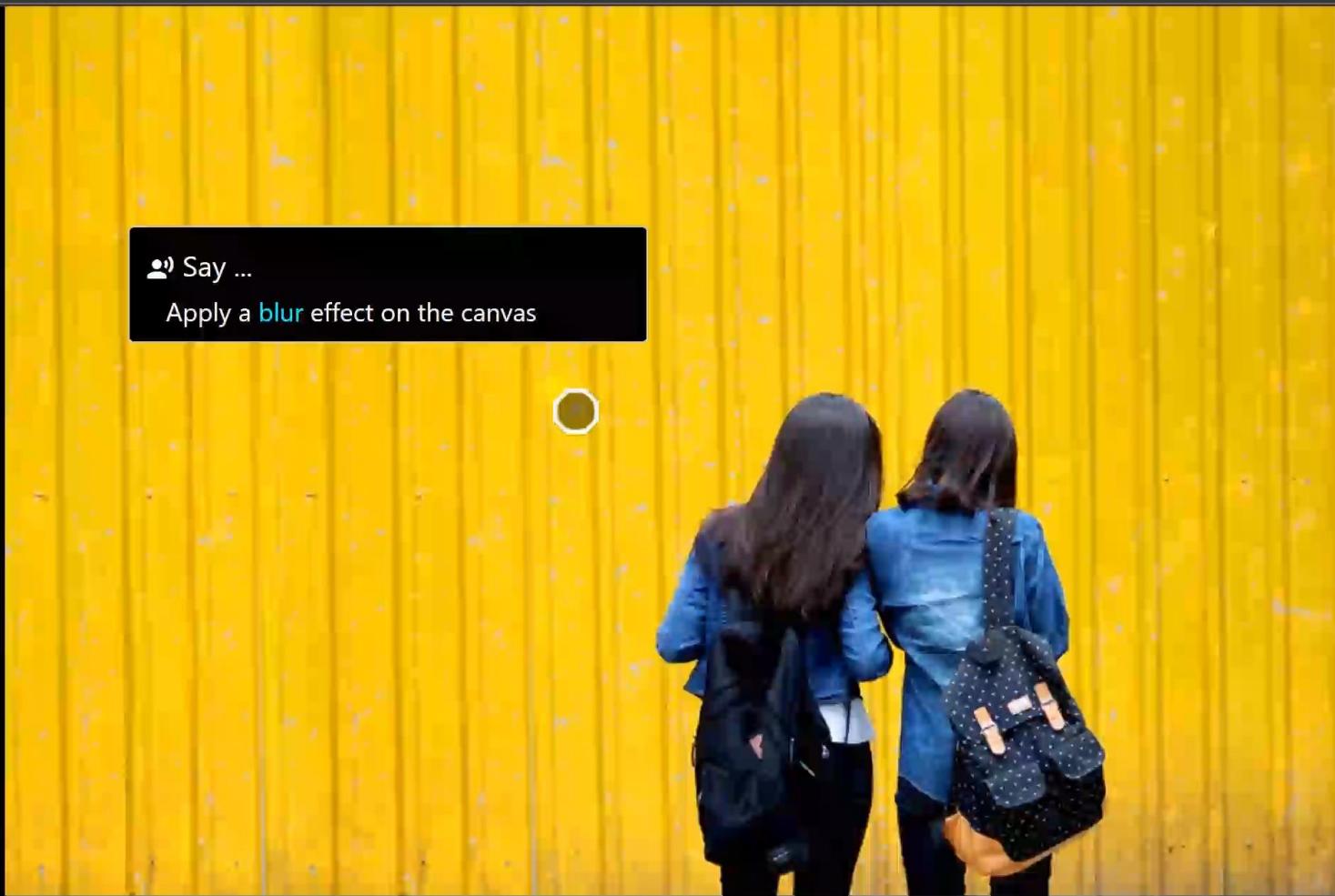
Effect:  
Choose an Effect...

Applied effects:

Listening...



System feedback for your commands will appear here.



Say ...

Apply a [blur](#) effect on the canvas

Label:  
Canvas

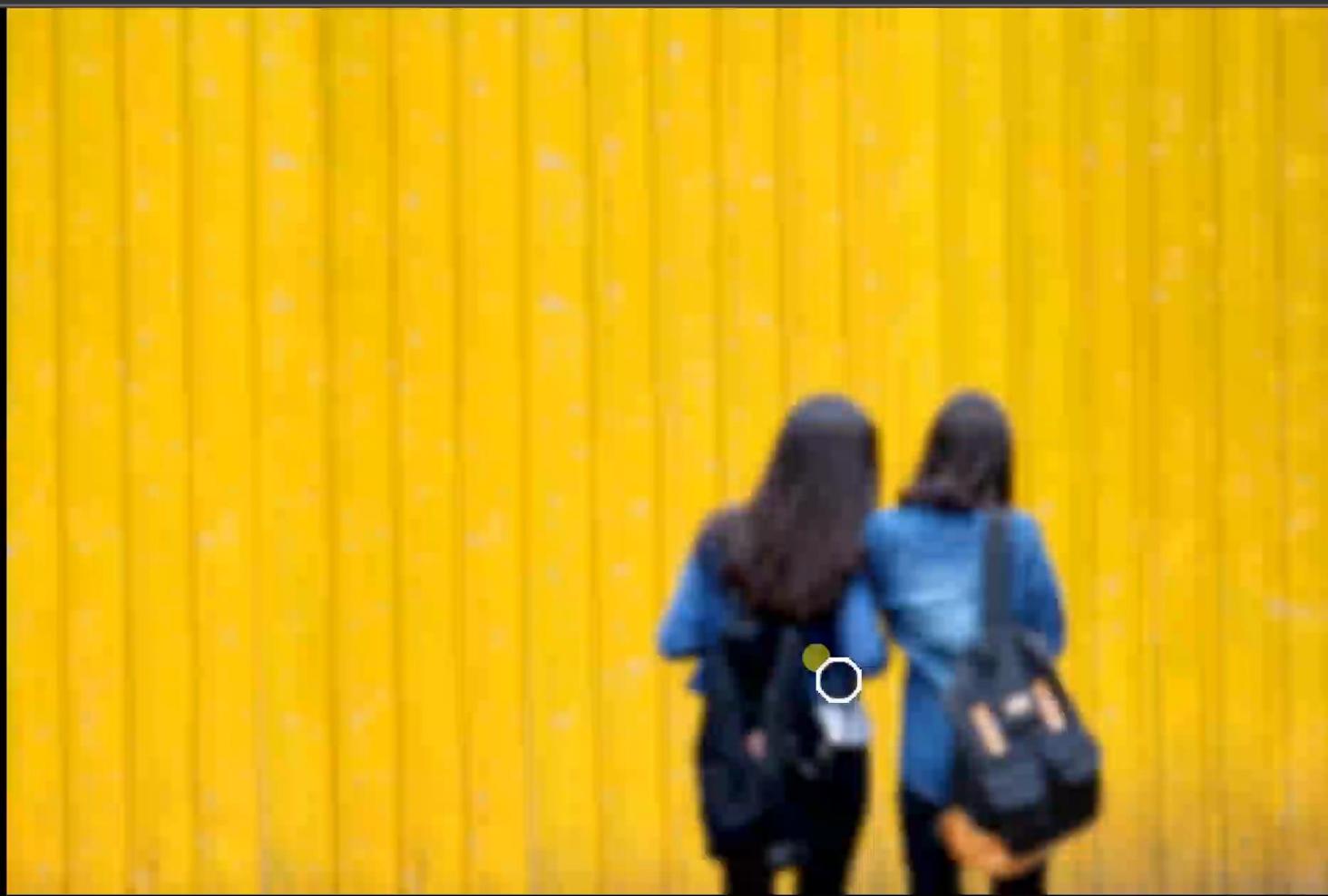
Effect:  
[Choose an Effect...](#)

Applied effects:

apply a blur effect on the canvas



Added a medium blur filter.



Label:  
Canvas

Effect:  
Choose an Effect...

Applied effects:

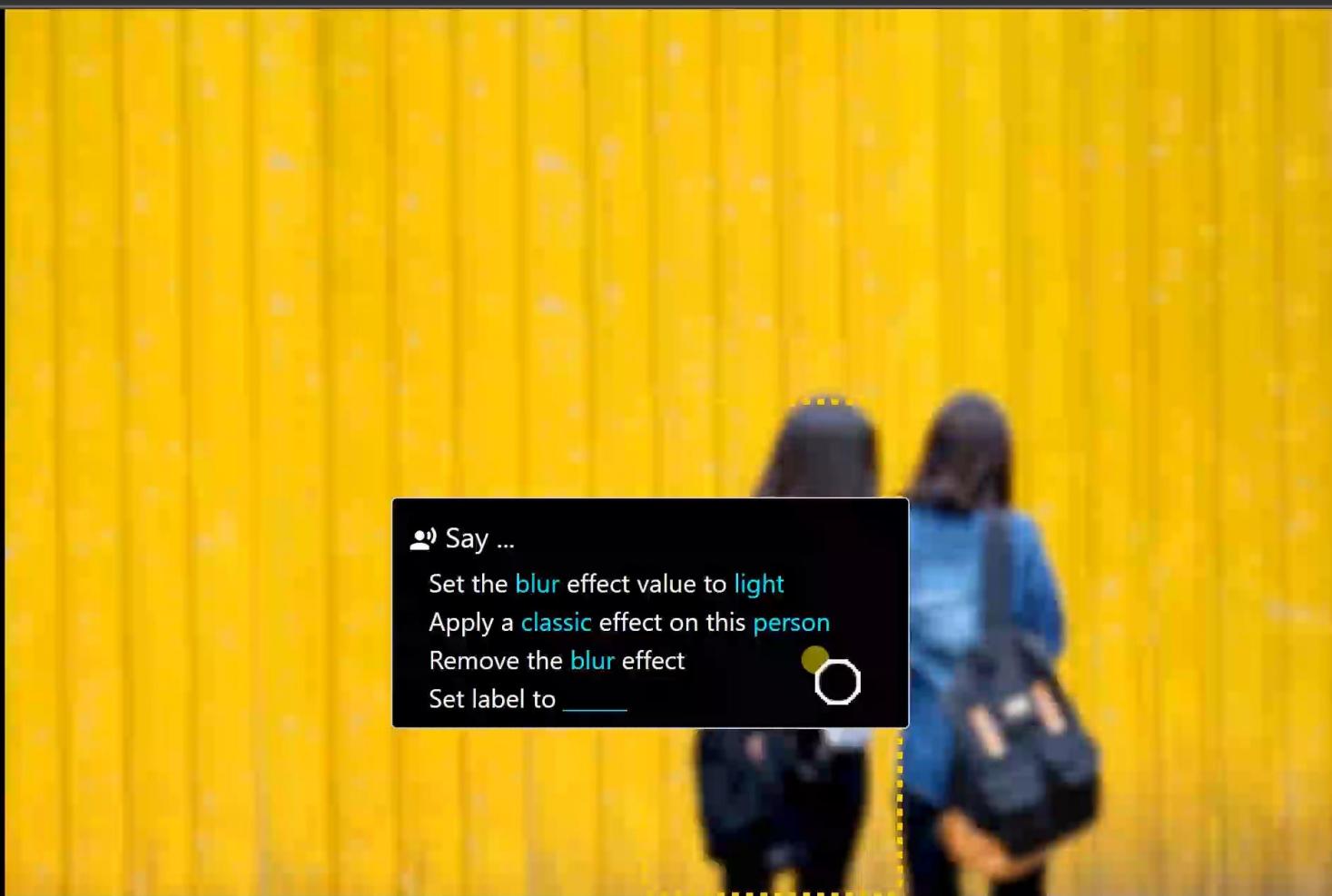
blur



apply a blur effect on the canvas



Added a medium blur filter.



👤 Say ...

Set the **blur** effect value to **light**

Apply a **classic** effect on this **person**

Remove the **blur** effect

Set label to \_\_\_\_\_



Label:

person

Effect:

Choose an Effect...

Applied effects:

blur



remove the blur effect



Removed blur filter.



Label:

person

Effect:

Choose an Effect...

Applied effects:

remove the blur effect



Removed blur filter.



Say ...

Add an image



Label:

person

Effect:

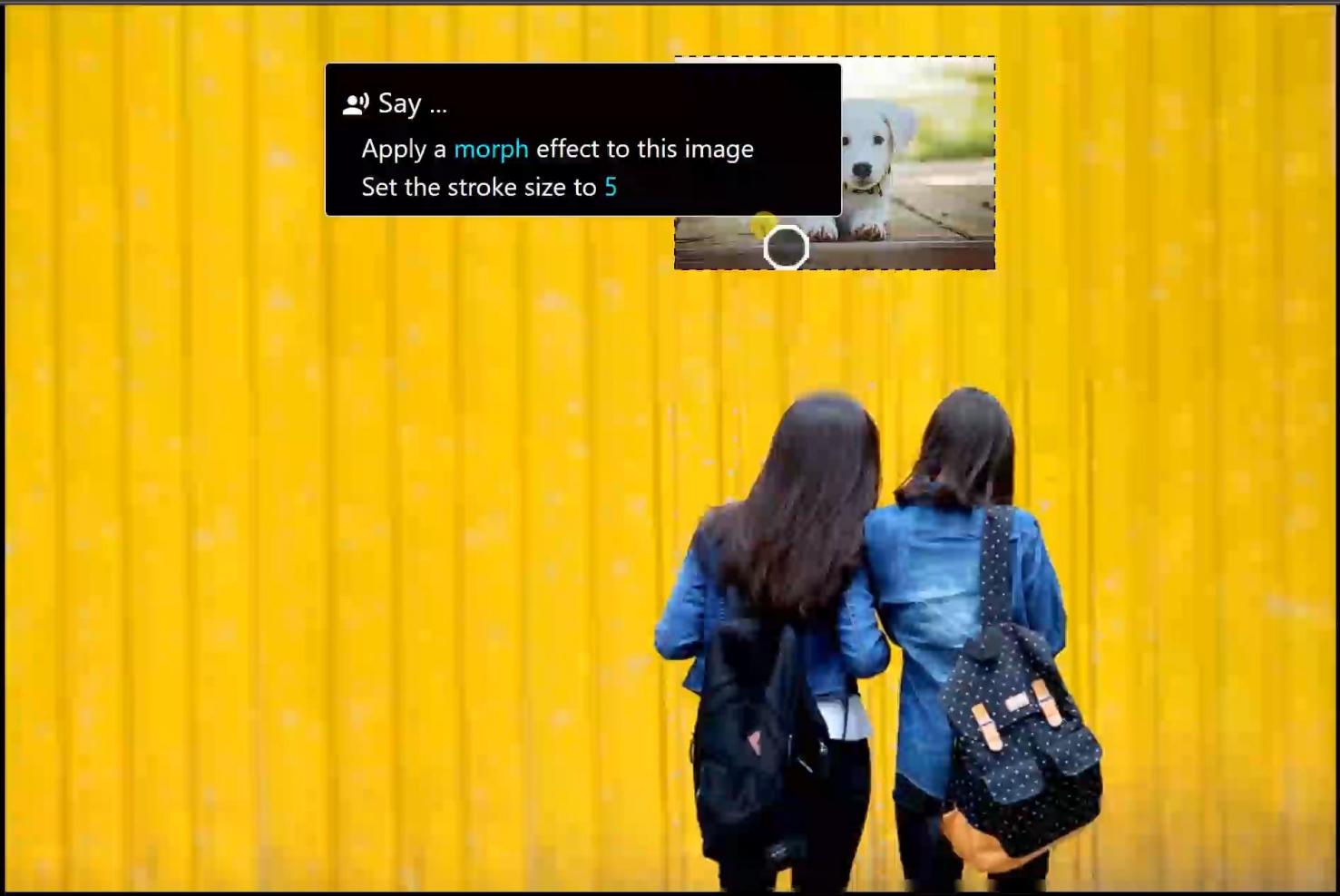
Choose an Effect...

Applied effects:

remove the blur effect



Removed blur filter.



Label:

IMAGE\_1



Border color:

Black

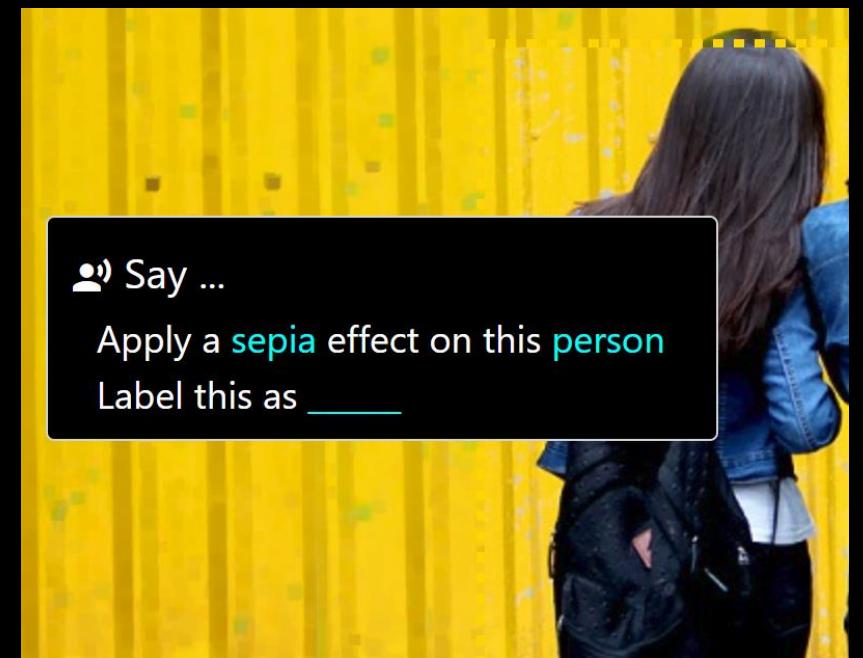
Border size:

1  10

Effect:

Choose an Effect...

Applied effects:



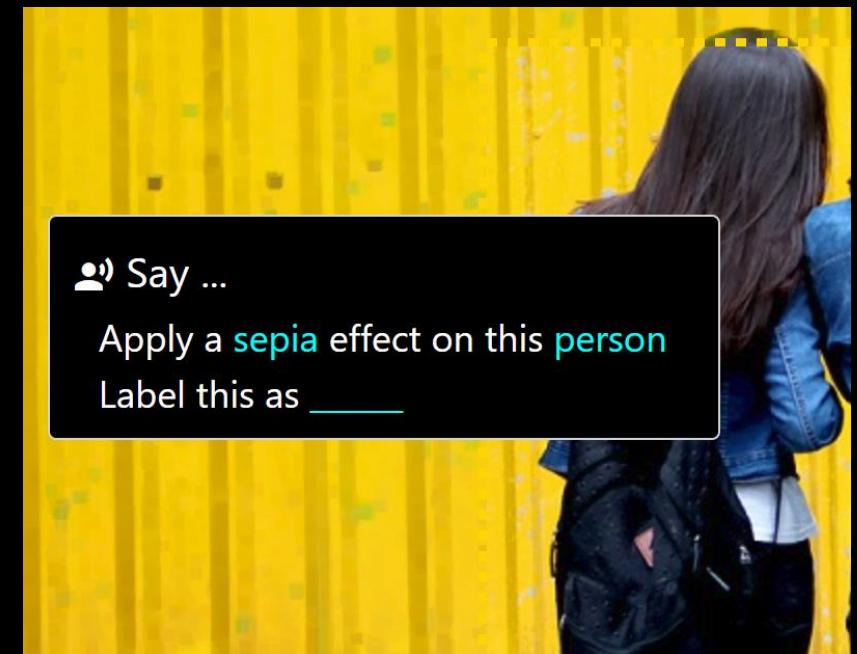
喋 Say ...

Apply a **sepia** effect on this **person**

Label this as \_\_\_\_\_

# When?

- Onboarding
- During a session
- On failure

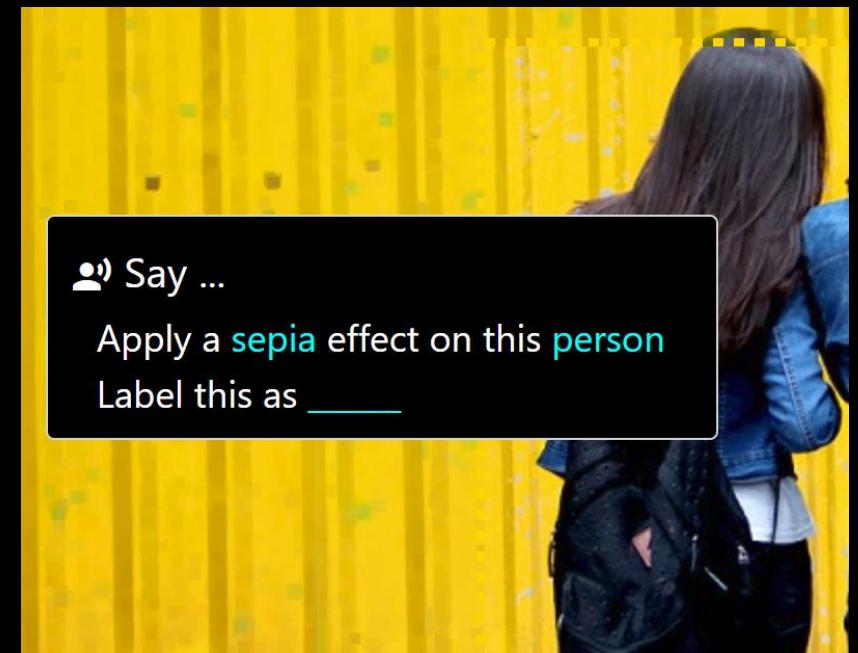


## When?

- Onboarding
- During a session
- On failure

## What?

- Number of commands
- Coverage vs. Relevance
- Complexity
- Phrasing
- Parameters



## When?

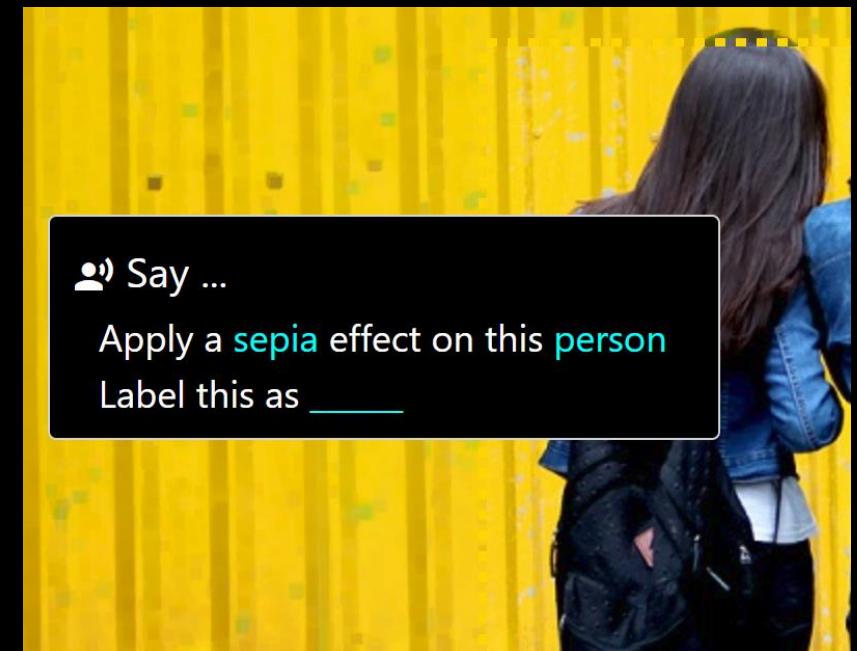
- Onboarding
- During a session
- On failure

## What?

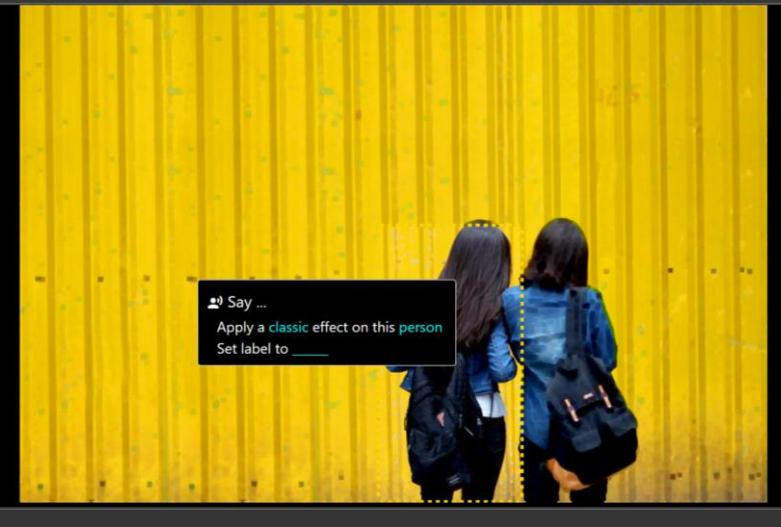
- Number of commands
- Coverage vs. Relevance
- Complexity
- Phrasing
- Parameters

## Where?

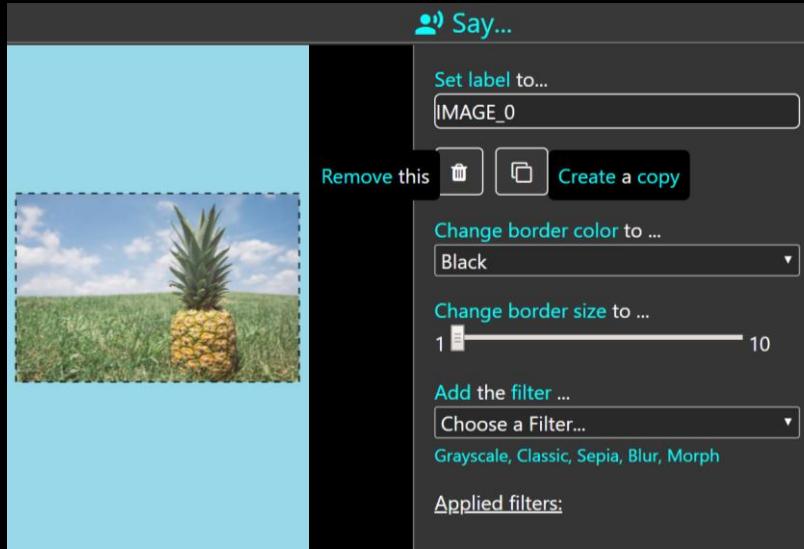
- Pop-up window
- Tooltips
- Embedded in GUI
- Panels



# Three interface variants to present command suggestions



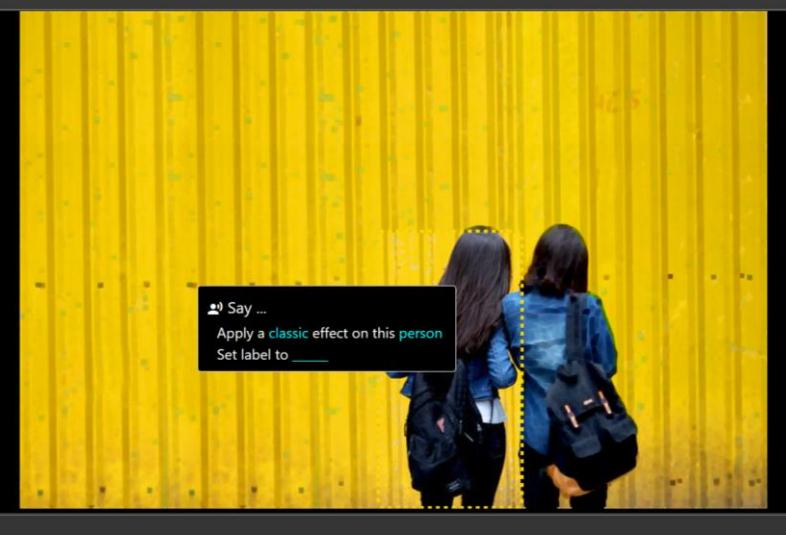
Adaptive



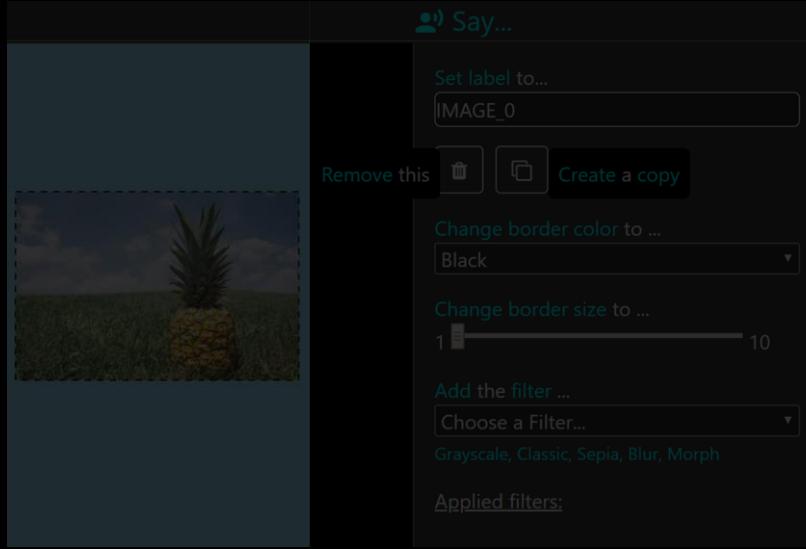
Embedded



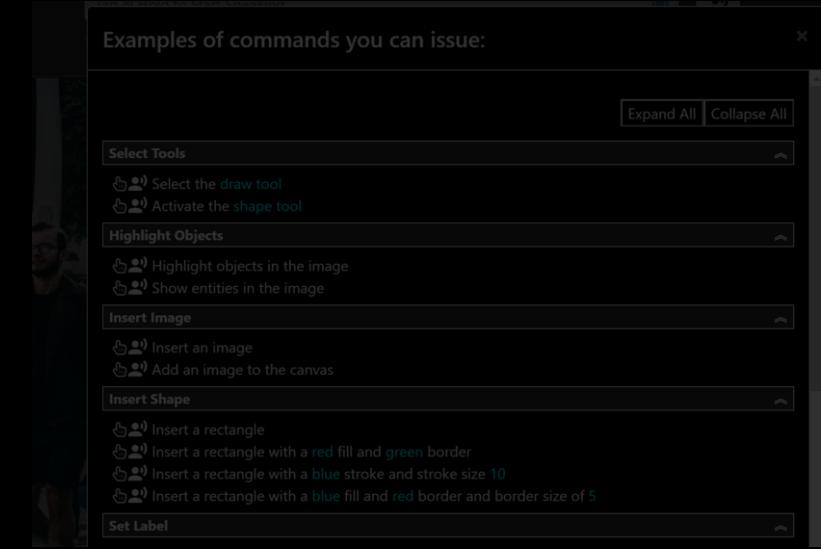
Exhaustive



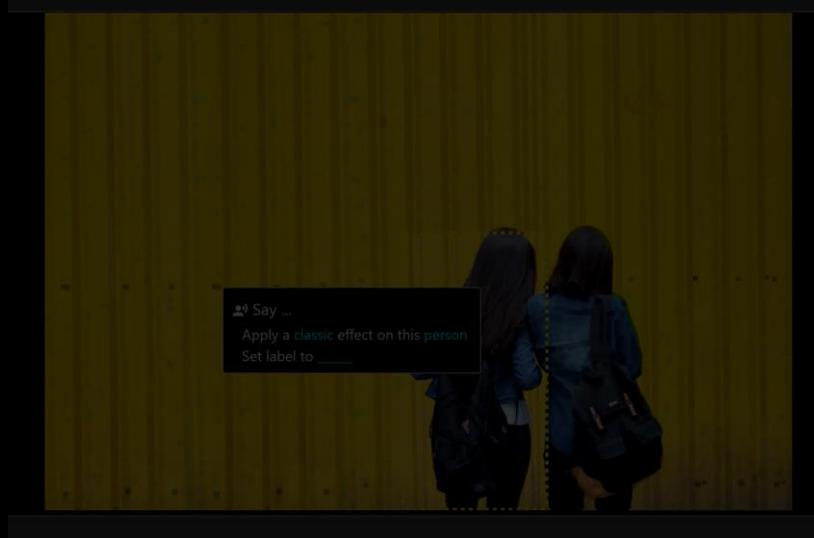
Adaptive



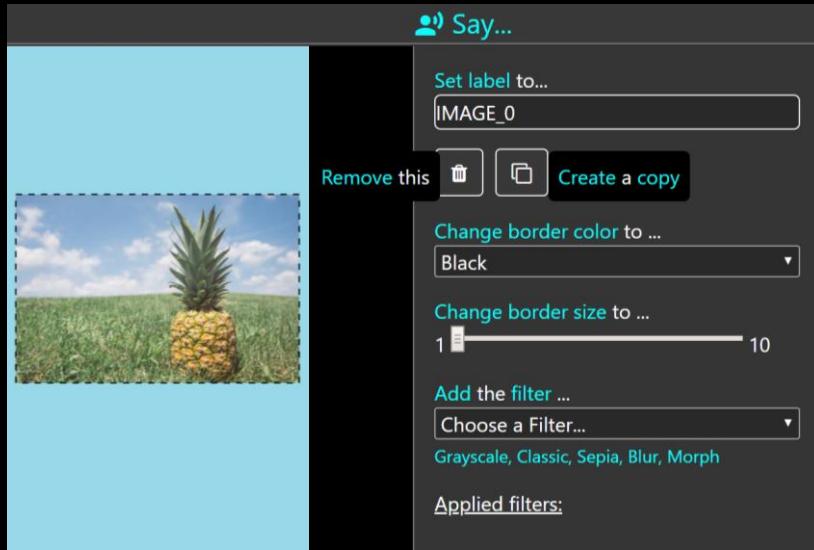
Embedded



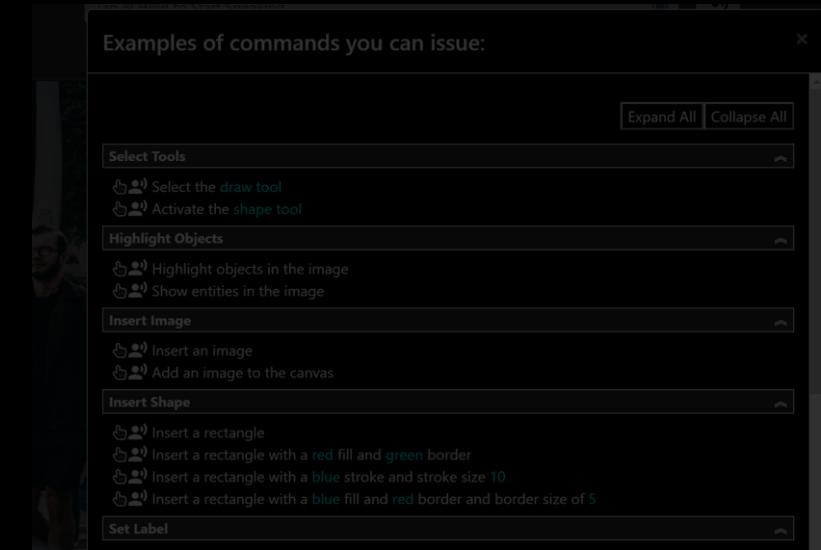
Exhaustive



Adaptive



Embedded

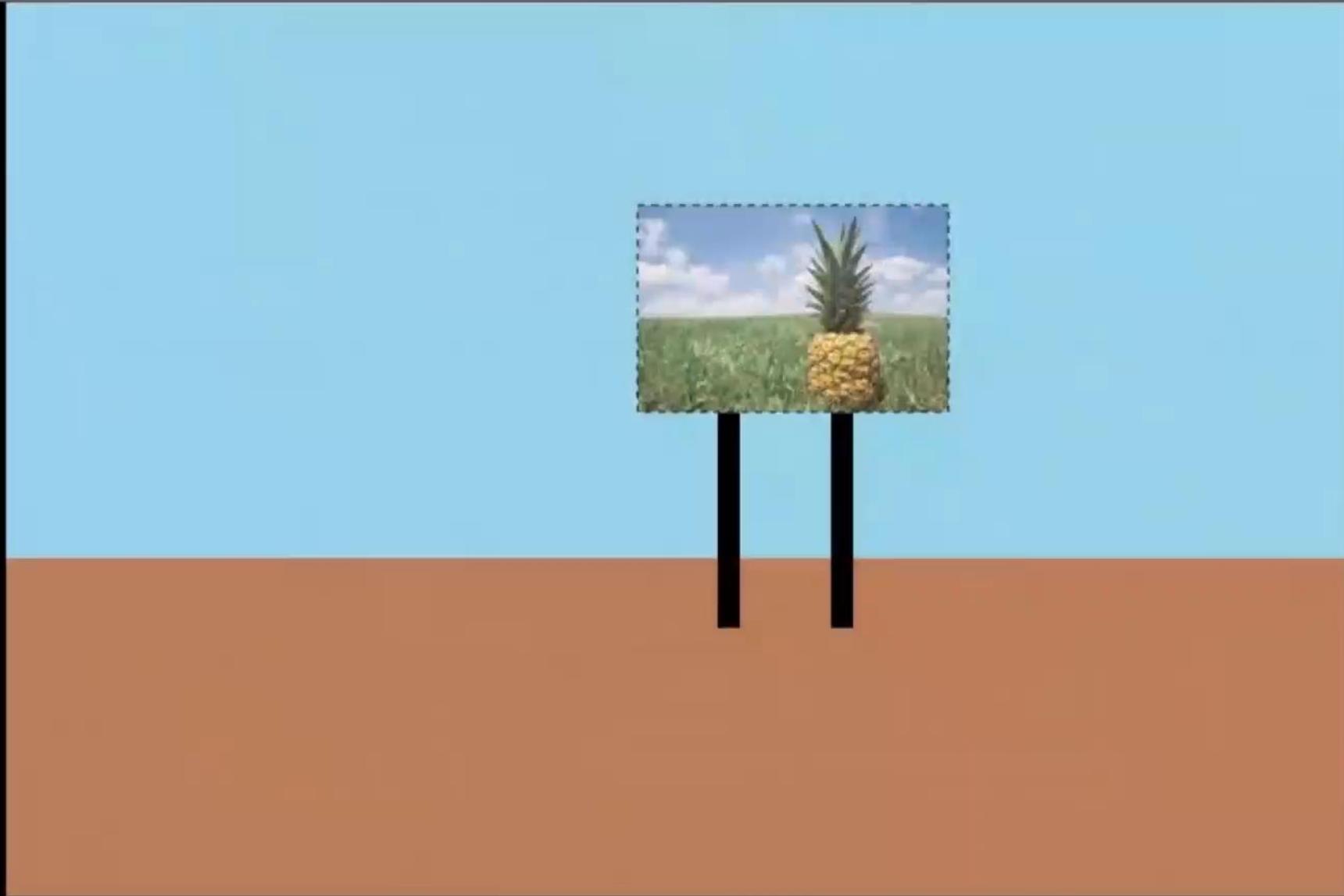
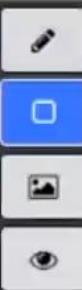


Exhaustive

Tap & Hold to Start Speaking



System feedback for your commands will appear here.



Label:

IMAGE\_1



Border color:

Black

Border size:

1  10

Filter:

Choose a Filter...

Applied filters:

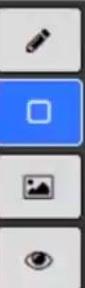


Listening...



System feedback for your commands will appear here.

Say...



Remove this



Create a copy

Set label to...

IMAGE\_1

Change border color to ...

Black

Change border size to ...

1 10

Add the filter ...

Choose a Filter...

Grayscale, Classic, Sepia, Blur, Morph

Applied filters:



Listening...



System feedback for your commands will appear here.

Say...



Select the draw tool



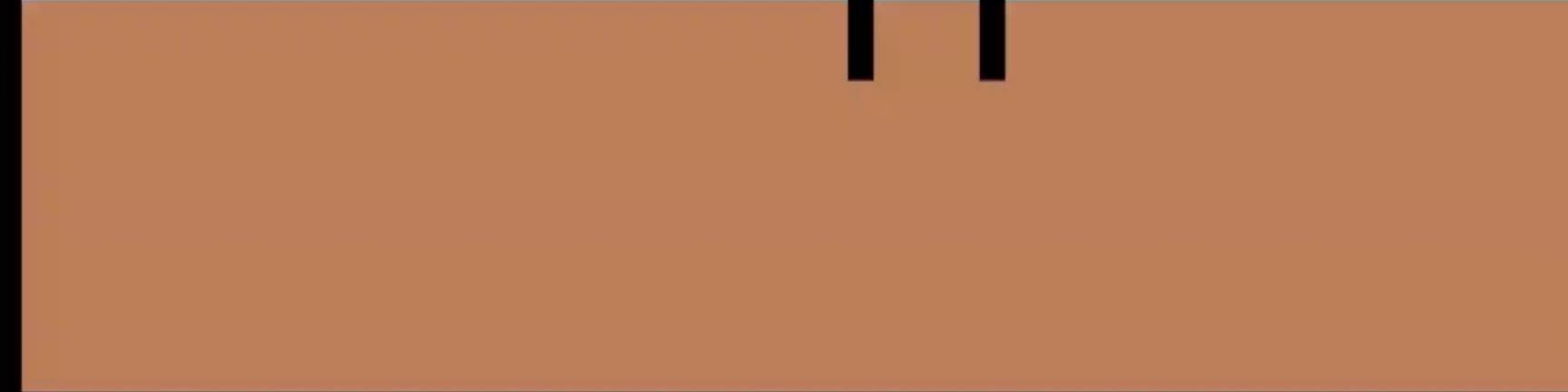
Insert a rectangle



Insert an image

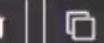


Show objects in the image



Label:

IMAGE\_1



Border color:

Black

Border size:

1 10

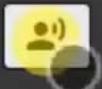
Filter:

Choose a Filter...

Applied filters:

Listening...

System feedback



Say...



Select the draw tool



Insert a rectangle



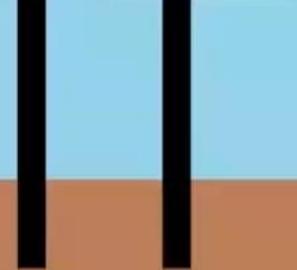
Insert an image



Show objects in the image

Say ...

Add a **classic** filter on the canvas  
Change border color of **all rectangles** to **green**  
Create a copy of **the image**  
Remove **all rectangles** from the canvas



Say...

Set label to...

IMAGE\_1

Remove this



Create a copy

Change border color to ...

Black

Change border size to ...

1 10

Add the filter ...

Choose a Filter...

Grayscale, Classic, Sepia, Blur, Morph

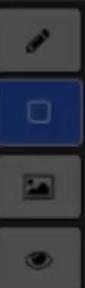
Applied filters:

Listening...



System feedback for your commands will appear here.

Say...



Remove this



Create a copy

Set label to...

IMAGE\_1

Change border color to ...

Black

Change border size to ...

1 10

Add the filter ...

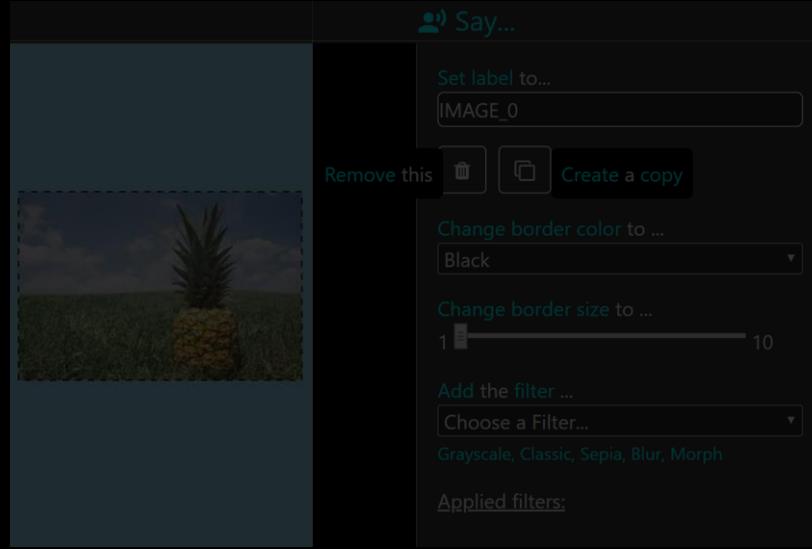
Choose a Filter...

Grayscale, Classic, Sepia, Blur, Morph

Applied filters:



Adaptive



Embedded



Exhaustive

Tap & Hold to Start Speaking



System feedback, for your commands will appear here.



Label:  
Canvas

Effect:  
Choose an Effect...

Applied effects:

Tap & Hold to Start Sketching

## Examples of commands you can issue:

👉👤 Apply a **classic** filter on **the canvas**

👉👤 Add a **light sepia** effect on **all people**

👉 + 👤 Add a **grayscale** filter here

👉 + 👤 Apply a **light morph** effect on this

### Edit Effects or Filters

👉👤 Set the value of the **sepia** effect on the person to **light**

👉👤 Make the **blur** filter on all regions **heavy**

👉 + 👤 Set **grayscale** effect to **heavy**

👉 + 👤 Make **morph** filter **medium**

### Remove Effects or Filters

👉👤 Remove the **blur** effect from **the background image**

👉👤 Delete the **sepia** filter from **all cars**

👉 + 👤 Remove the **classic** effect here

👉 + 👤 Delete the **grayscale** filter

### Change Shape Fill Color

👉👤 Change the fill color of **all rectangles** to **green**

👉👤 Set fill of **the rectangle** to **blue**

👉 + 👤 Set fill to **red**

👉 + 👤 Change fill color of **this rectangle** to **orange**

### Change Shape/Image Border Color

👉👤 Set border color of **the rectangle** to **green**

👉👤 Change the stroke of **all images** to **blue**

👉 + 👤 Change stroke color to **red**

👉 + 👤 Set border to **gray**

### Change Shape/Image Border Thickness

👉👤 Set the stroke size of **the rectangle** to **7**

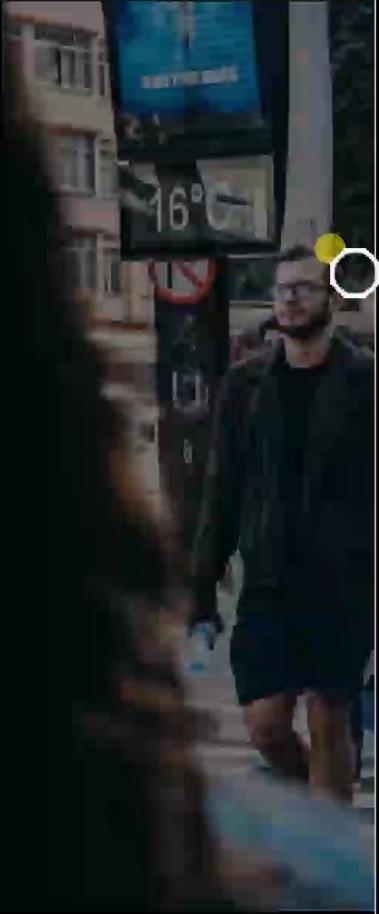
Label:

Canvas

Effect:

Choose an Effect...

Applied effects:



Tap & Hold to Start Creating

## Examples of commands you can issue:

Insert a rectangle with a blue fill and red border and border size of 5

### Set Label

- Set label to \_\_\_\_\_
- Label this as \_\_\_\_\_

### Add Effects or Filters

- Apply a classic filter on the canvas
- Add a light sepia effect on all people
- Add a grayscale filter here
- Apply a light morph effect on this

### Edit Effects or Filters

- Set the value of the sepia effect on the person to light
- Make the blur filter on all regions heavy
- Set grayscale effect to heavy
- Make morph filter medium

### Remove Effects or Filters

- Remove the blur effect from the background image
- Delete the sepia filter from all cars
- Remove the classic effect here
- Delete the grayscale filter

### Change Shape Fill Color

- Change the fill color of all rectangles to green
- Set fill of the rectangle to blue
- Set fill to red
- Change fill color of this rectangle to orange

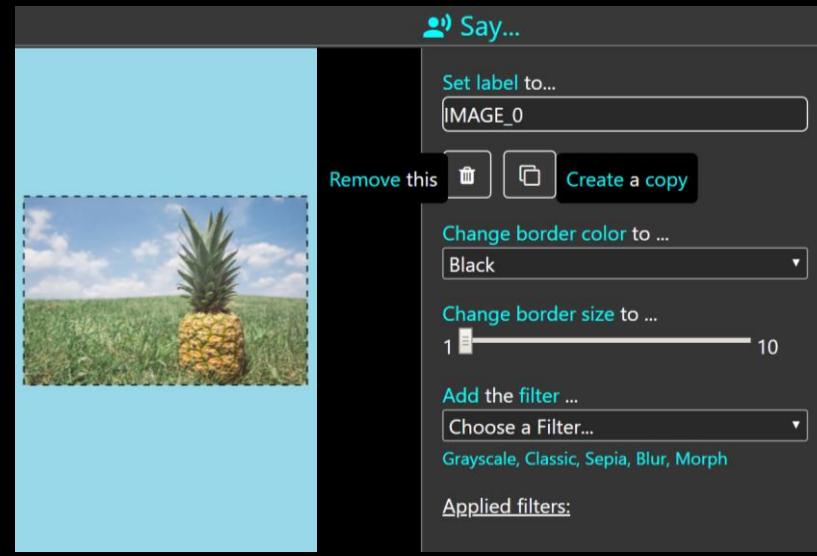
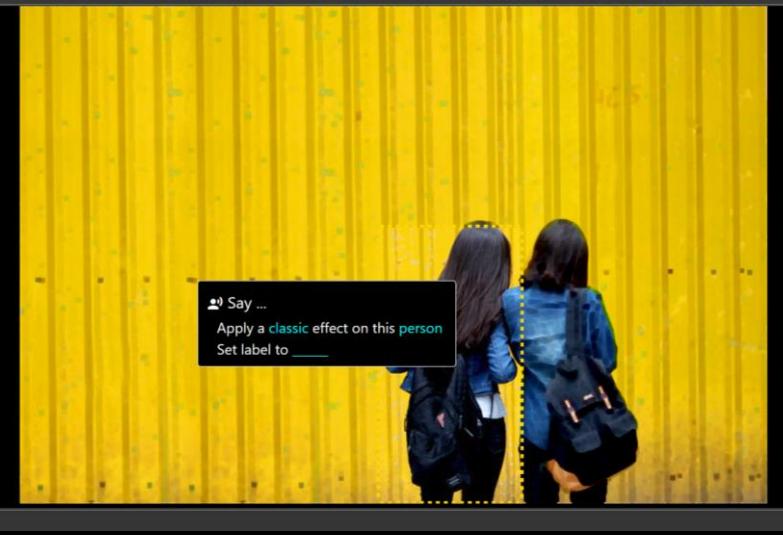
### Change Shape/Image Border Color

- Set border color of the rectangle to green

Label:  
Canvas

Effect:  
Choose an Effect...

Applied effects:



Adaptive

Embedded

Exhaustive

Command  
Suggestions



Command  
Templates



Filter, Rank,  
Parameterize



Examples



## Command Templates

Add a name filter on target

Make the name filter strength

Set fill color to color

Change border to color

Set stroke size to size

Make count copies

Remove target

Highlight entities in the image

...

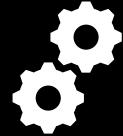


Command  
Templates

Filter, Rank,  
Parameterize

Add a name filter on target  
Make the name filter strength  
Set fill color to color  
Change border to color  
Set stroke size to size  
Make count copies  
Remove target  
Highlight entities in the image  
...

Change border to color  
Set fill color to color  
Set stroke size to size  
Make count copies  
...  
color = [red, blue, ...]  
size = [1-10]  
...



## Command Templates

Add a name filter on target  
Make the name filter strength  
Set fill color to color  
Change border to color  
Set stroke size to size  
Make count copies  
Remove target  
Highlight entities in the image  
...



## Filter, Rank, Parameterize

Change border to color  
Set fill color to color  
Set stroke size to size  
Make count copies  
...  
  
color = [red, blue, ...]  
size = [1-10]  
...



## Examples

Change border to **blue**  
Set fill color to **red**  
Set stroke size to **10**  
Make **5** copies  
...

# Details in the paper



## Command Templates

Add a name filter on target  
Make the name filter strength  
Set fill color to color  
Change border to color  
Set stroke size to size  
Make count copies  
Remove target  
Highlight entities in the image  
...



## Filter, Rank, Parameterize

Change border to color  
Set fill color to color  
Set stroke size to size  
Make count copies  
...  
color = [red, blue, ...]  
size = [1-10]  
...



## Examples

Change border to **blue**  
Set fill color to **red**  
Set stroke size to **10**  
Make **5** copies  
...



*Color this green  
Add a red stroke  
Make 2 copies  
Delete*

## Available Operations

- Add Effect
- Fill
- Delete
- Copy
- Border



## Available Operations

### Operation Selection

Target Type

Usage Freq.

Display Freq.

Add Effect

Fill

Delete

Copy

Border



## Available Operations

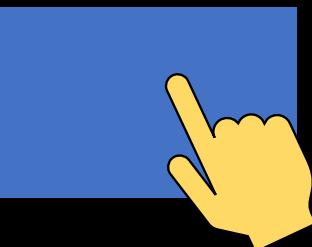
Operation Selection

Target Type

Usage Freq.

Display Freq.

## Phrasing Templates



- Fill
- Border
- Copy
- Delete

## Available Operations

### Operation Selection

## Phrasing Templates

Target Type

Usage Freq.

Display Freq.

Fill

Border

Copy

Delete



Change color to \_\_

Color this \_\_

Set the fill to \_\_

Change fill of \_\_ to \_\_

...

## Available Operations

### Operation Selection

Target Type

Usage Freq.

Display Freq.

## Phrasing Templates

### Template Selection

Input Type

Usage Freq.

Display Freq.

Fill

Border

Copy

Delete



Change color to \_\_

Color this \_\_

Set the fill to \_\_

Change fill of \_\_ to \_\_

...

## Available Operations

### Operation Selection

## Phrasing Templates

### Template Selection & Parameterization

Target Type

Usage Freq.

Display Freq.

Input Type

Usage Freq.

Display Freq.

Target State

Fill

Border

Copy

Delete



Change color to \_\_      \_\_ = [blue,

Color this \_\_      green,

Set the fill to \_\_      red,

Change fill of \_\_ to \_\_      ...]

## Available Operations

### Operation Selection

## Phrasing Templates

### Template Selection & Parameterization

## Examples

Target Type

Usage Freq.

Display Freq.

Input Type

Usage Freq.

Display Freq.

Fill

Border

Copy

Delete

Change color to \_\_

\_\_ = [blue,  
green,  
red,  
...]

Color this \_\_

Set the fill to \_\_

Change fill of \_\_ to \_\_

...

**Color this green**



## Available Operations

### Operation Selection

## Phrasing Templates

### Template Selection & Parameterization

## Examples

Target Type

Usage Freq.

Display Freq.

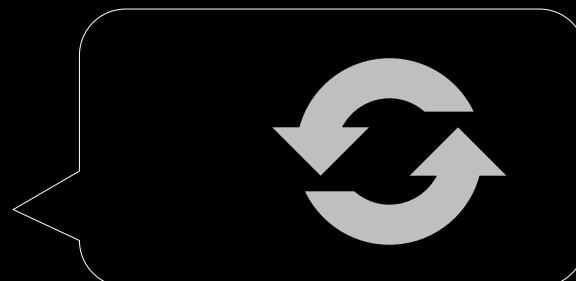
Input Type

Usage Freq.

Display Freq.



- Fill
- Border
- Copy
- Delete



*Color this green  
Add a red stroke  
Make 2 copies  
Delete*

# Evaluation

# Evaluation

- Between-subjects online study with 24 participants on UserTesting.com
- Platform: Chrome running on a touch-enabled Microsoft Surface Pro
- Minimal Training: Short videos about the basic interface and how to invoke suggestions  
(no details about available operations and speech commands)

# Evaluation

- **Task:** Three before-after image editing tasks
- **Duration:** 32 min (avg.)
- **Compensation:** \$10

Edit the image on the left to make it look like the image on the right. Note that it is okay if your output does not look exactly the same as the target image below but try to make it look as similar as possible.



**(source)**



**(target)**

# Speech Usage Summary

- Total of 834 spoken commands issued (avg. 49) during 17/24 sessions (6 exhaustive, 5 adaptive, 6 embedded)

# Speech Command Failures

- 369/834 (44%) spoken commands failed:

Error %	Error Type
65%	Speech recognition & recording errors
18%	Phrasing errors
7%	Operation-object mapping errors
5%	Unsupported operations
5%	Parameter errors

# Speech Command Failures

- 369/834 (44%) spoken commands failed:

Error %	Error Type
65%	Speech recognition & recording errors
18%	Phrasing errors
7%	Operation-object mapping errors
5%	Unsupported operations
5%	Parameter errors



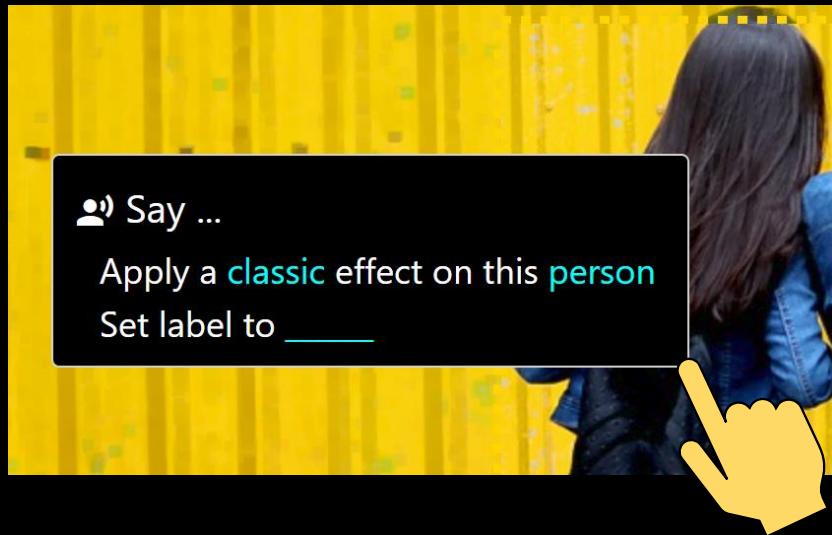
# Suggestions encourage and aid natural language interaction

	Exhaustive (avg.)	Embedded (avg.)	Adaptive (avg.)	Overall (avg.)
Suggestions helped me learn how to talk to the system	4	3.67	4.4	4.02
Suggestions encouraged me to talk to the system	3.83	3.67	4.2	3.88

\*scores between 1-5  
5 is “*strongly agree*”

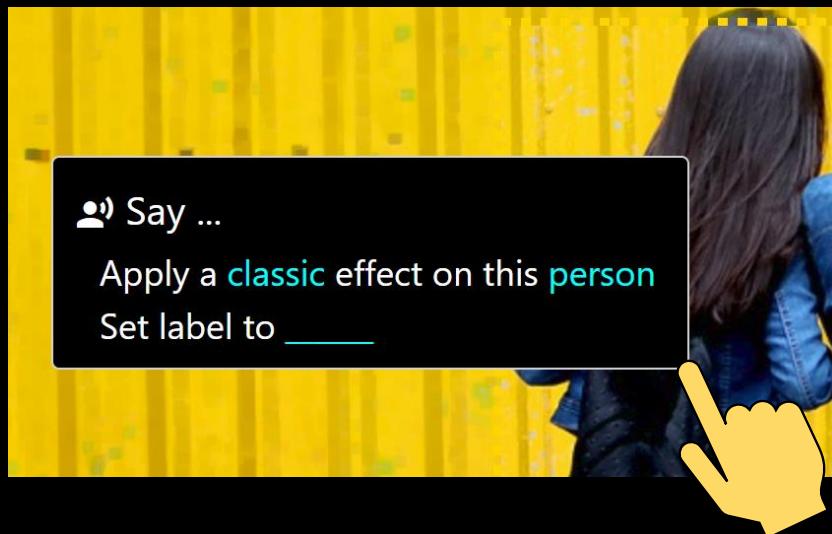
# Explanations for domain specific commands

- Suggestions do not overcome lack of domain knowledge



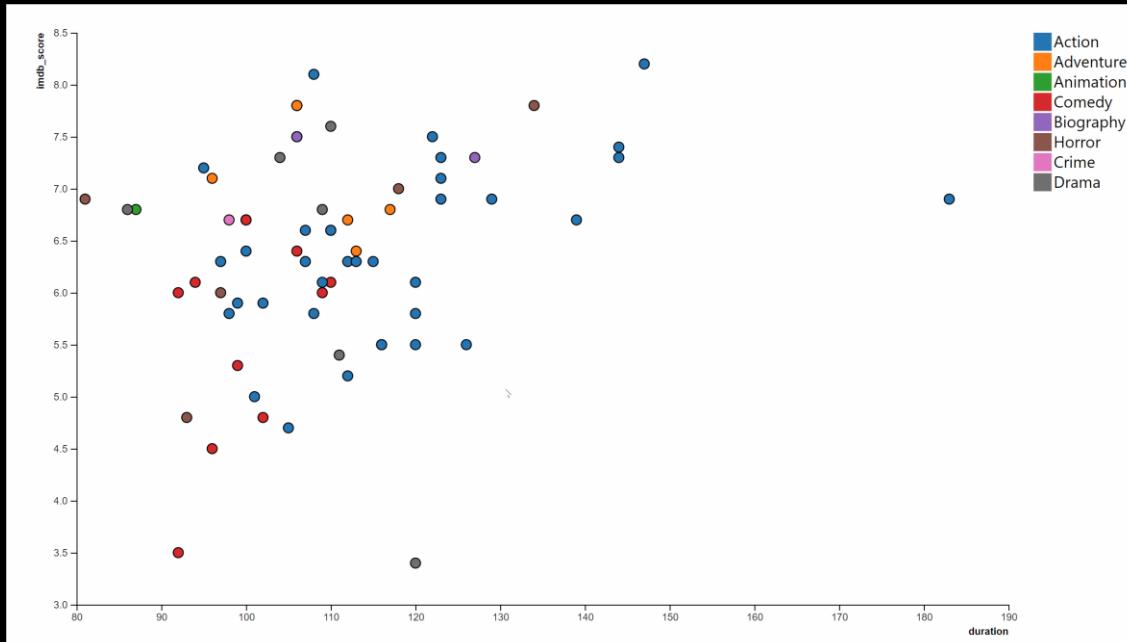
# Explanations for domain specific commands

- Command suggestions as interactive widgets



# Future work

- Validating framework in other application domains (e.g. data visualization)
- Supporting additional command types (e.g. gesture + speech)



*PixelTone: A Multimodal Interface for Image Editing*  
Laput et al., CHI 2013

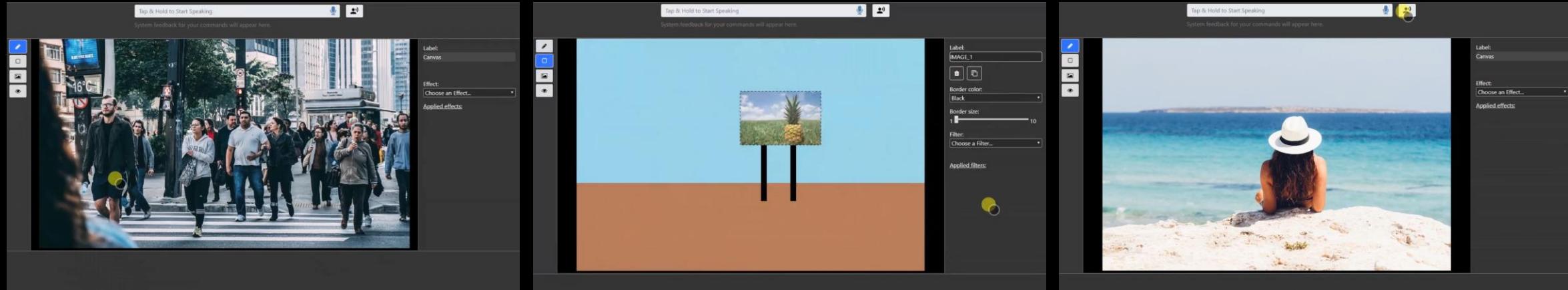
# Conclusions

- Contextual command suggestions aid discoverability and encourage natural language interaction
- Direct manipulation can be used to teach natural language interaction

# Thank you

bit.ly/

# voice-hints



- Contextual command suggestions aid discoverability and encourage natural language interaction
- Direct manipulation can be used to teach natural language interaction

Arjun Srinivasan ([@10\\_arjun](https://twitter.com/10_arjun))  
Mira Dontcheva  
Eytan Adar  
Seth Walker

