[301] Function Scope

Tyler Caraza-Harter

Learning Objectives Today

Understand **local variables**
- When are they created?
- When do they die?
- When are they shared?
- Where are they stored? (frames)

Understand **global variables**
- How are they accessed? (global keyword)
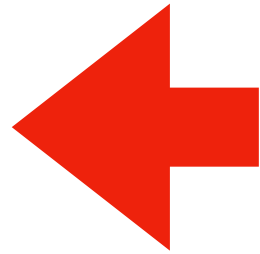- Where are they stored? (global frame)

Understand argument passing
- Meaning of "pass by value"

Today's Outline

Context

- Examples

Frames

Demos: Local Variables

Demos: Global Variables

Demos: Argument Passing

Context

Often (in life and programming), the same name can mean different things in different contexts

- Examples?

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- Examples?
- Human name: Matthew (who is in the room?)
- Street address: 534 State Street (what city are we in?)
- Functions: speak (cat module or dog module?)
- Files: main.ipynb (which directory are we in?)

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- How do we keep variable names organized?

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- How do we keep variable names organized? **with groups called "frames"**

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Python programs will often have different variables with the same name
- How do we keep variable names organized? **with groups called "frames"**
- How do we know what a variable name is referring to?

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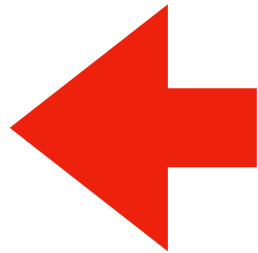- Files: main.ipynb (which directory are we in?)

Python programs will often have different variables with the same name
- How do we keep variable names organized? **with groups called "frames"**
- How do we know what a variable name is referring to? **we'll learn some rules for this**

Today's Outline

Context

Frames ⬅

Demos: Local Variables

Demos: Global Variables

Demos: Argument Passing

Frames

Every time a function is invoked (i.e., called), the invocation gets a new "frame" for holding variables

- The parameters also exist in a frame

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- The parameters also exist in a frame

Global frame
- There is always one global frame that all functions can access

When a variable name is used, Python looks two places:

1 the function invocation's frame

2 the global frame

Example from Think Python (3.8)

```
1  def print_twice(bruce):
2      print(bruce)
3      print(bruce)
4
5  def cat_twice(part1, part2):
6      cat = part1 + part2
7      print_twice(cat)
8
9  line1 = 'Bing tiddle'
10 line2 = 'tiddle bang.'
11 cat_twice(line1, line2)
```
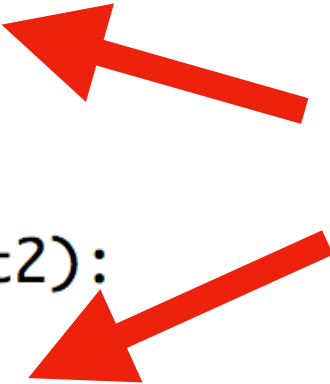
Example from Think Python (3.8)

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line1 and line2 will be in the global frame

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two frames will exist during the time we're executing in print_twice

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Downney illustrates like this (this is called a stack diagram)

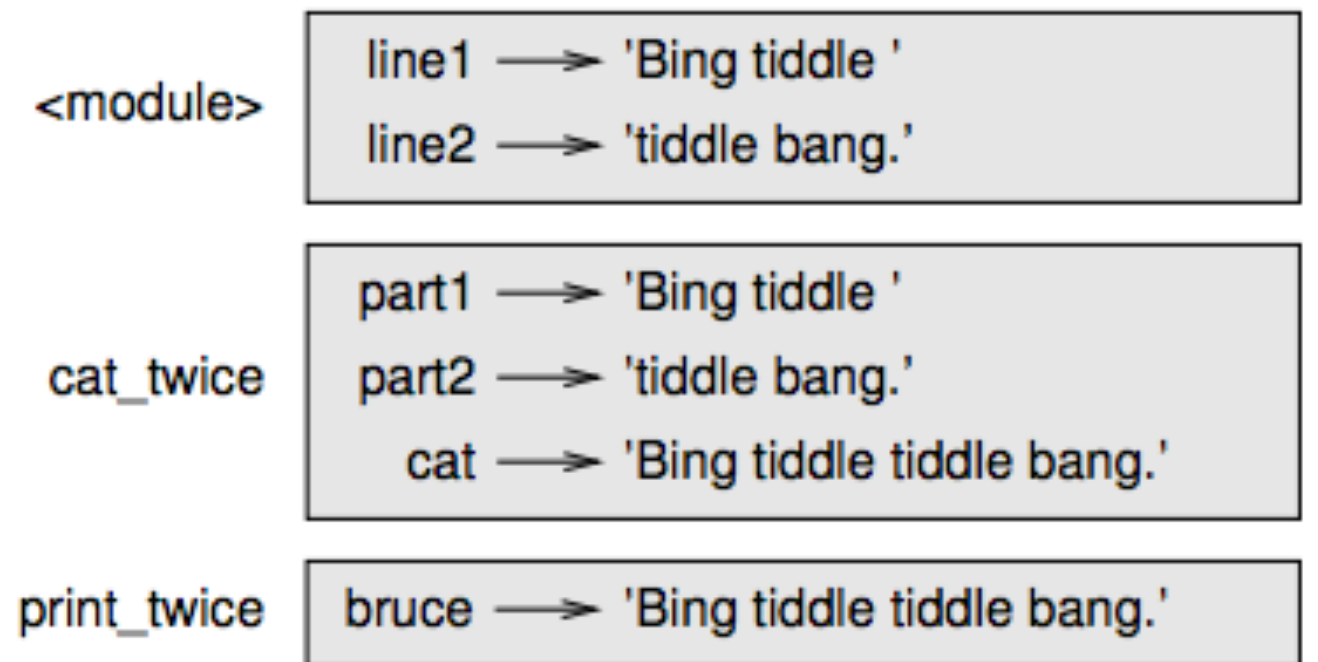| <module>	line1 ⟶ 'Bing tiddle ' line2 ⟶ 'tiddle bang.'
cat_twice	part1 ⟶ 'Bing tiddle ' part2 ⟶ 'tiddle bang.' cat ⟶ 'Bing tiddle tiddle bang.'
print_twice	bruce ⟶ 'Bing tiddle tiddle bang.'

Figure 3.1: Stack diagram.

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this code can access: `line1, line2`

global frame ➡️

| <module> | line1 ⟶ 'Bing tiddle ' |
| | line2 ⟶ 'tiddle bang.' |

cat_twice	part1 ⟶ 'Bing tiddle '
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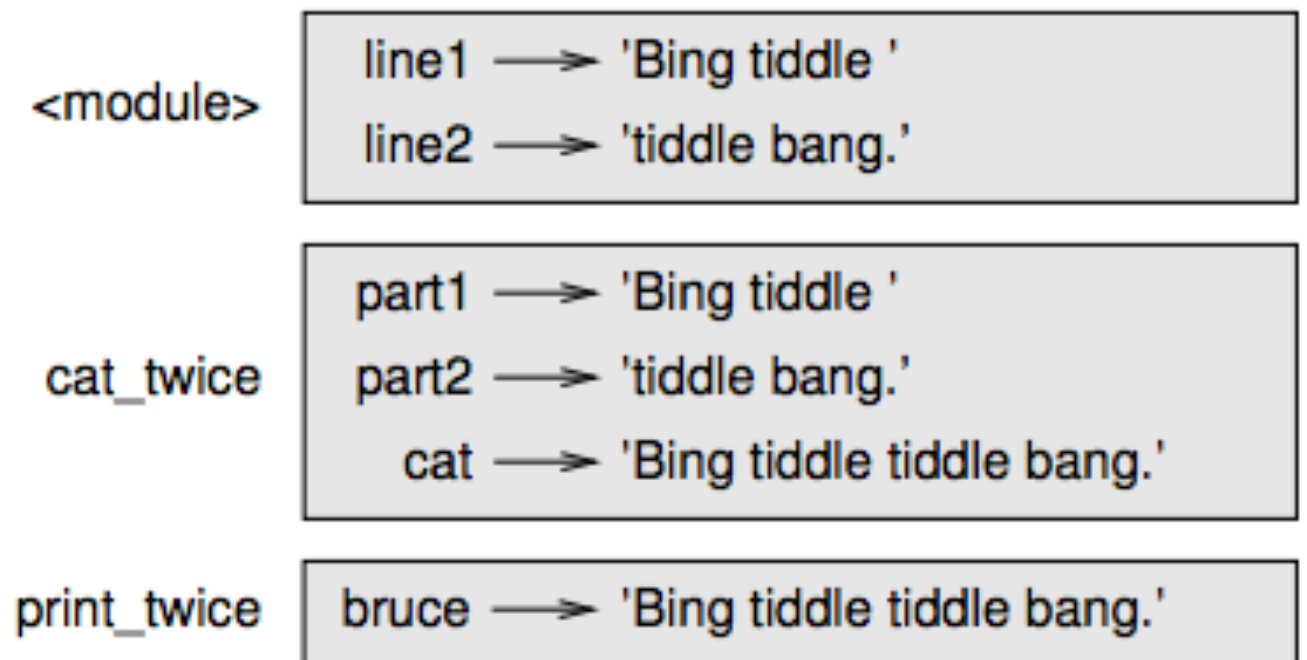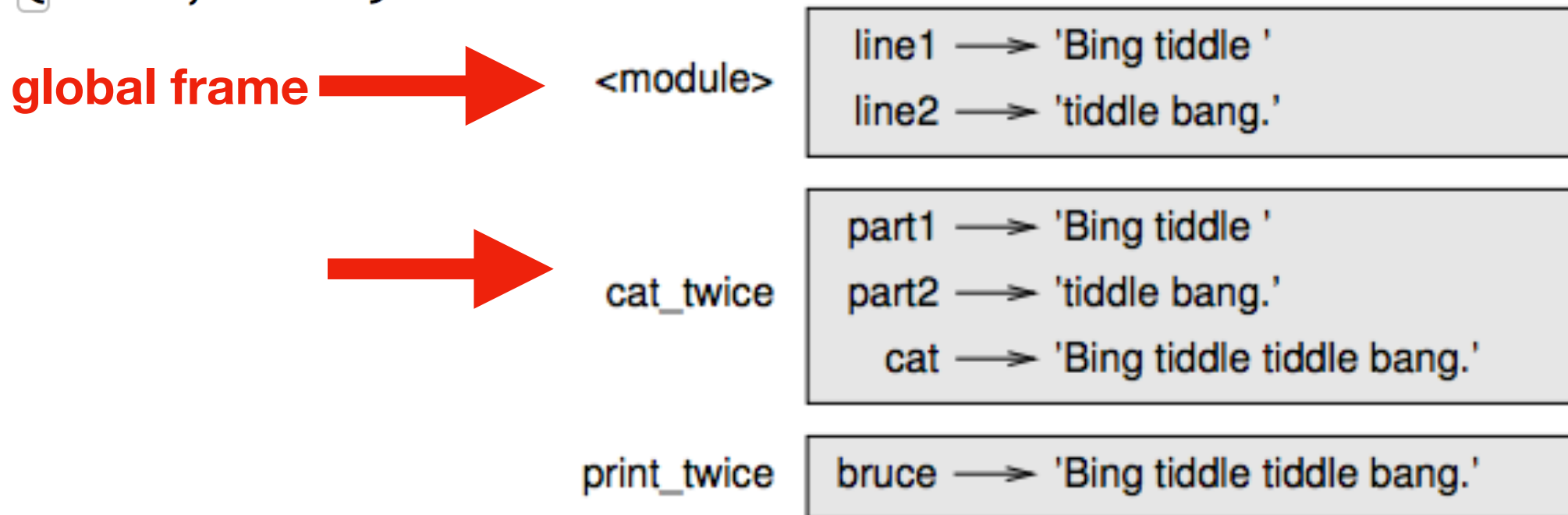| print_twice | bruce ⟶ 'Bing tiddle tiddle bang.' |

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```

can access: `line1, line2, part1, part2, cat`

global frame

<module>	line1 ⟶ 'Bing tiddle '
	line2 ⟶ 'tiddle bang.'

cat_twice	part1 ⟶ 'Bing tiddle '
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print_twice	bruce ⟶ 'Bing tiddle tiddle bang.'

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global frame ➡

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cat_twice	part1 ⟶ 'Bing tiddle '
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```

can access: `line1, line2, bruce`

we call the variables that can currently be accessed "in scope" and variables that cannot be "out of scope"

global frame ➡️ <module>

| line1 ⟶ 'Bing tiddle ' |
| line2 ⟶ 'tiddle bang.' |

cat_twice

| part1 ⟶ 'Bing tiddle ' |
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➡️ print_twice

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**Arguments are copied to parameters:
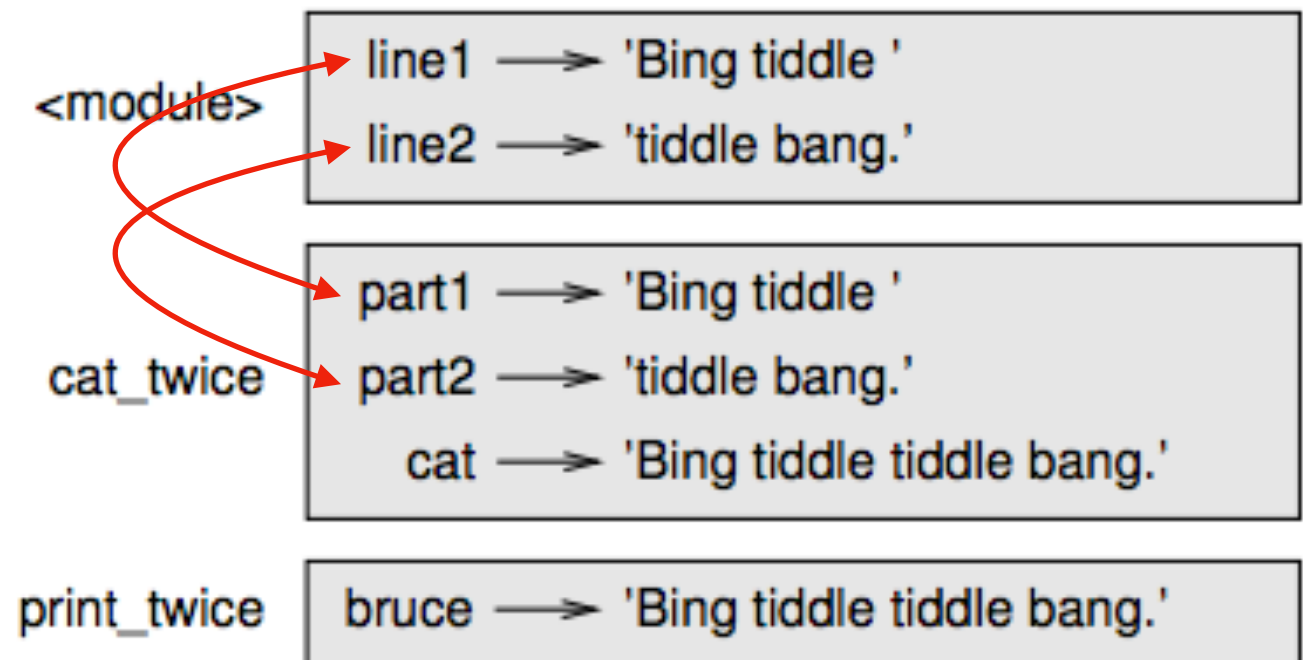this is called "pass by value"**

Figure 3.1: Stack diagram.
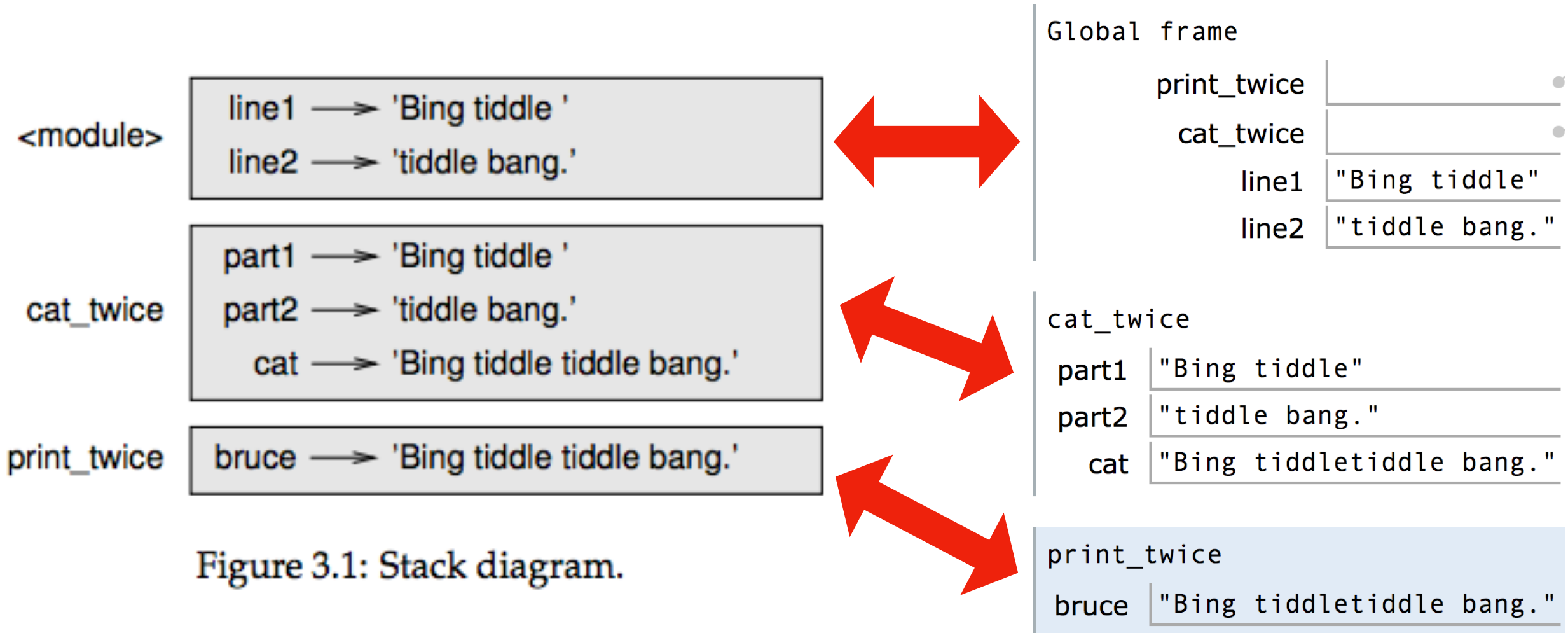
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Think Python vs PythonTutor

Figure 3.1: Stack diagram.
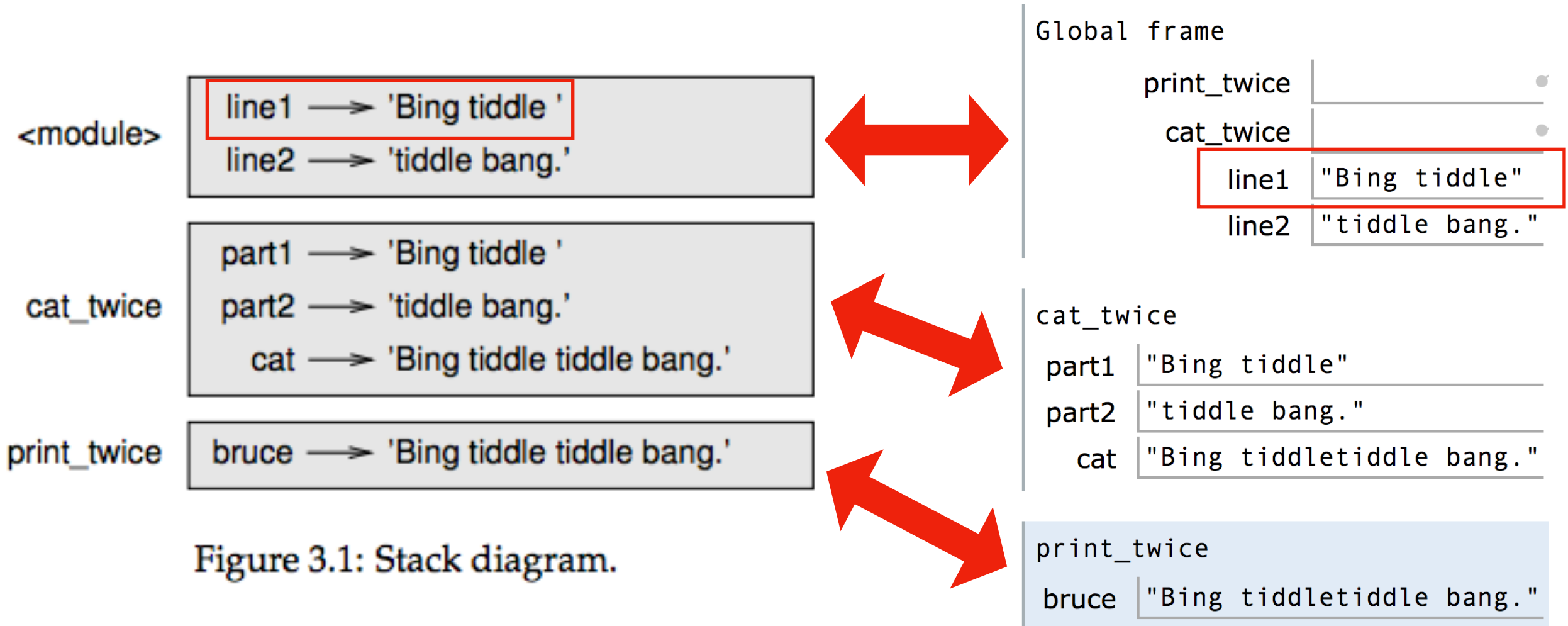
Think Python vs PythonTutor

Figure 3.1: Stack diagram.

Difference 1: PythonTutor uses boxes instead of arrows
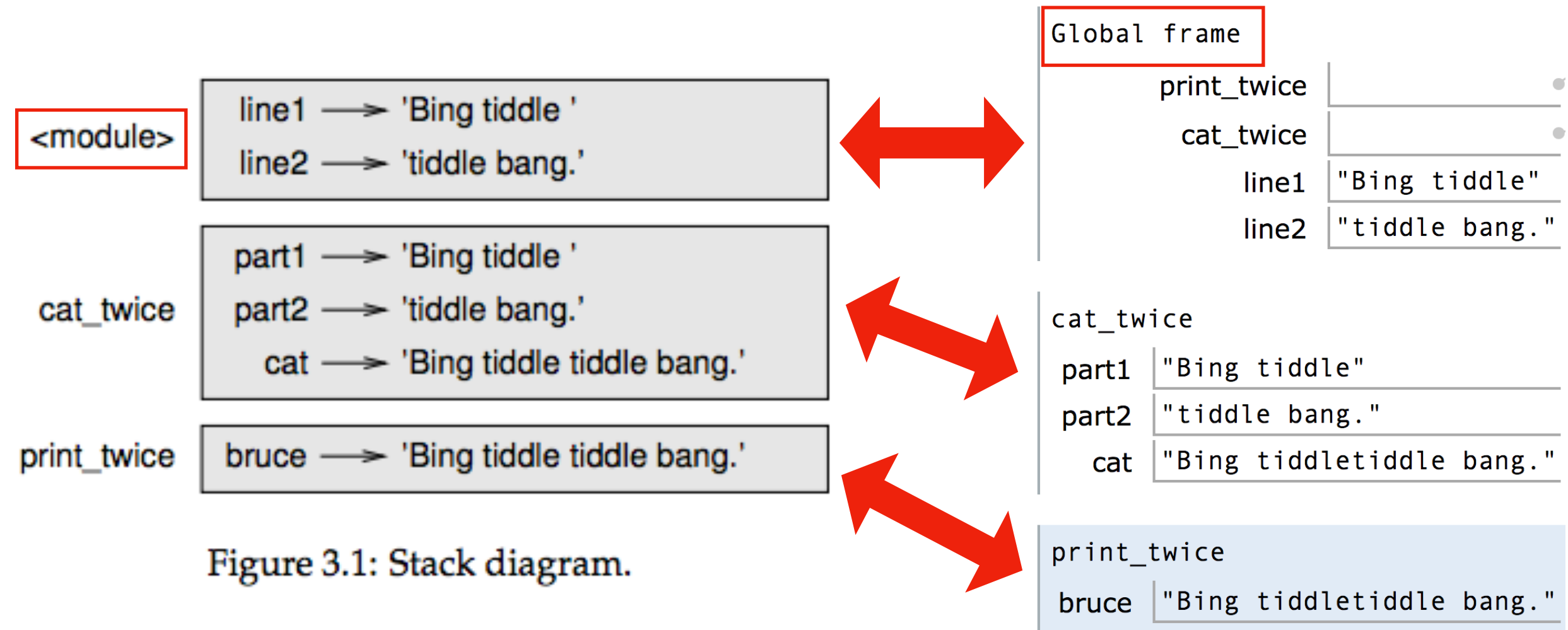
Think Python vs PythonTutor

<module>

```
line1 ──➤ 'Bing tiddle '
line2 ──➤ 'tiddle bang.'
```

cat_twice

```
part1 ──➤ 'Bing tiddle '
part2 ──➤ 'tiddle bang.'
    cat ──➤ 'Bing tiddle tiddle bang.'
```

print_twice

```
bruce ──➤ 'Bing tiddle tiddle bang.'
```

Figure 3.1: Stack diagram.

Global frame

print_twice	●
cat_twice	●
line1	"Bing tiddle"
line2	"tiddle bang."

cat_twice

part1	"Bing tiddle"
part2	"tiddle bang."
cat	"Bing tiddletiddle bang."

print_twice

bruce	"Bing tiddletiddle bang."

Difference 2: PythonTutor more clearly indicates the global frame

Think Python vs PythonTutor

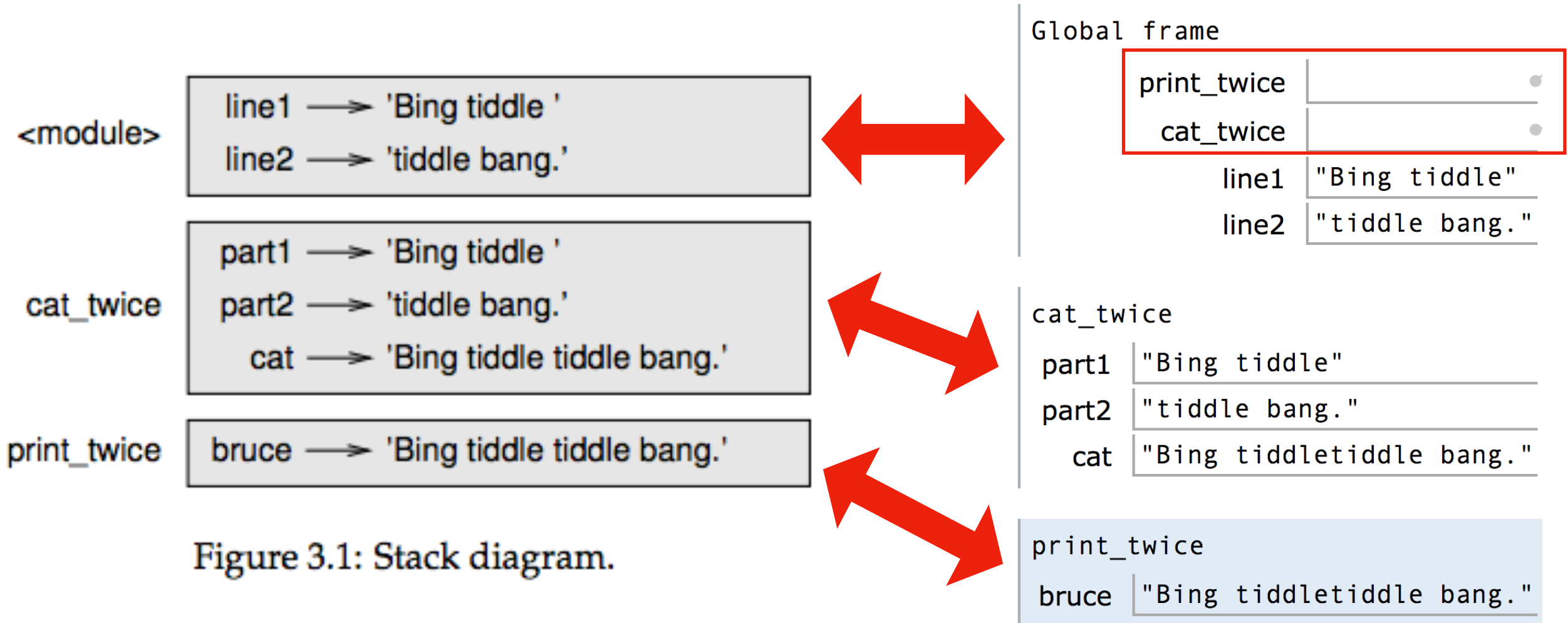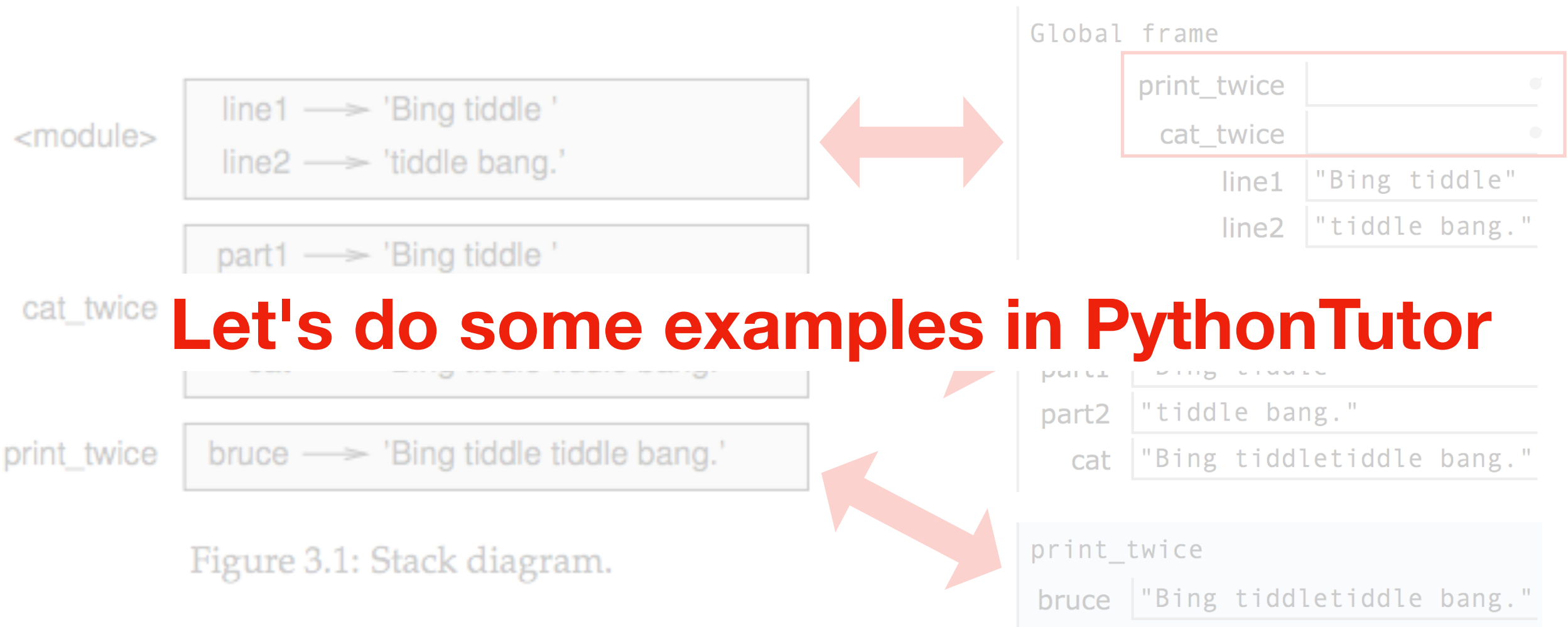Figure 3.1: Stack diagram.

Difference 3: PythonTutor also shows function definitions in the global frame

Think Python vs PythonTutor

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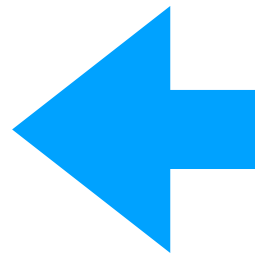
Let's do some examples in PythonTutor

Difference 3: PythonTutor also shows function definitions in the global frame

Today's Outline

Context

Frames

Demos: Local Variables ⬅

Demos: Global Variables

Demos: Argument Passing

Lessons about Local Variables

```
def set_x():
    x = 100

print(x)
```

Lesson 1: functions don't execute unless they're called

Lessons about Local Variables

```
def set_x():
    x = 100

set_x()
print(x)
```

Lesson 2: variables created in a function die after function returns

Lessons about Local Variables

```python
def count():
    x = 1
    x += 1
    print(x)

count()
count()
count()
```

Lesson 3: variables start fresh every time a function is called again

Lessons about Local Variables

```
def display_x():
    print(x)

def main():
    x = 100
    display_x()

main()
```

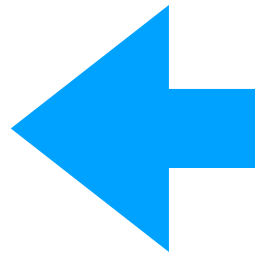**Lesson 4: you can't see the variables of other function invocations, even those that call you**

Today's Outline

Context

Frames

Demos: Local Variables

Demos: Global Variables ⬅

Demos: Argument Passing

Lessons about Global Variables

```python
msg = 'hello' # global, outside any func

def greeting():
    print(msg)

print('before: ' + msg)
greeting()
print('after: ' + msg)
```

Lesson 5: you can generally just use global variables inside a function

Lessons about Global Variables

```python
msg = 'hello'

def greeting():
    msg = 'welcome!'
    print('greeting: ' + msg)

print('before: ' + msg)
greeting()
print('after: ' + msg)
```

Lesson 6: if you do an assignment to a variable in a function, Python assumes you want it local

Lessons about Global Variables

```
msg = 'hello'

def greeting():
    print('greeting: ' + msg)
    msg = 'welcome!'

print('before: ' + msg)
greeting()
print('after: ' + msg)
```

Lesson 7: assignment to a variable should be before its use in a function, even if there's a a global variable with the same name

Lessons about Global Variables

```python
msg = 'hello'

def greeting():
    global msg
    print('greeting: ' + msg)
    msg = 'welcome!'

print('before: ' + msg)
greeting()
print('after: ' + msg)
```

Lesson 8: use a global declaration to prevent Python from creating a local variable when you want a global variable
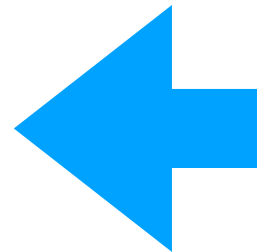
Today's Outline

Context

Frames

Demos: Local Variables

Demos: Global Variables

Demos: Argument Passing

Lessons about Argument Passing

```python
def f(x):
    x = 'B'
    print('inside: ' + x)

val = 'A'
print('before: ' + val)
f(val)
print('after: ' + val)
```

Lesson 9: in Python, arguments are "passed by value", meaning reassignments to a parameter don't change the argument outside

Lessons about Argument Passing

```
x = 'A'

def f(x):
    x = 'B'
    print('inside: ' + x)

print('before: ' + x)
f(x)
print('after: ' + x)
```

Lesson 10: it's irrelevant whether the argument (outside) and parameter (inside) have the same variable name

Lesson Summary

Local

Lesson 1: functions don't execute unless they're called

Lesson 2: variables created in a function die after function returns

Lesson 3: variables start fresh every time a function is called again

Lesson 4: you can't see the variables of other function invocations, even those that call you

Global

Lesson 5: you can generally just use global variables inside a function

Lesson 6: if you do an assignment to a variable in a function, Python assumes you want it local

Lesson 7: assignment to a variable should be before its use in a function, even if there's a a global variable with the same name

Lesson 8: use a global declaration to prevent Python from creating a local variable when you want a global variable

Parameters

Lesson 9: in Python, arguments are "passed by value", meaning reassignments to a parameter don't change the argument outside

Lesson 10: it's irrelevant whether the argument (outside) and parameter (inside) have the same variable name