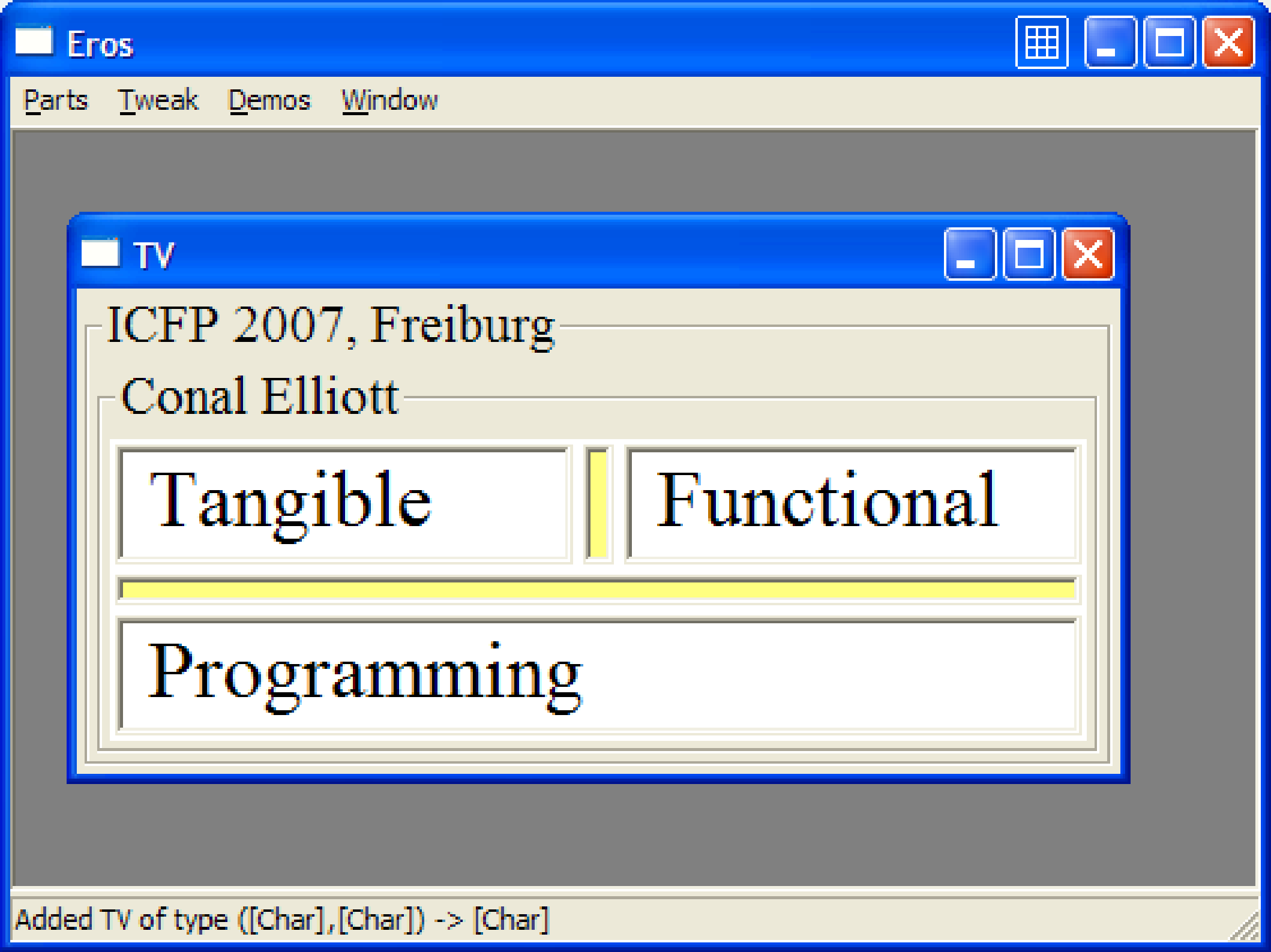
Tangible Functional Programming

Conal Elliott

ICFP 2007


Eros
Parts
Tweak
Demos
Window
TV
ICFP 2007, Freiburg
Conal Elliott
Tangible
Functional
Programming
Added TV of type ([Char],[Char]) -> [Char]

Programming favors left-brain creativity.

- Abstract & linguistic
- Usually sequential
- Selects & influences creative processes
- Powerful medium of expression
- with limited access

Can functional programming be artist-friendly?

- Non-sequential
- Still abstract & linguistic
- “Authoring”: concrete & non-composable
- Goal: concrete and composable
- So artists can make their own tools

The insight:

Authoring *is* functional programming.

- In disguise
- Full of interpreted graphs
- Lacks reuse & parameterization
- Scripting bolted on

Programming is a way to express interfaces and denotations.

- Code is a command-line UI.
- Handy & inessential
- Necessarily indirect

Where are we going?

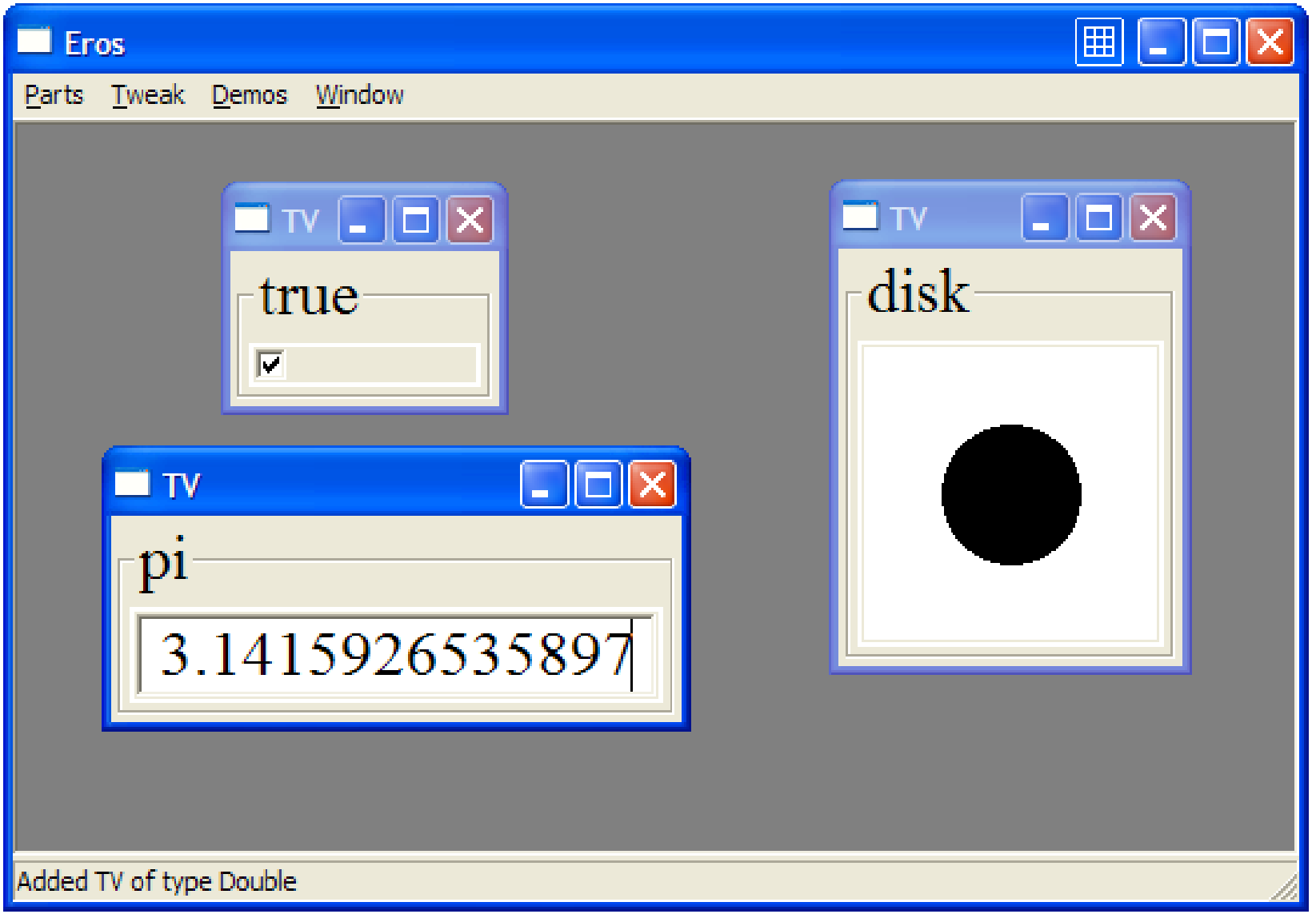
- **Eros user experience**
- λ-mechanics

Key idea #1 (of 4):

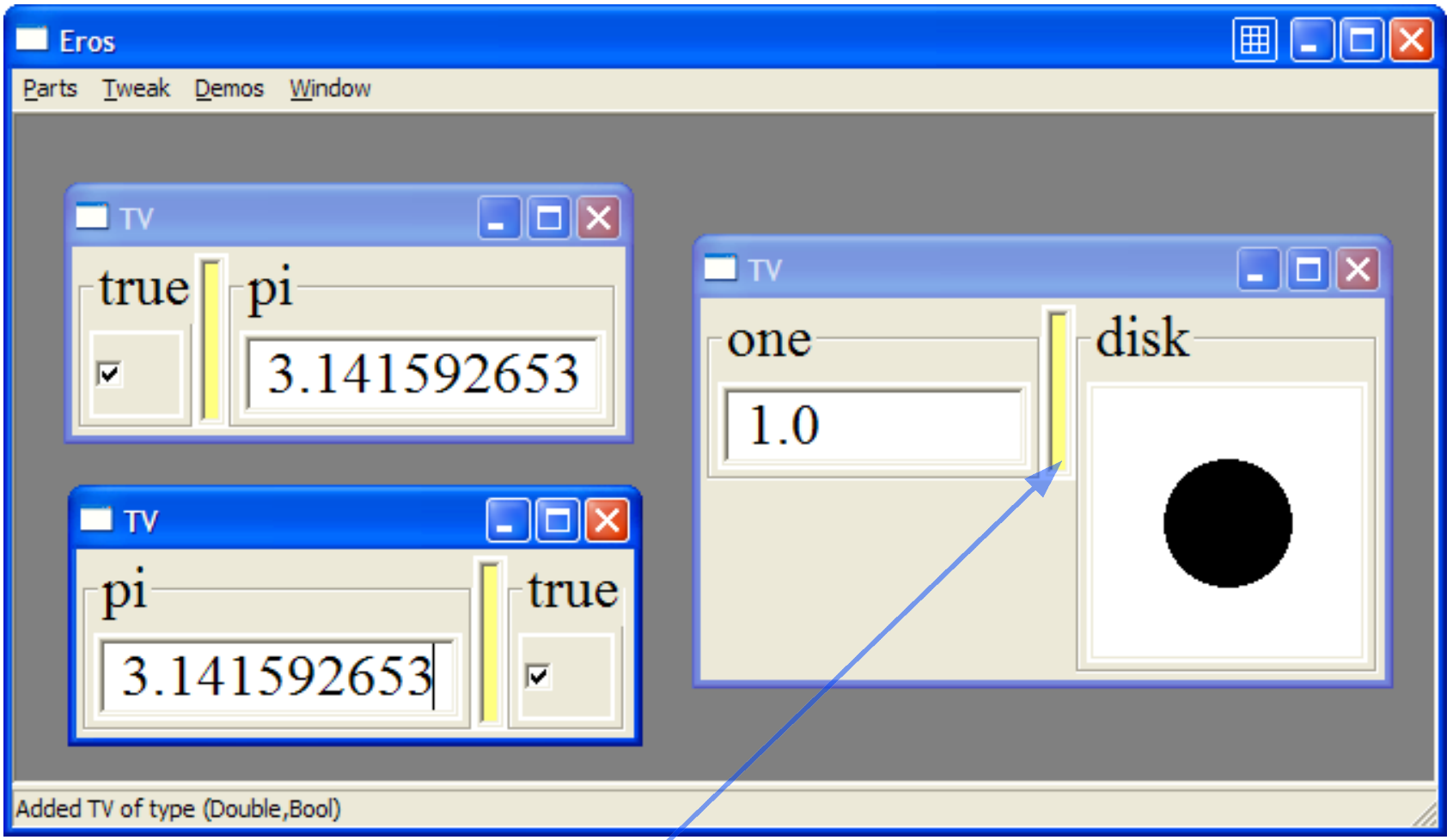
Use GUIs to visualize typed values.

- GUI *structure* follows type.
- GUI *content* presents value.
- Functions visualize as *interactive* GUIs.
- “Tangible values”

Base type values are widgets.



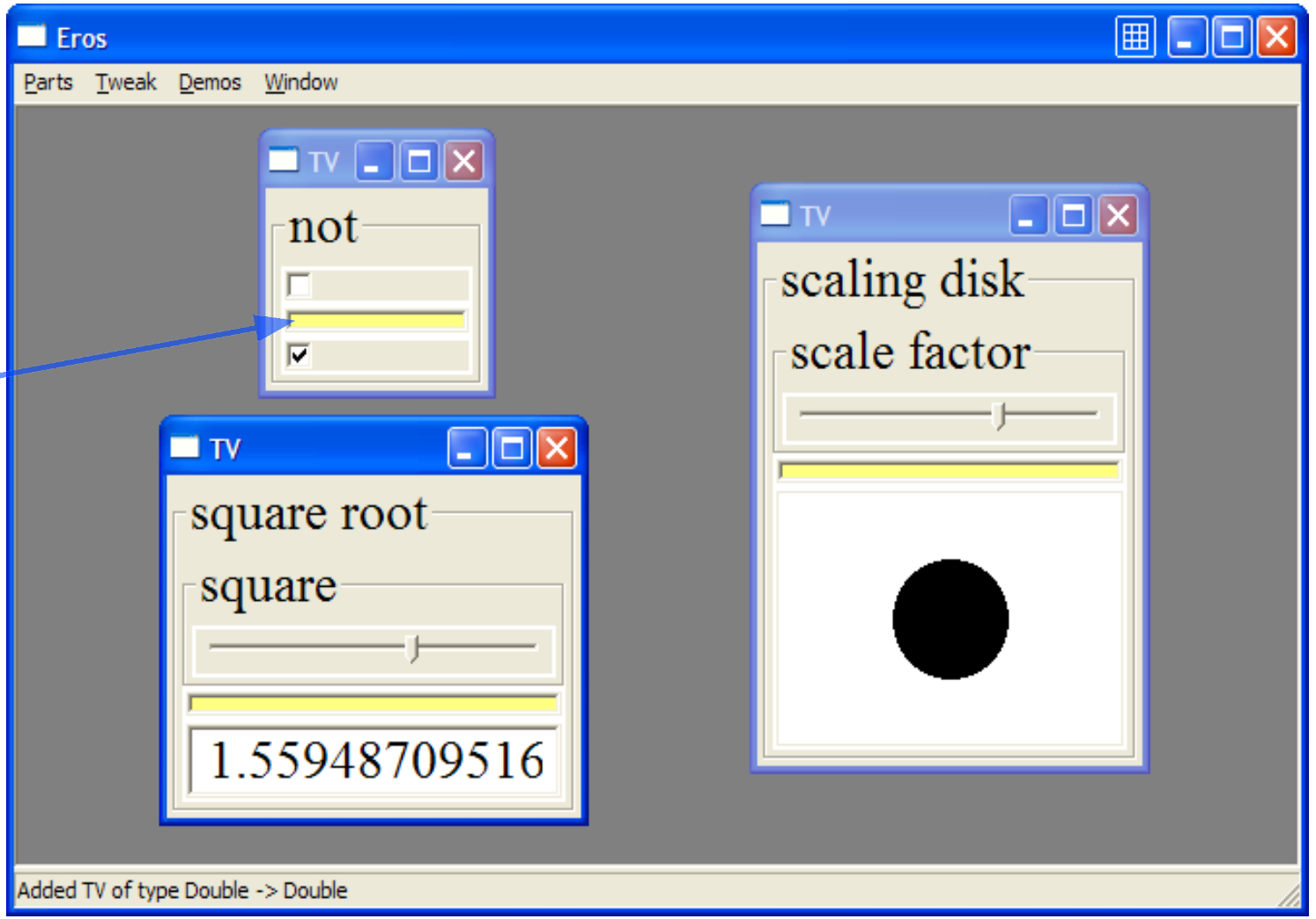
Pairs lay out horizontally.



“,” in (α , β) and (a,b)

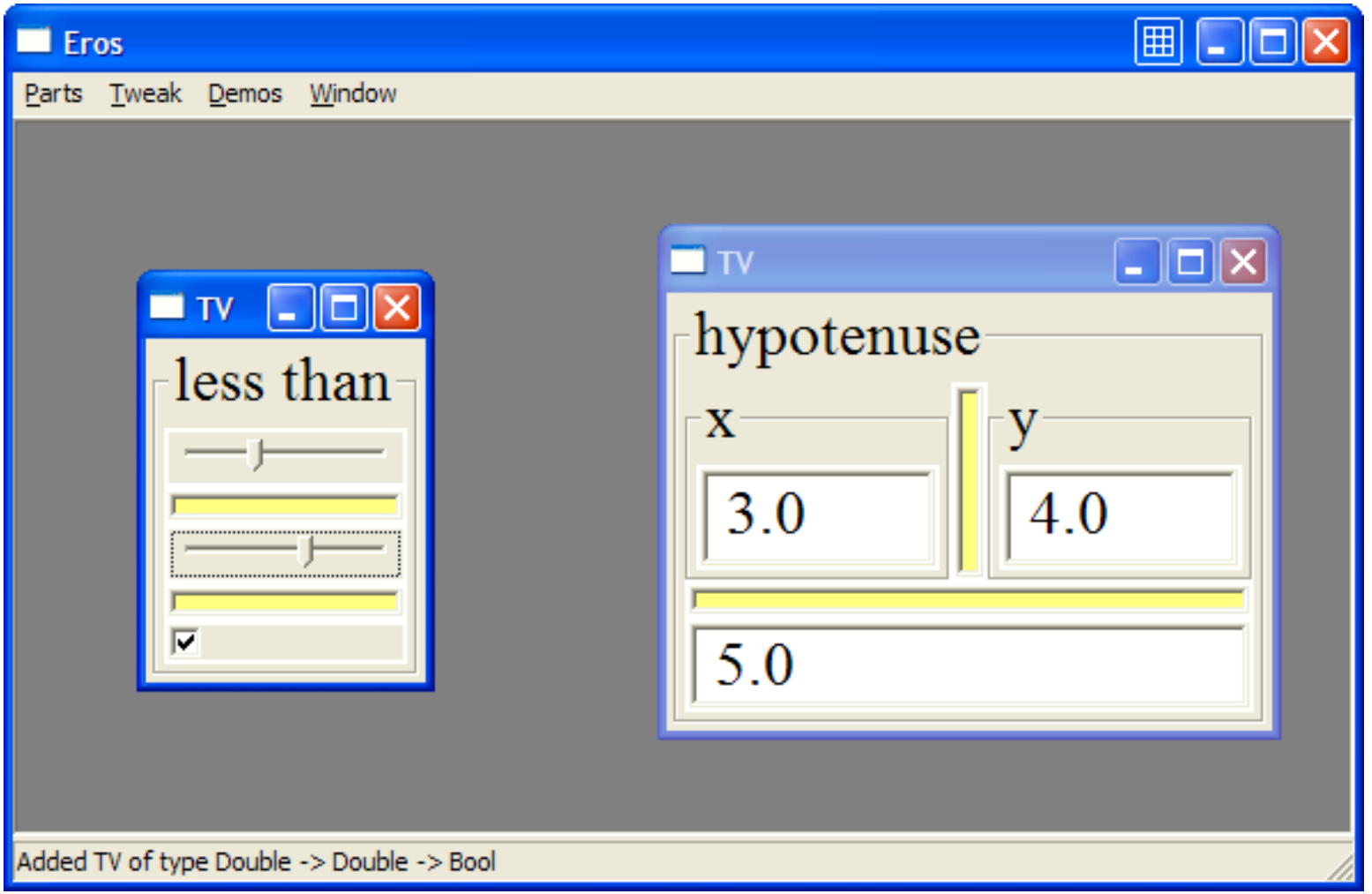
Functions lay out vertically.

“$\rightarrow$”
in
$\alpha \rightarrow \beta$
and
$\lambda\, a \rightarrow b$



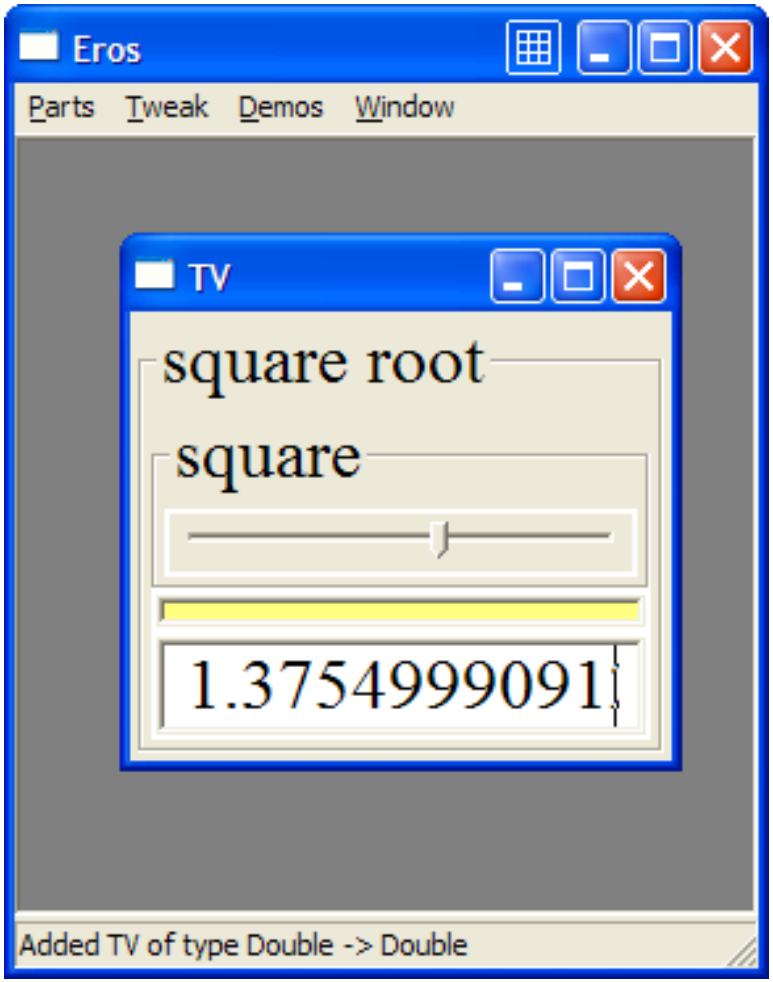
Functions may be

curried or uncurried.



Functions visualize

as *interactive* GUIs.

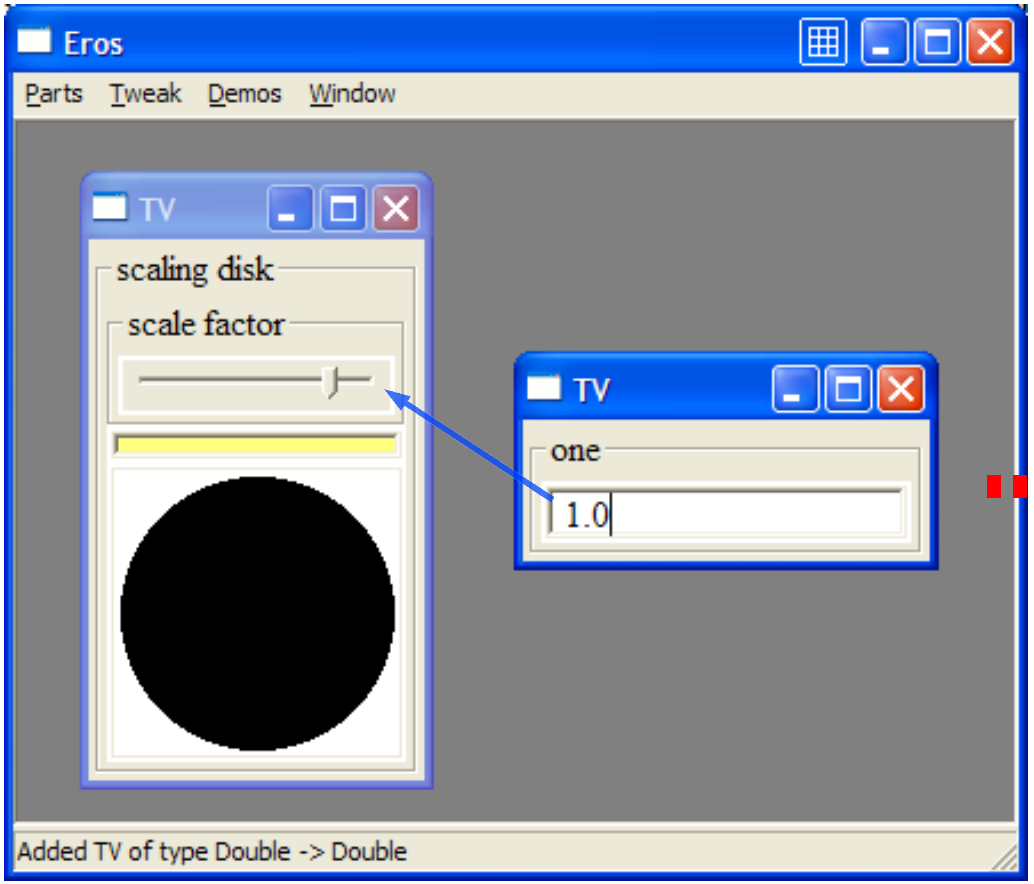


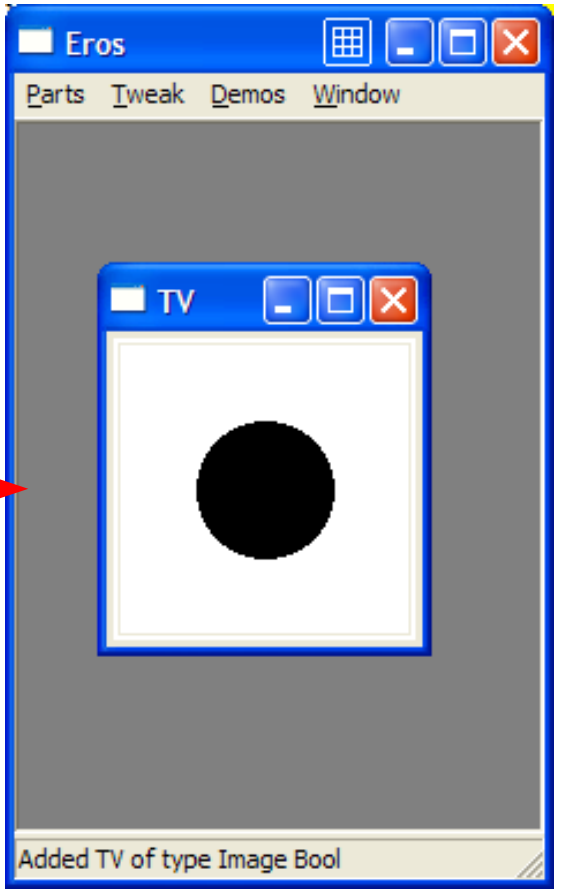
Key idea #2:

Users make new TVs by *fusion*.

- Select compatible input & output,
- which disappear.
- Everything else remains,
- fused into a single new TV.

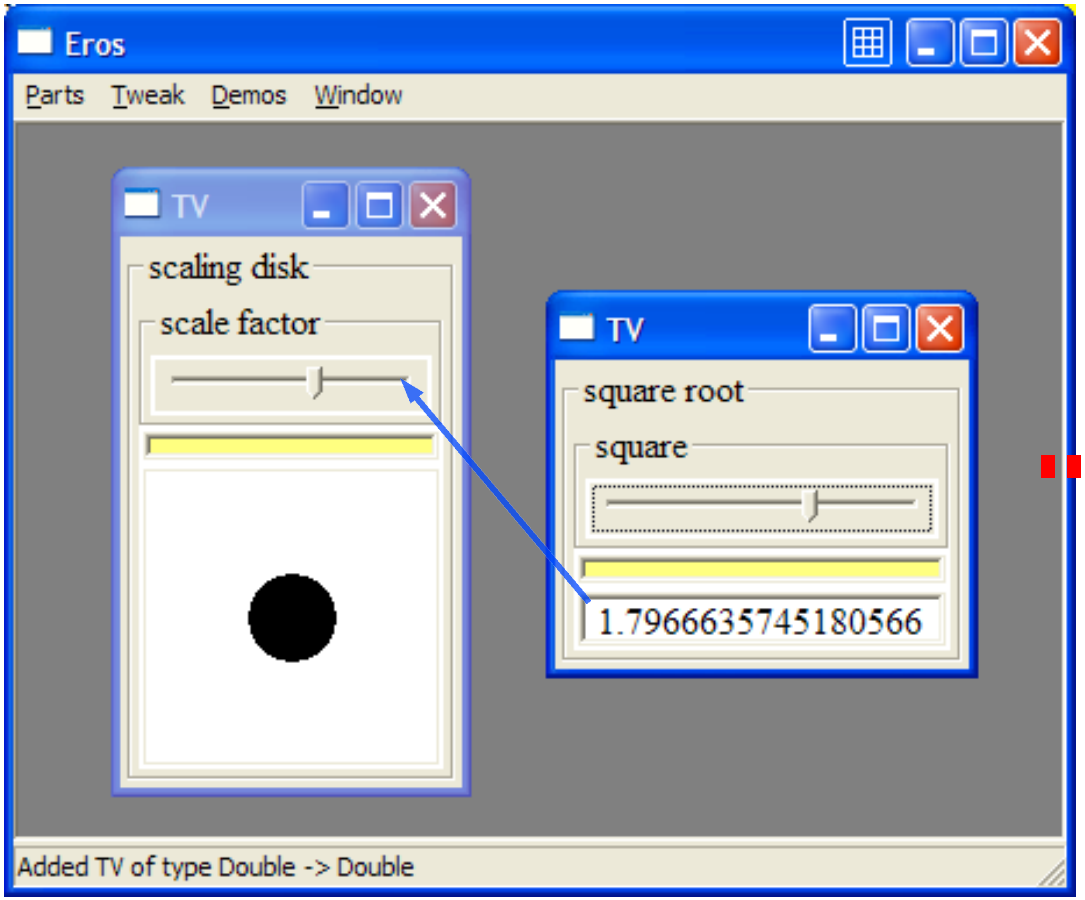
TV fusion subsumes function *application*.

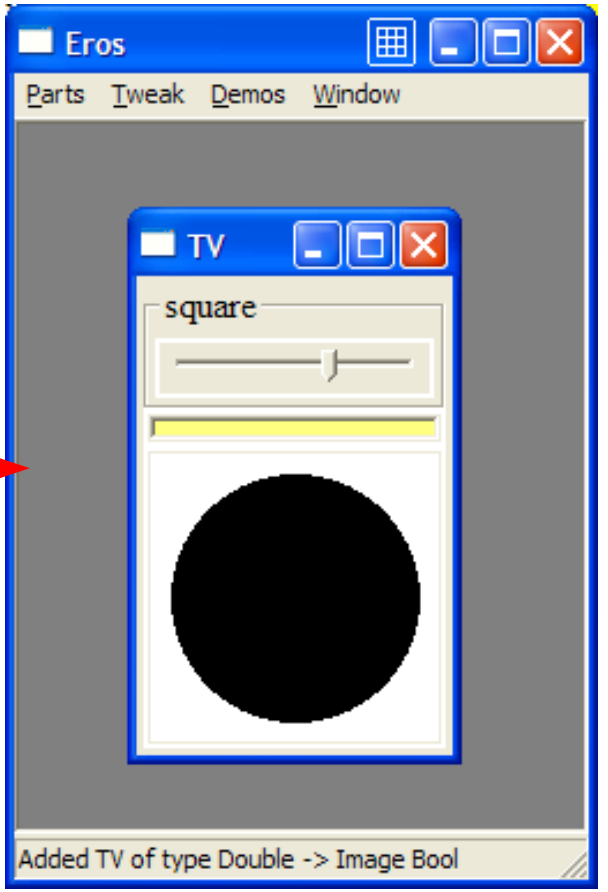




$R \to Region$ R $Region$

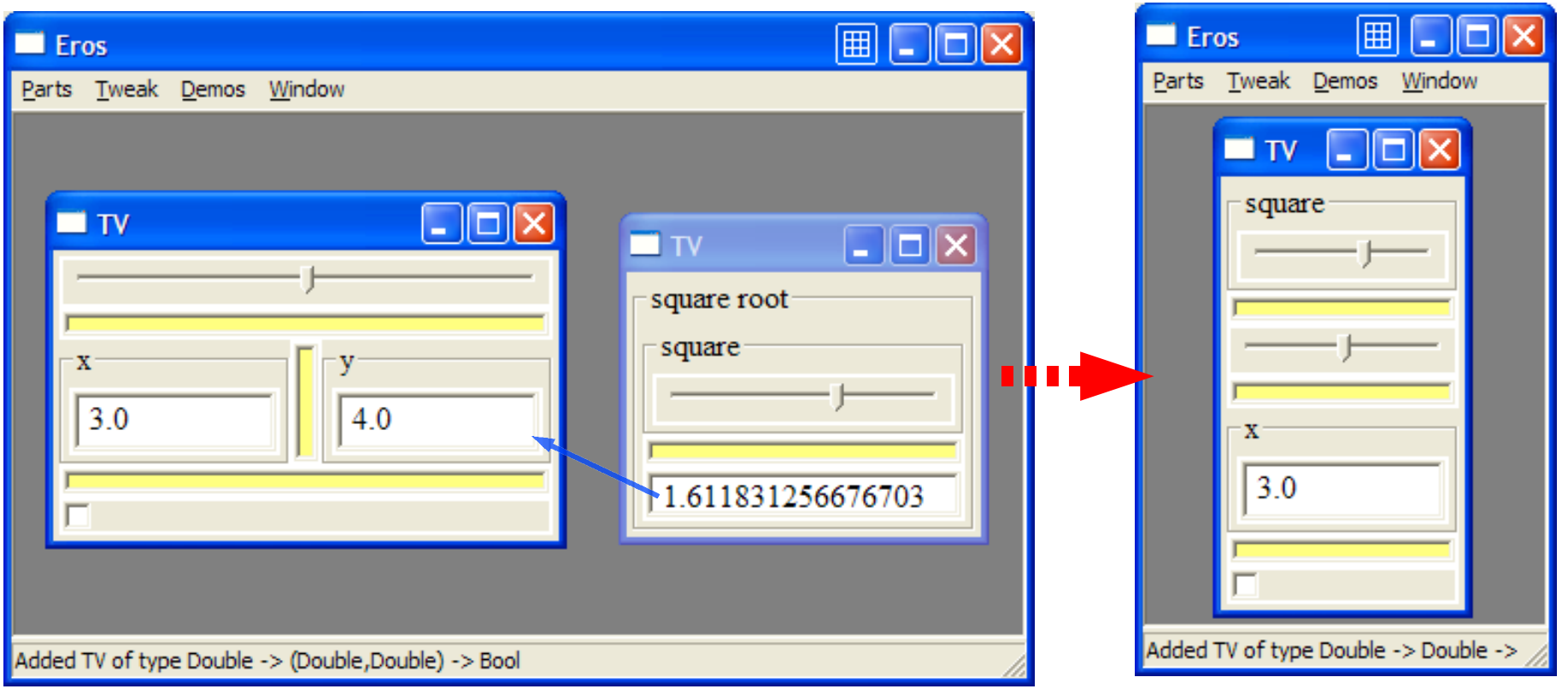
TV fusion subsumes function *composition*.





$R \to Region$ $R \to R$ $R \to Region$

Fusion may reach into nested inputs.



$R \rightarrow (R,R) \rightarrow Bool$ $\quad R \rightarrow R$ $\quad R \rightarrow R \rightarrow R \rightarrow Bool$

Let's take a look.

demo

Where are we?

- Eros user experience
- **λ-mechanics**

Key idea #3:

Keep visualization & value combined and separable.

```
type TV a = (Out a, a)
```

- Operate on both parts in tandem
- Combined for convenience
- Separable for composability

Visualizations *assemble*

as types and values do.

```
type Out a = ...
put      :: Put a -> Out a
opair    :: Out a -> Out b -> Out (a, b)
olambda  :: In  a -> Out b -> Out (a->b)

type In a = ...
get    :: Get a -> In a
ipair  :: In a -> In b -> In (a,b)
```

Key idea #4:

Translate gestural fusion to combinator sequences.

- "Deep application". Reaches buried
  - *arguments,*
  - *functions,* and
  - *inputs.*
- Define for values & extend to TVs.

We already have the tools to

aim functions at buried arguments.

```
first  :: (a -> a') -> ((a, b) -> (a',b ))
second :: (b -> b') -> ((a, b) -> (a ,b'))
result :: (b -> b') -> ((a->b) -> (a->b'))

first         f       = \ (a, b) -> (f a,b  )
second        g       = \ (a, b) -> (a  ,g b)
result        g       = \   f    ->   g . f
```

Compositions describe type paths to edit *deeply* buried arguments.

```
sf     :: (b->b') -> (a,(b ,c))
                  -> (a,(b',c))
sf     =  second.first

frsrf :: (c->c') -> (a->(f,b->(c ,g)),e)
                  -> (a->(f,b->(c',g)),e)
frsrf =  first.result.second.result.first
```

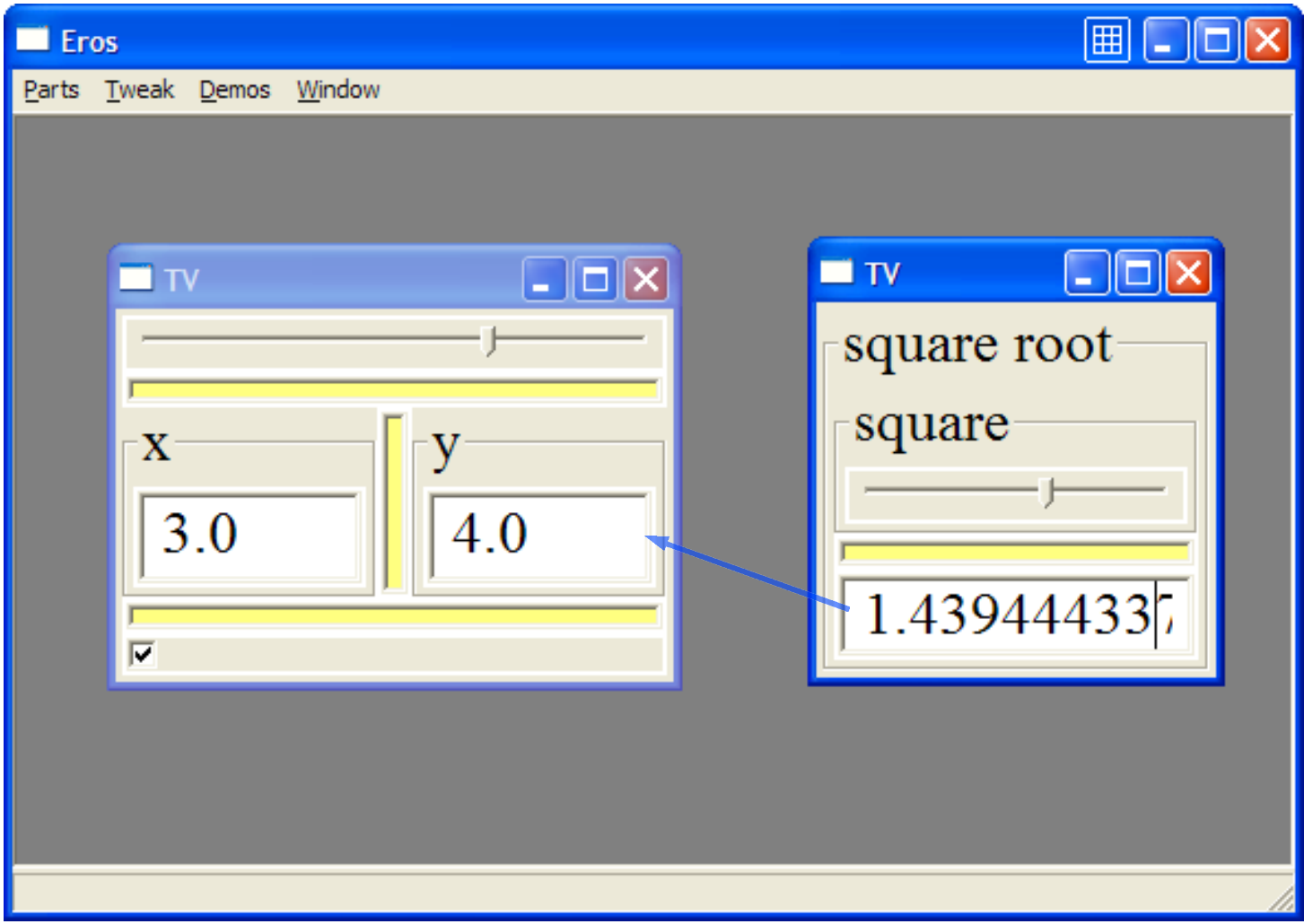
A similar game

reaches buried *functions*.

```
funFirst ::
  (d -> (c->a)) -> ((d,b) -> (c->(a,b)))
```

- Promotes a *function extractor*
- Similarly, `funSecond`, `funResult`
- Form type paths, as before.

The final combinators reach buried *inputs*.



These tools generalize.

- `first` and `second` work on arrows.
- Add **`DeepArrow`** subclass & instances for
- visualizations & pairings,
- types, code, etc.

Functional programming can be artist-friendly.

- Use GUIs to visualize typed values.
- Users make new TVs by fusion.
- Viz & value combined and separable.
- Gestural fusion via combinator sequences.

To explore

- Tangible polymorphism?
- Direct structural tweaks
- Symmetric `In`/`Out` (`ilambda`)
- “GUIs are types” as GUI design guide
- TVs as composable MVC