[301] Function Scope

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Learning Objectives Today

Understand **local variables**

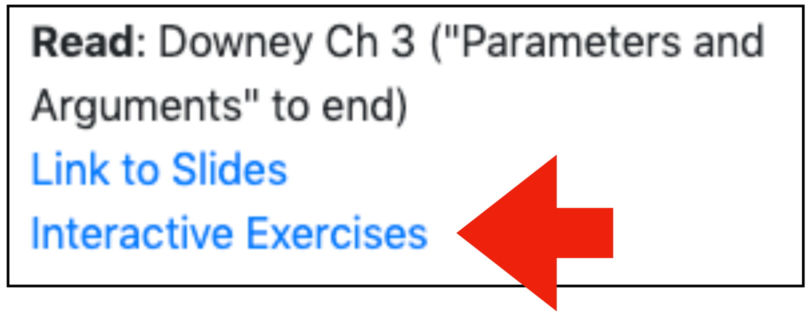
- When are they created?
- When do they die?
- When are they shared?
- Where are they stored? (frames)

Understand **global variables**

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

Understand argument passing

- Meaning of "pass by value"



Read: Downey Ch 3 ("Parameters and Arguments" to end)
Link to Slides
Interactive Exercises

don't memorize the examples, learn the rules of Python

good question: *why did PyTutor do this thing I didn't expect at this specific line (ask us!)*

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?

Context

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- Examples?
- Human name: Nicholas (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?)

Context

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- Examples?
- Human name: Nicholas (who is in the room?)
- Street address: 534 State Street (what city are we in?)
- Functions: speak (cat module or dog module?)
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Our code often have different variables with the same name

- How do we keep variable names organized?
- How do we know what a variable name is referring to?

Context

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

- Examples?
- Human name: Nicholas (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?)

Our code 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

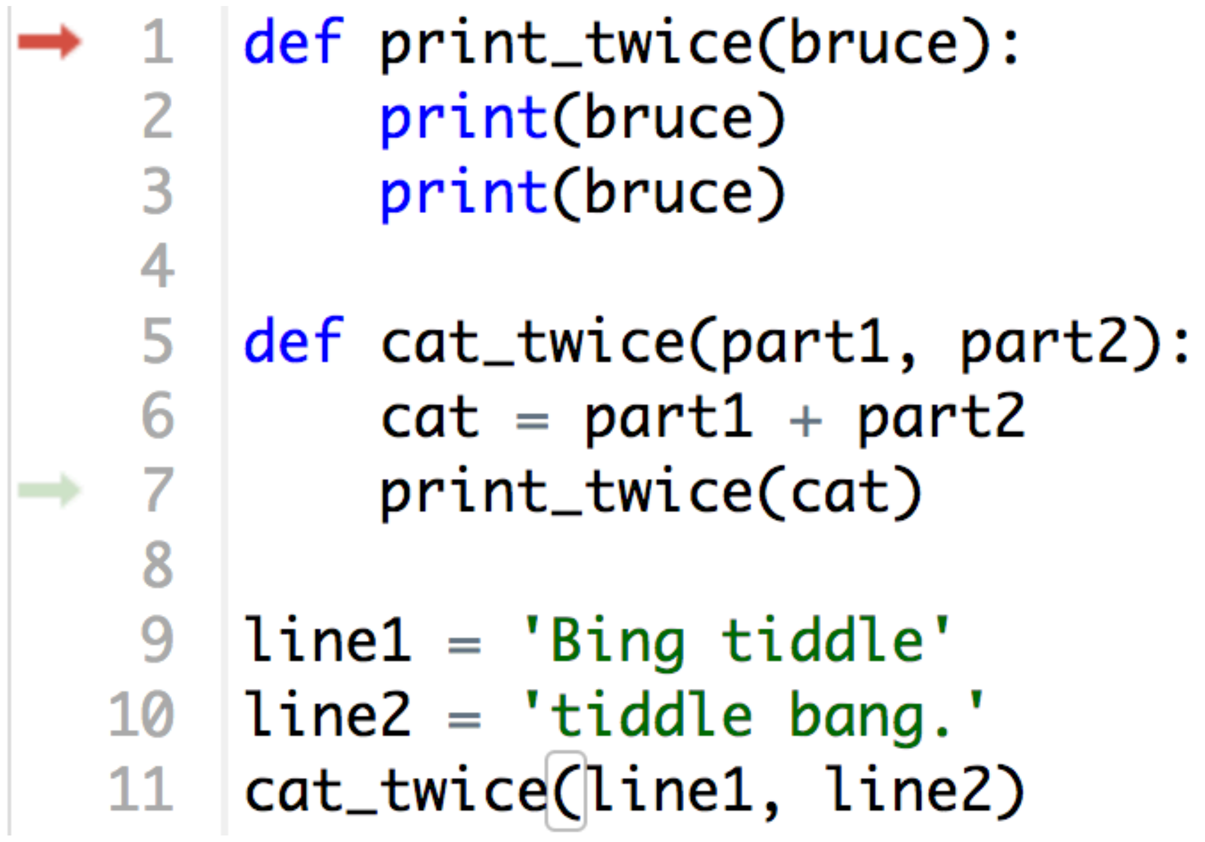
Global frame

- 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)



```python
def print_twice(bruce):
    print(bruce)
    print(bruce)

def cat_twice(part1, part2):
    cat = part1 + part2
    print_twice(cat)

line1 = 'Bing tiddle'
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cat_twice(line1, line2)
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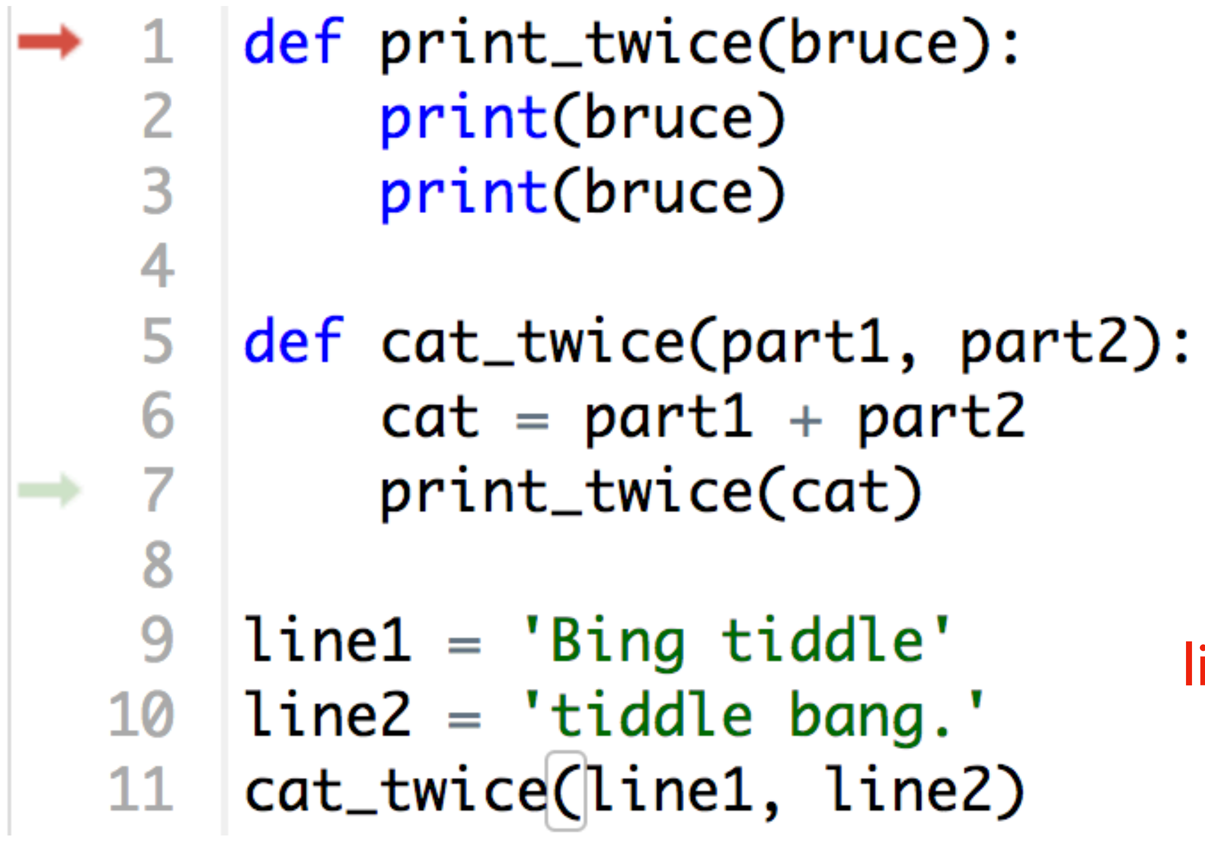

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line1 and line2 will be in the global frame

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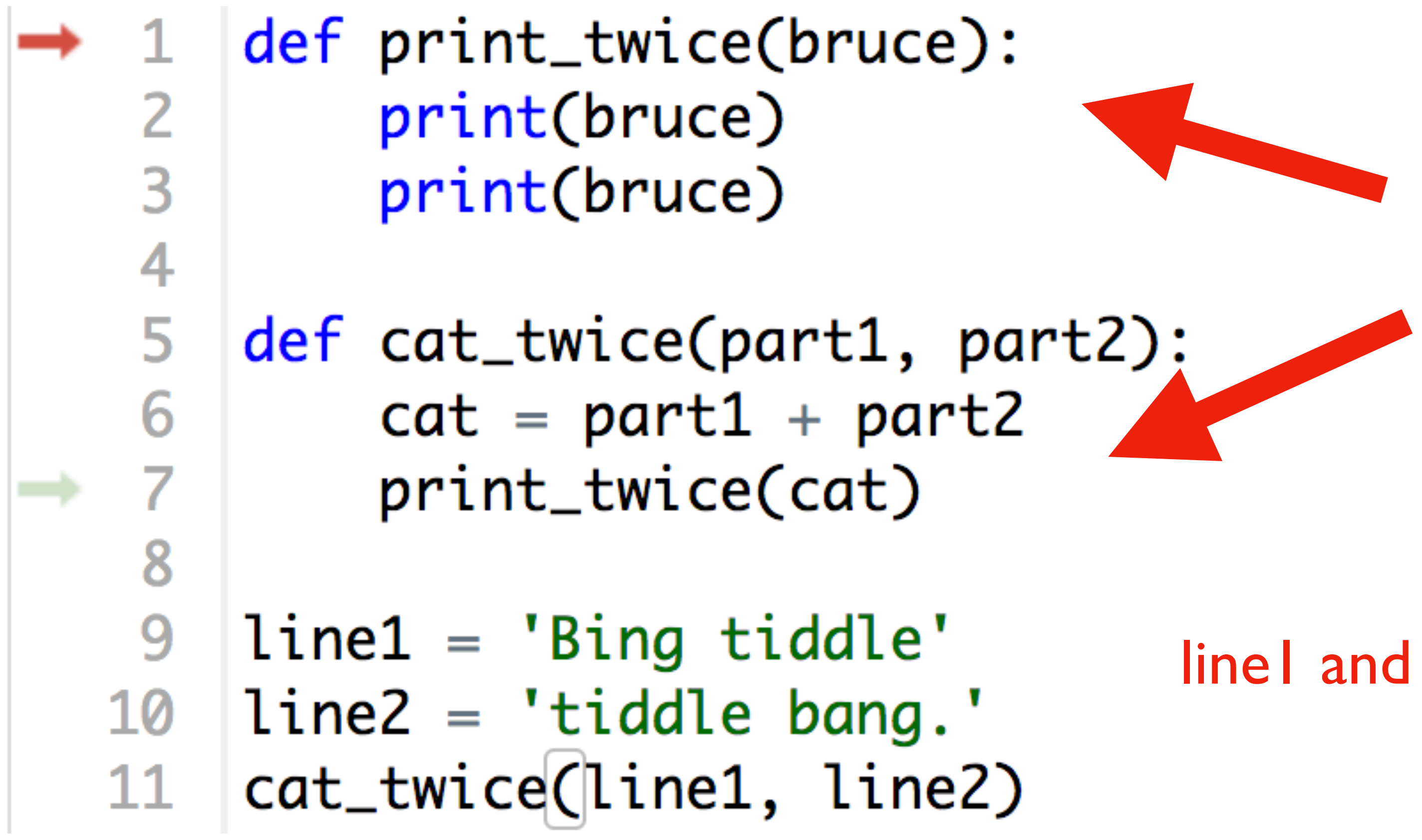

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two frames will exist during the time we're executing in print_twice

line1 and line2 will be in the global frame

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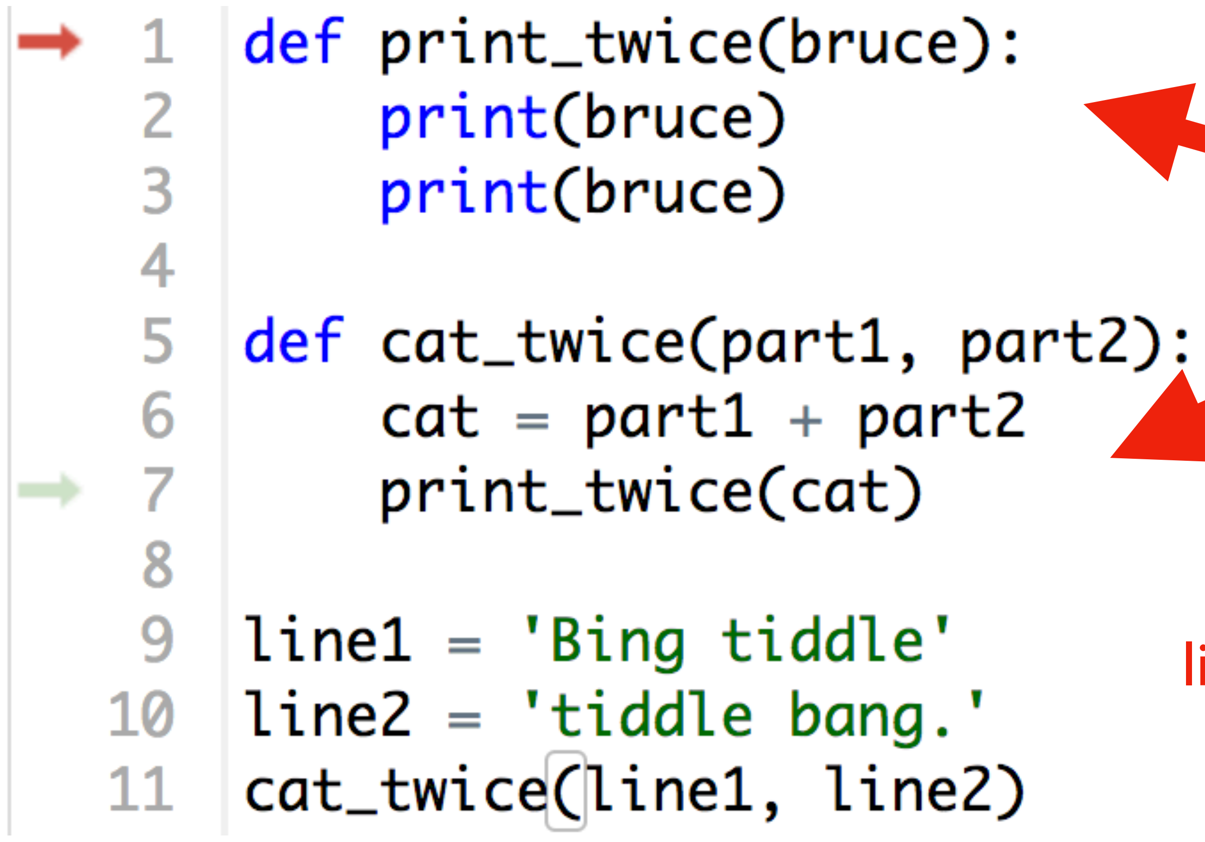

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two frames will exist during the time we're executing in print_twice

line1 and line2 will be in the global frame

you don't generally see or interact with frames when programming, but it's an important mental model

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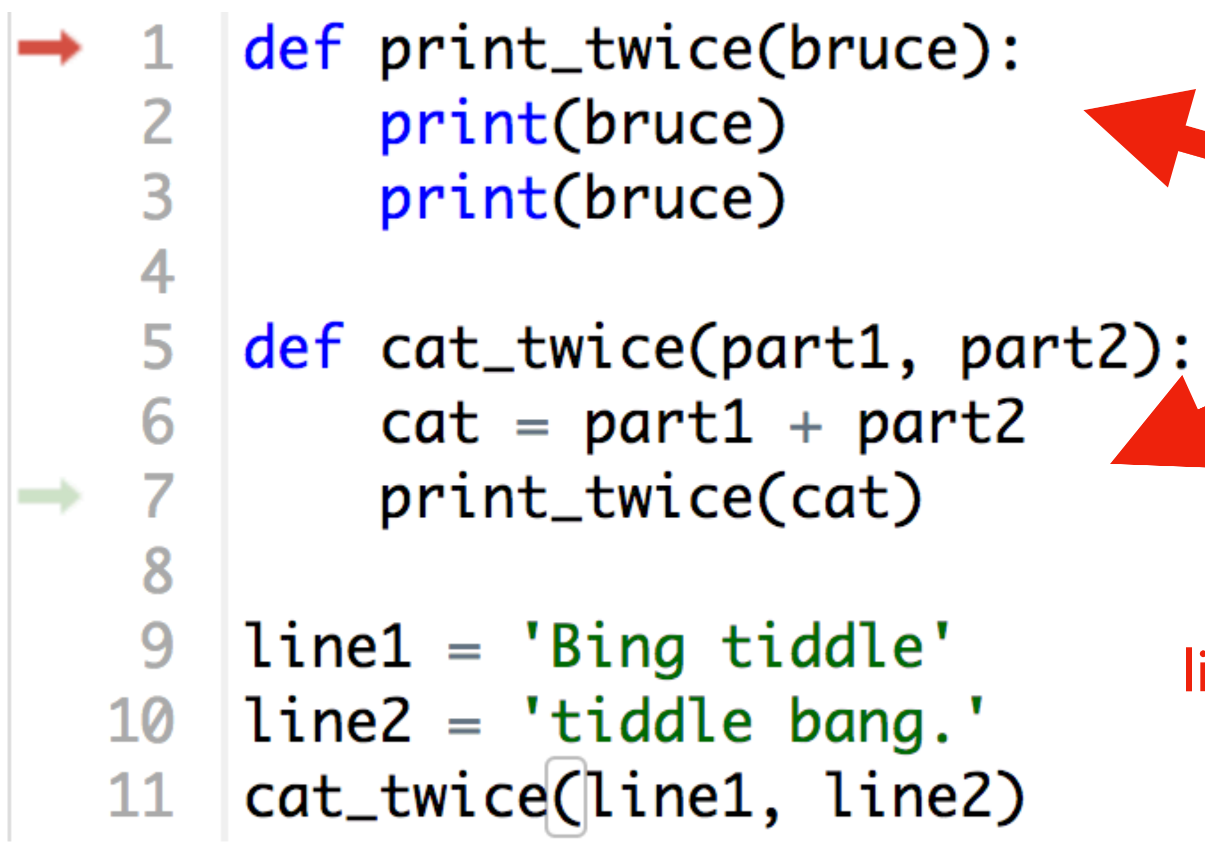

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Downey illustrates like this (this is called a stack diagram)

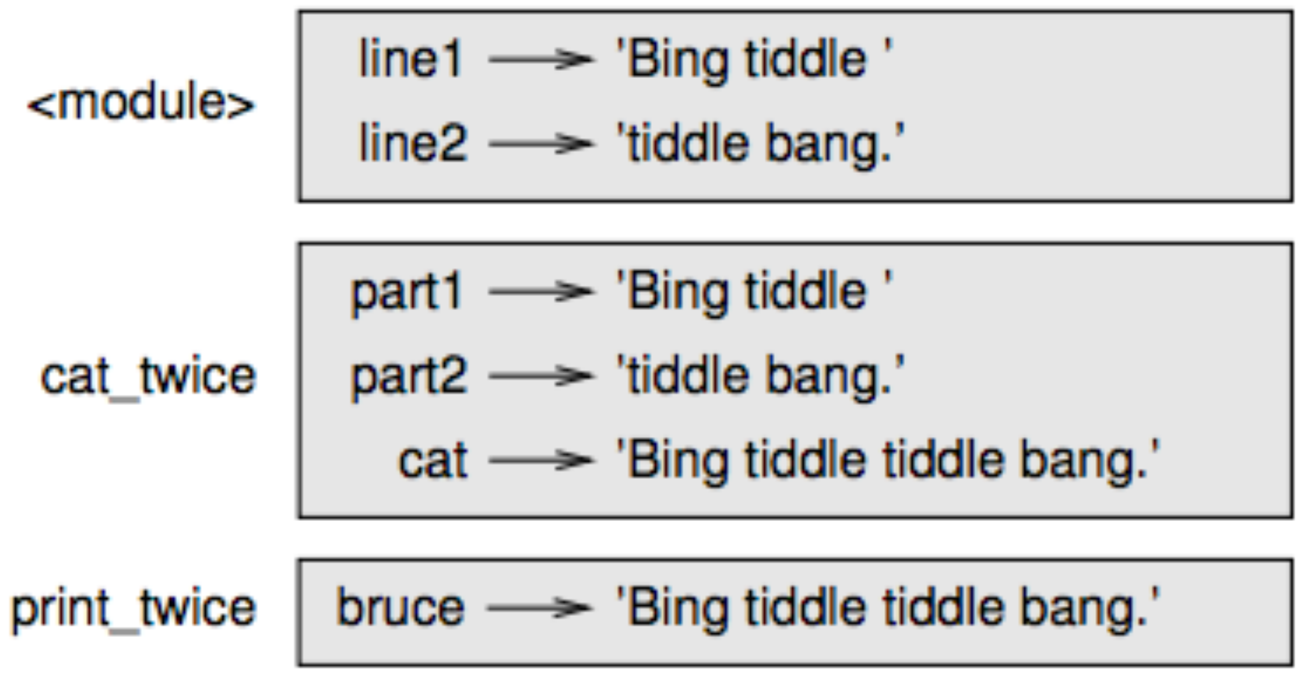

Figure 3.1: Stack diagram.

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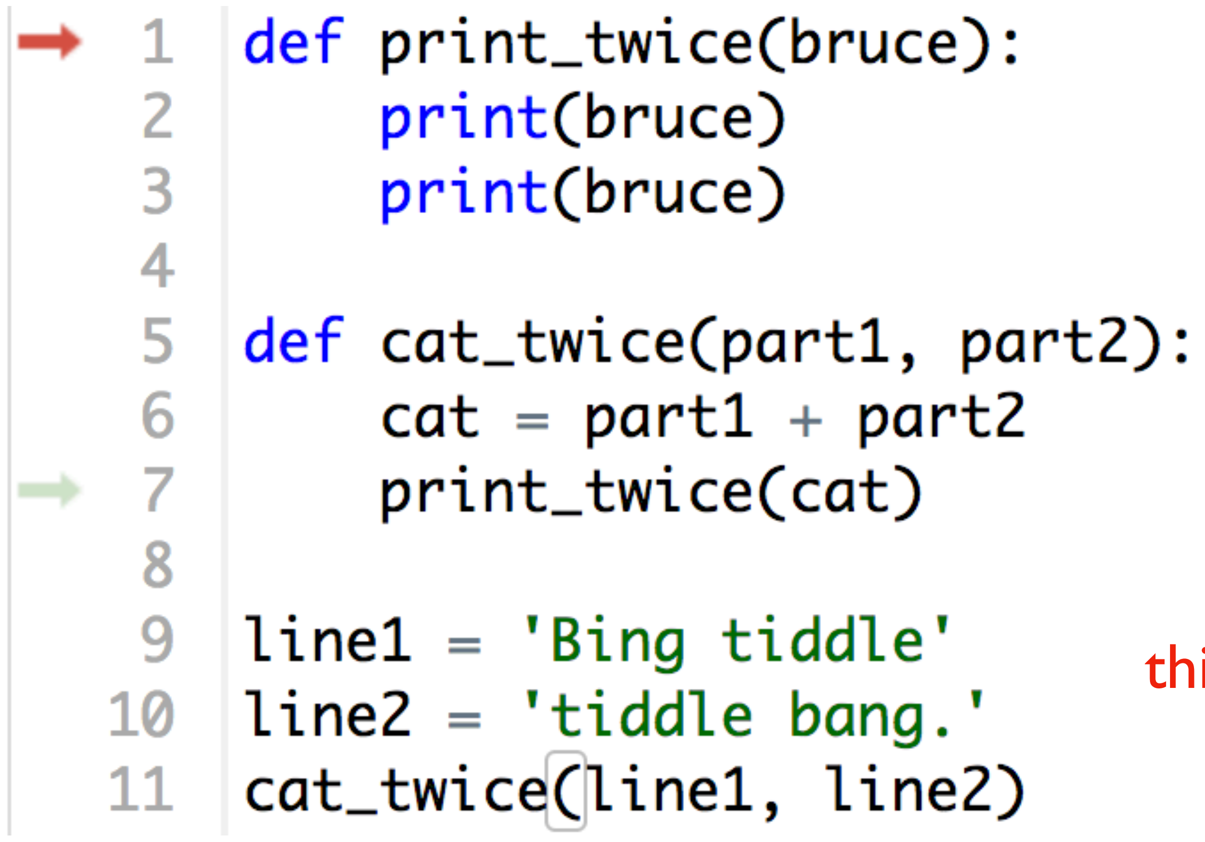

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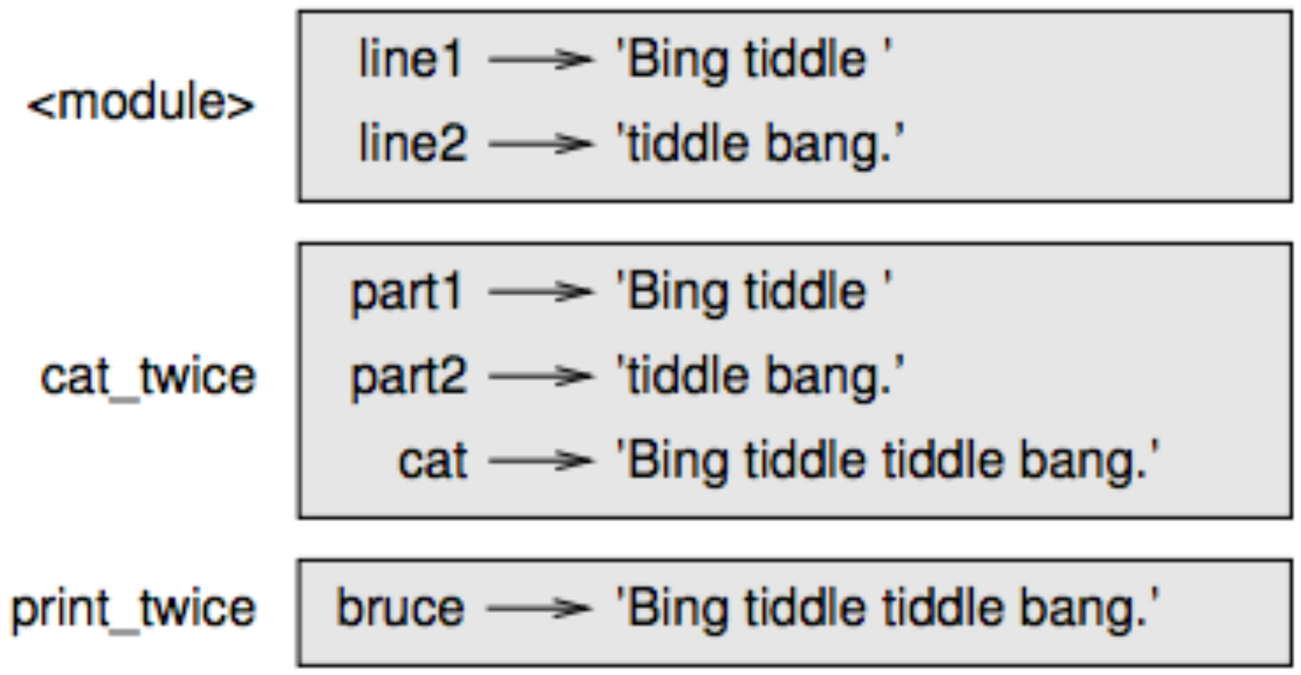
```

this code can access: `line1, line2`

global frame



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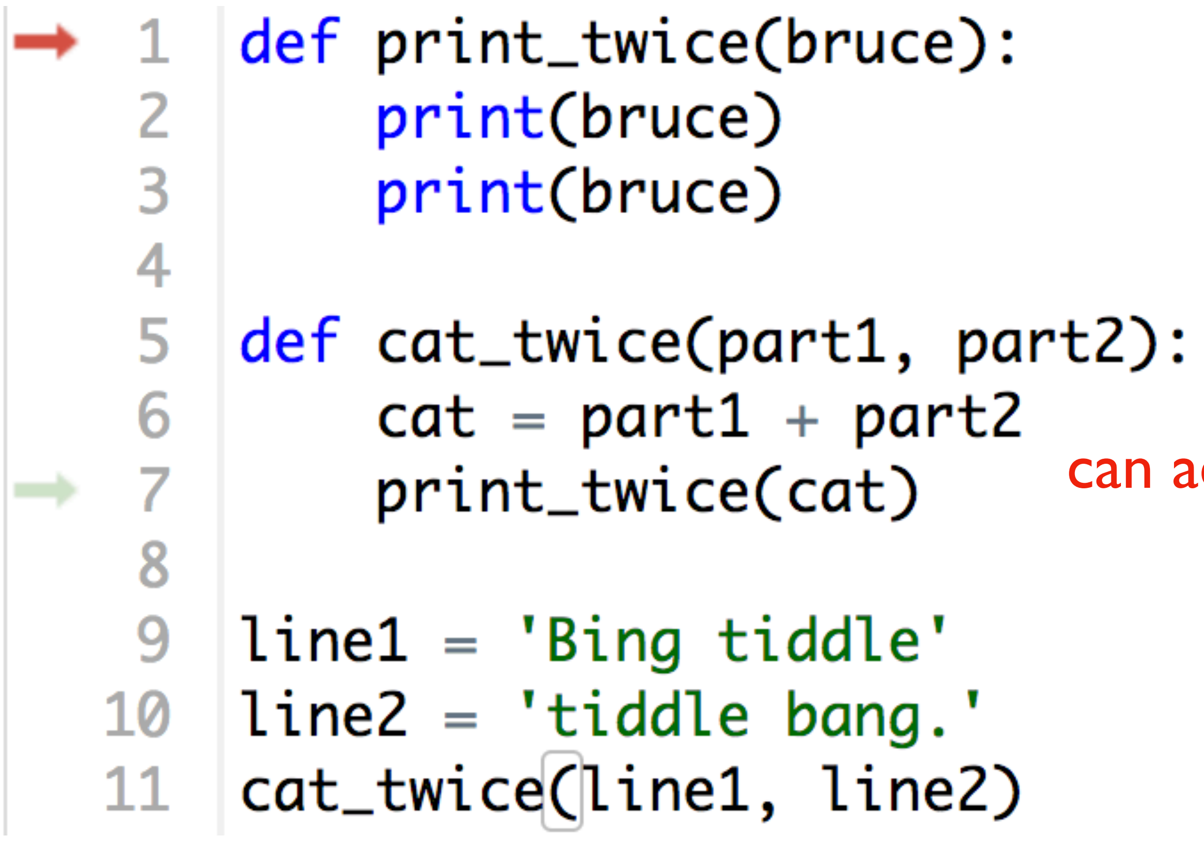

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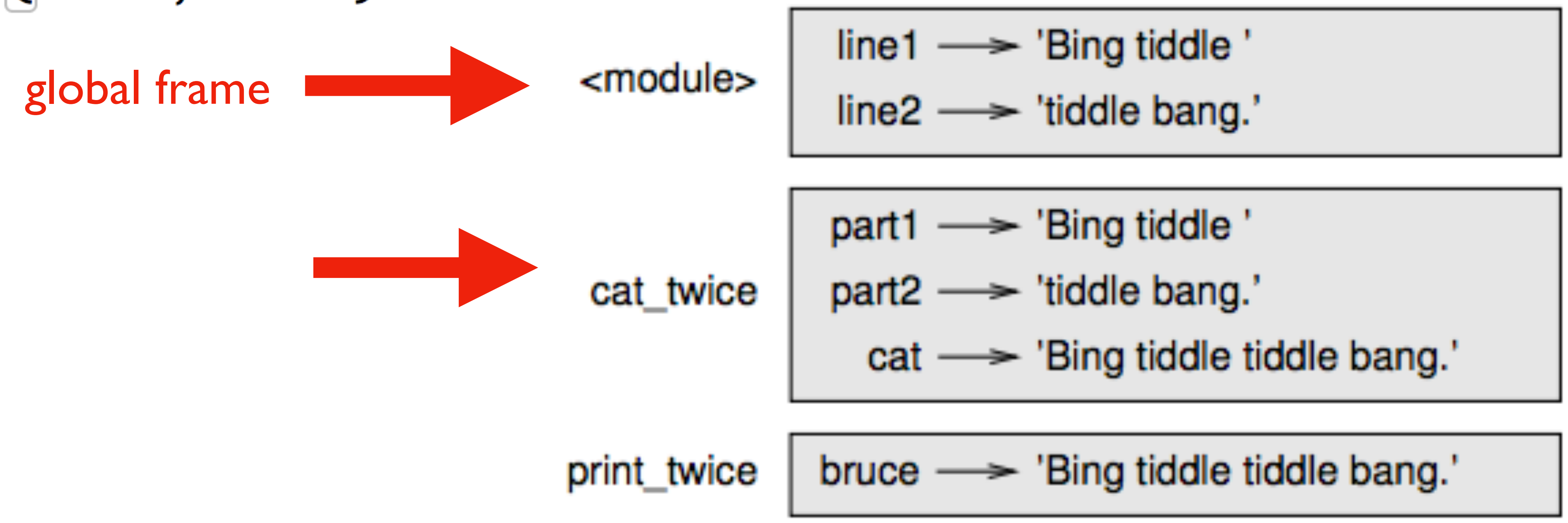
can access: `line1, line2, part1, part2, cat`



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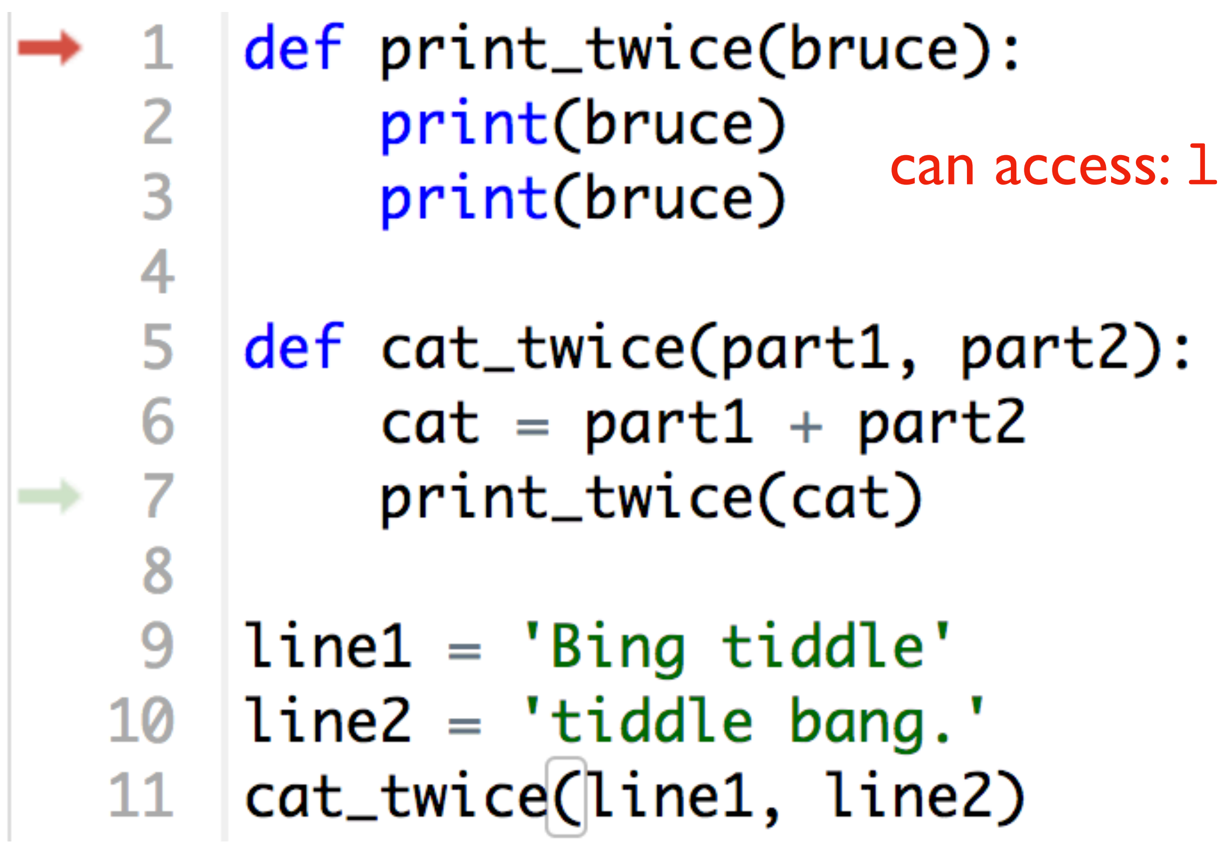

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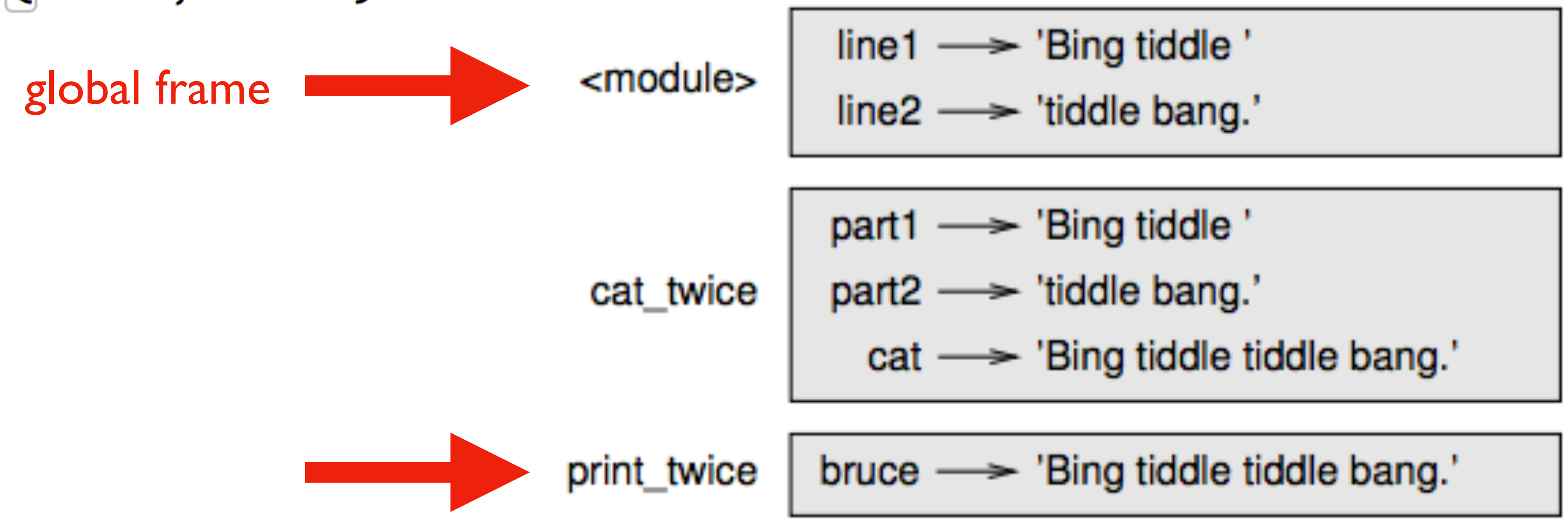

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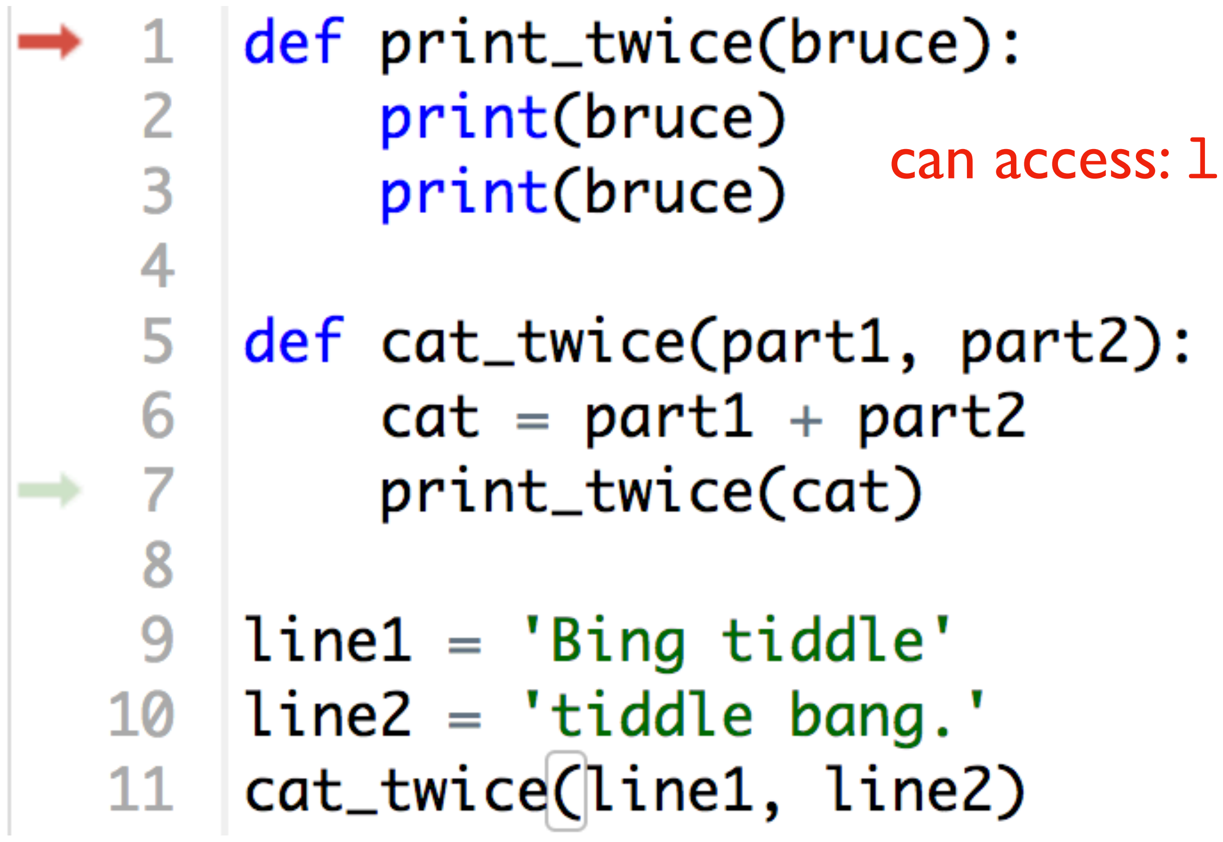

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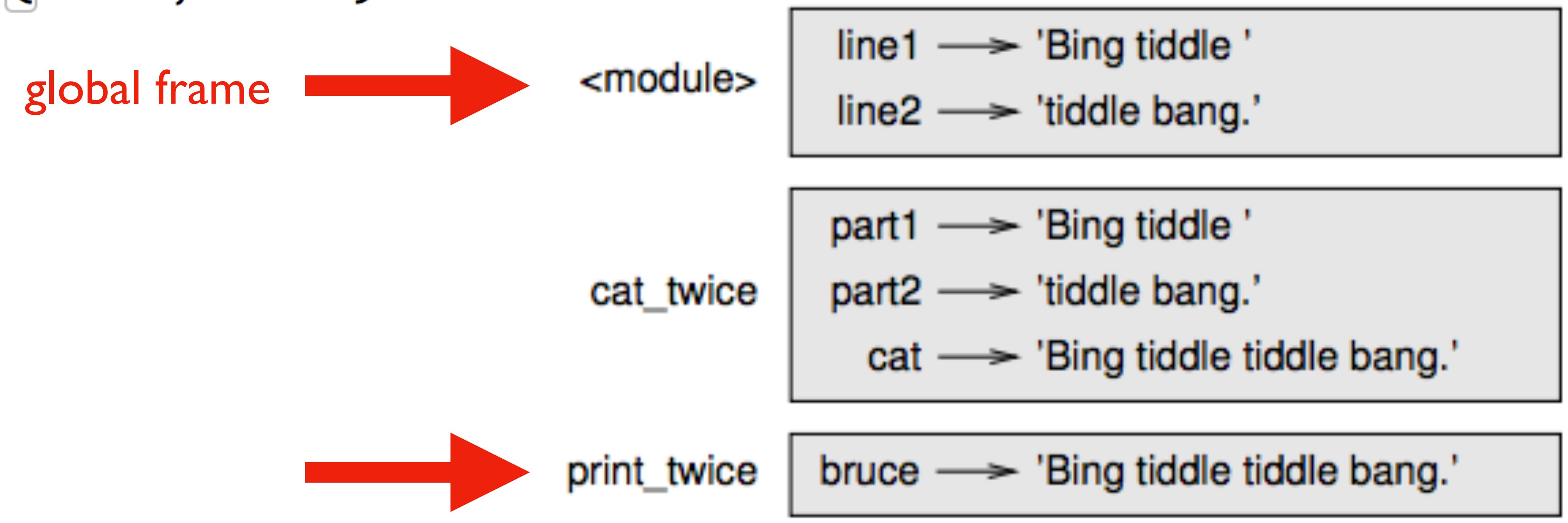
can access: `line1, line2, bruce`

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



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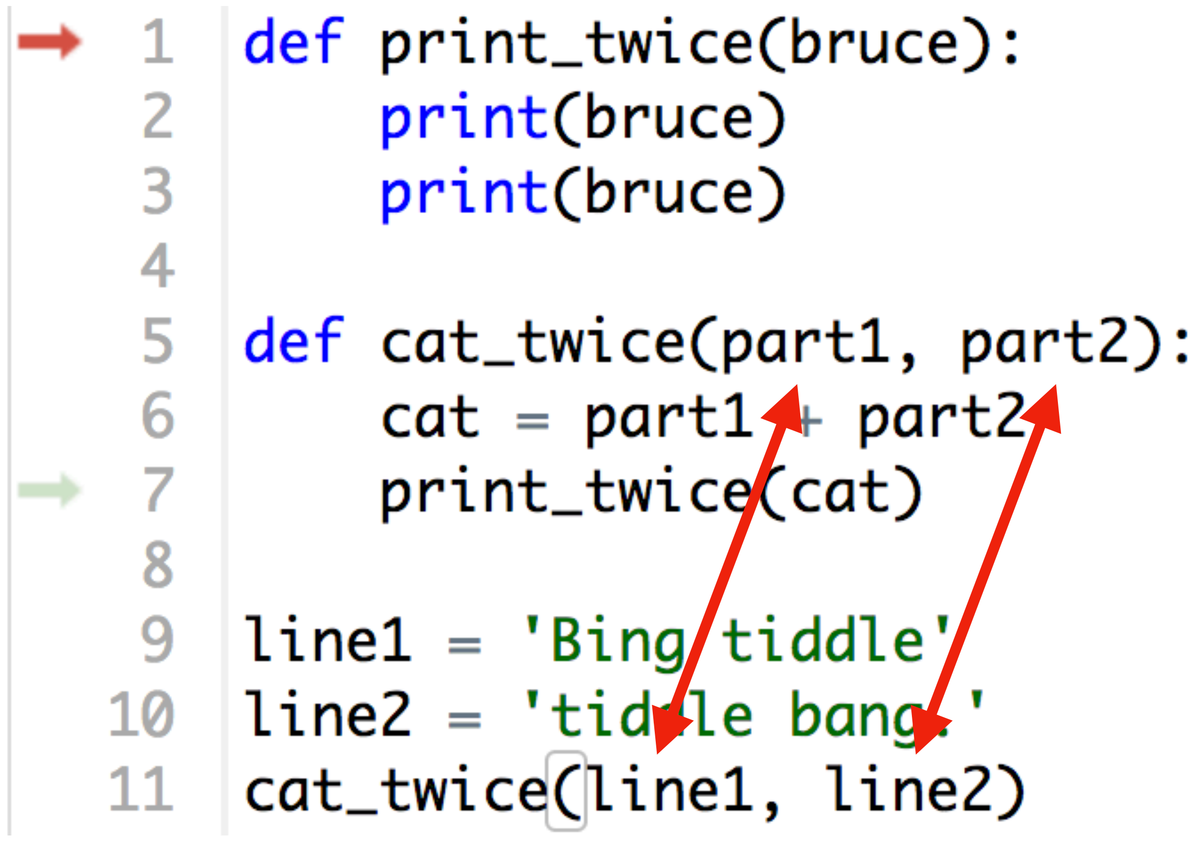

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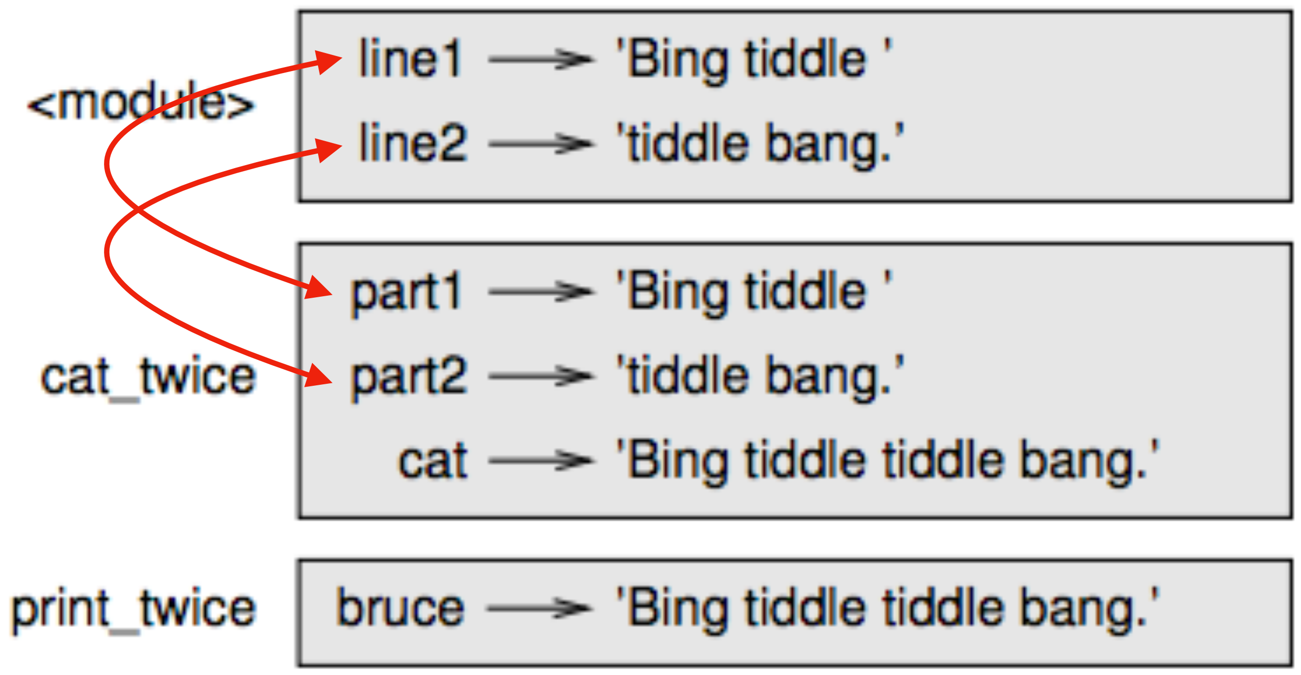
```

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



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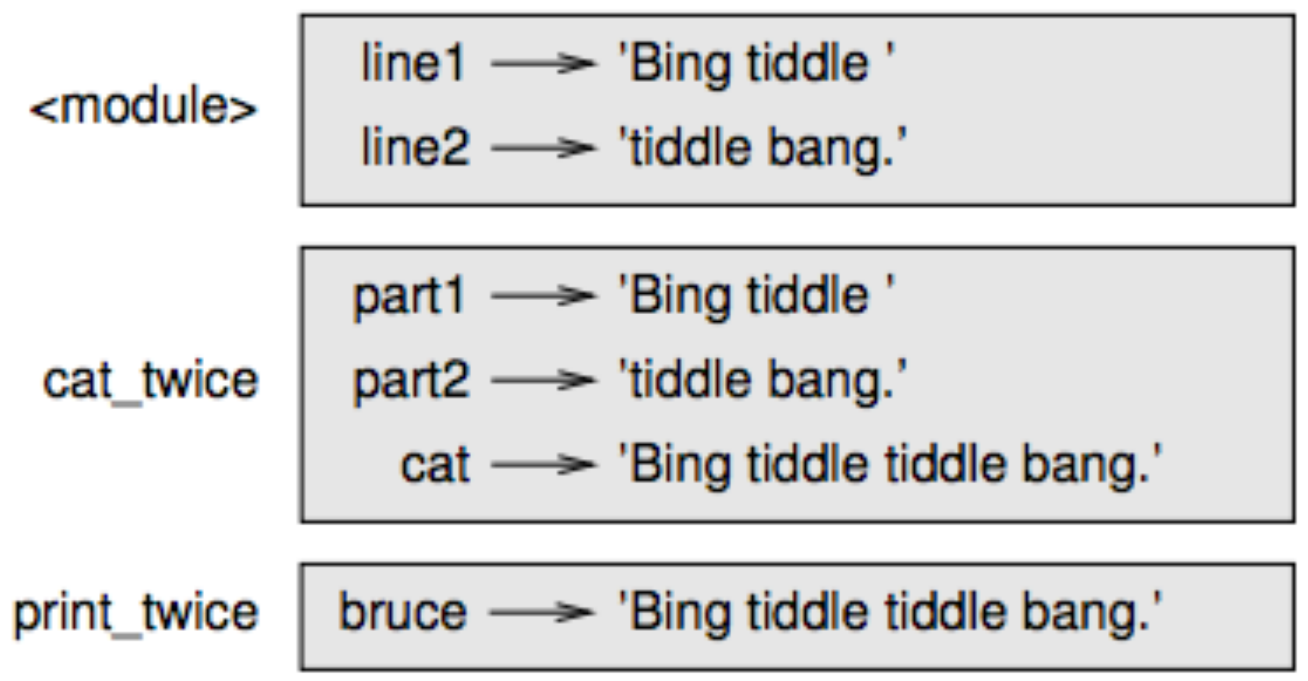
Think Python vs PythonTutor



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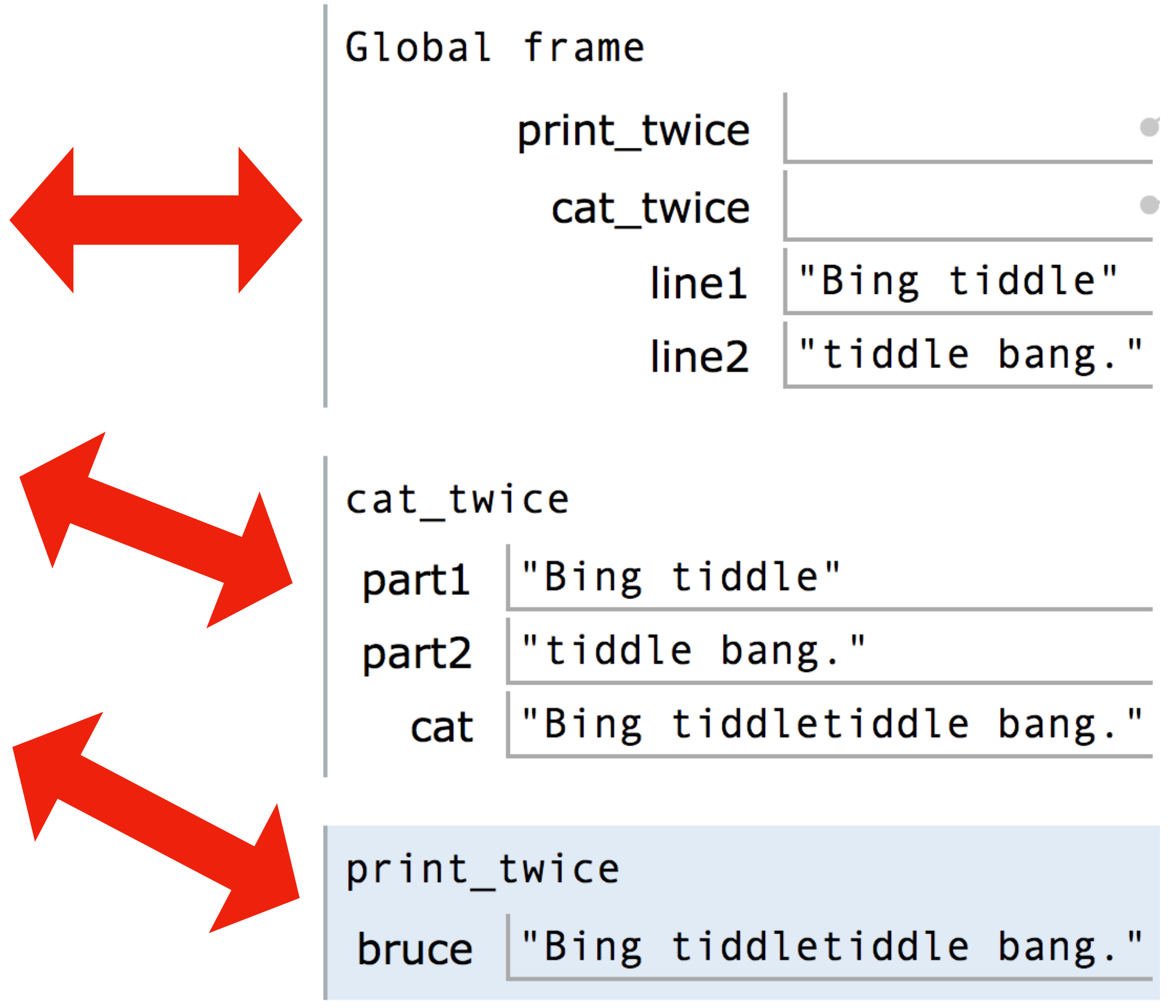

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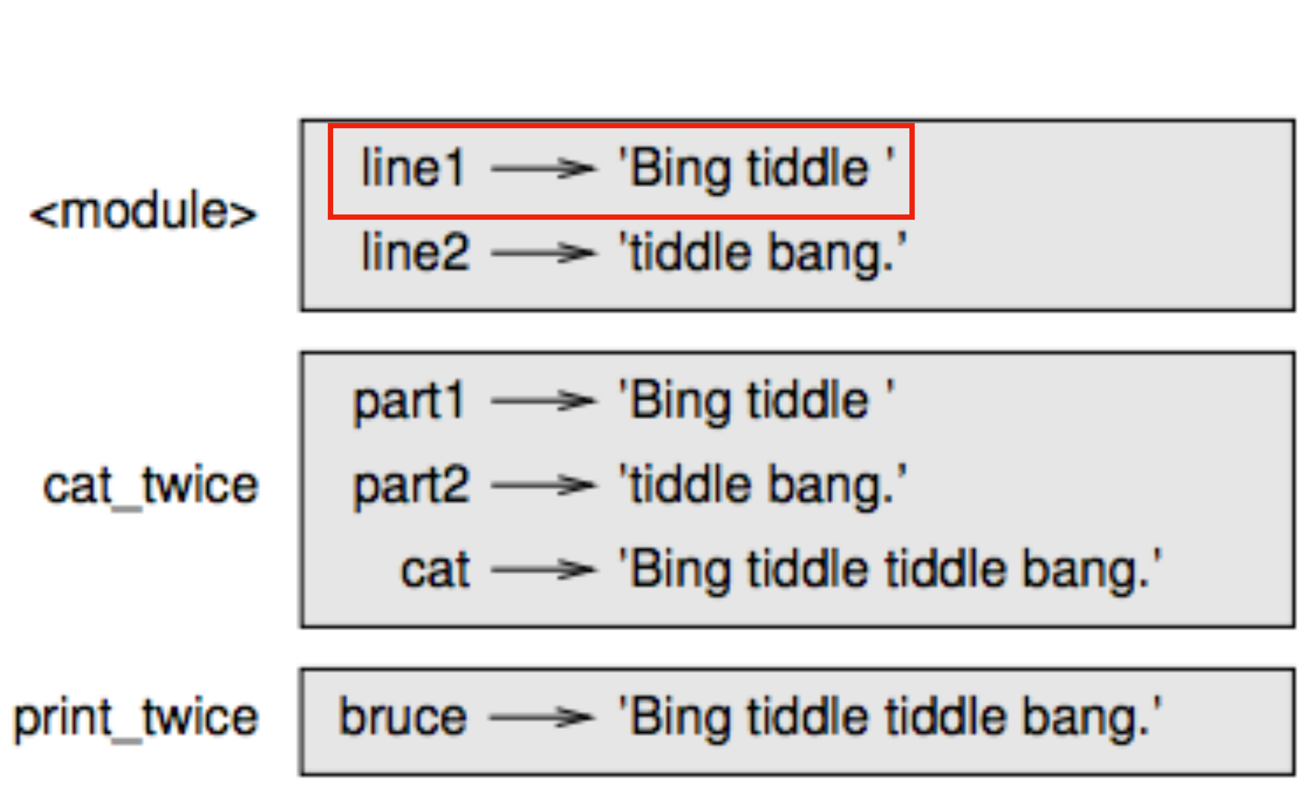

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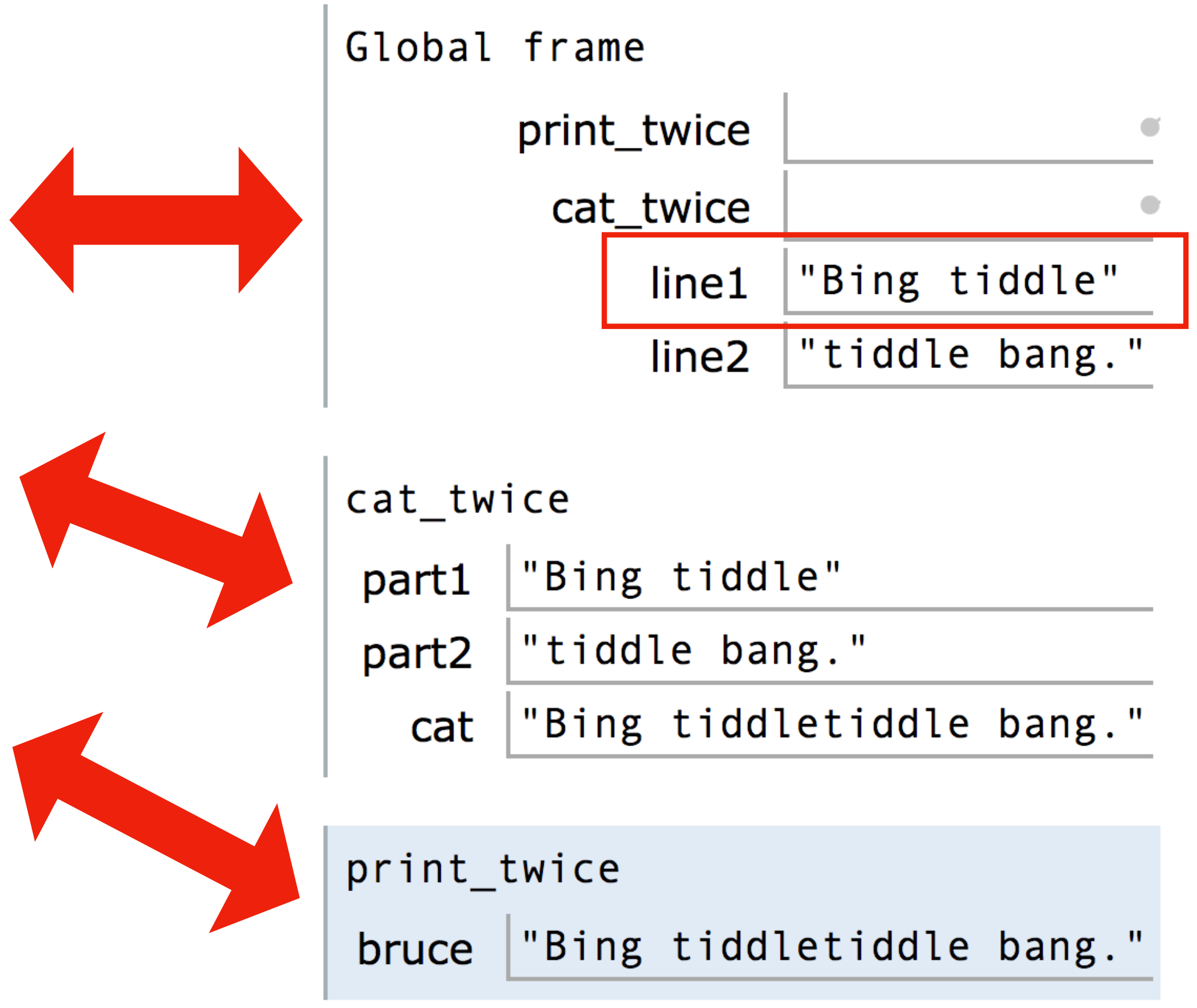
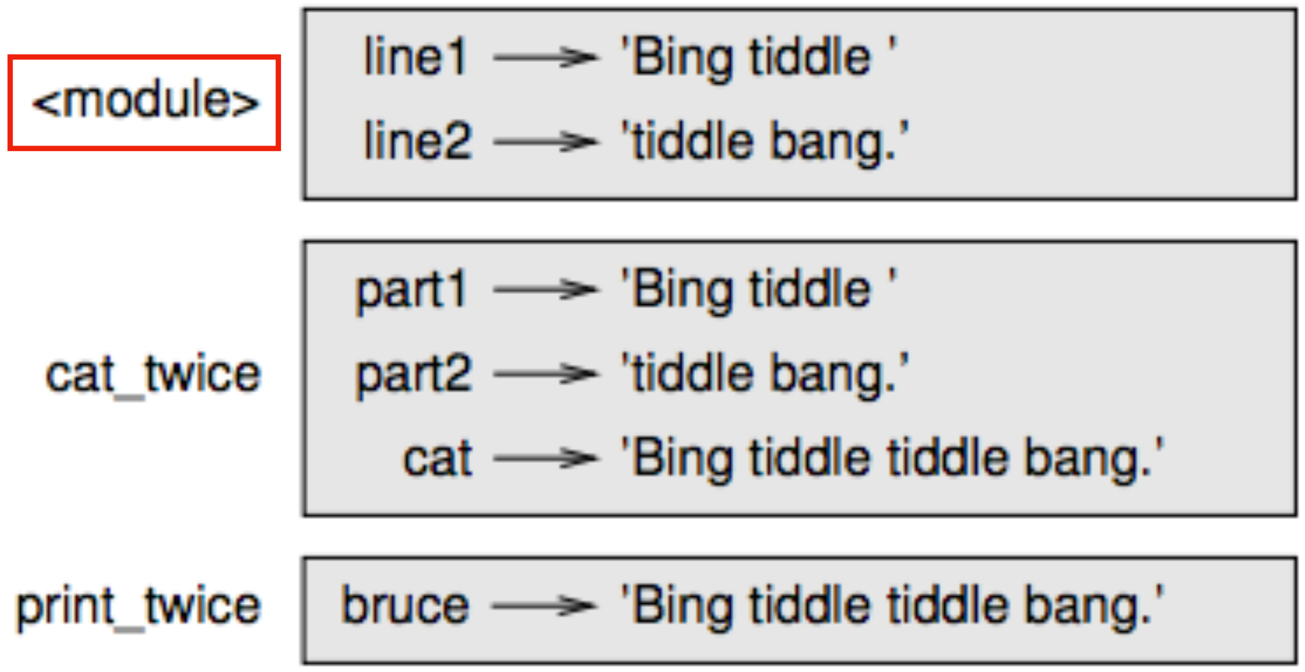


Difference 1: PythonTutor uses boxes instead of arrows (by default)

Think Python vs PythonTutor



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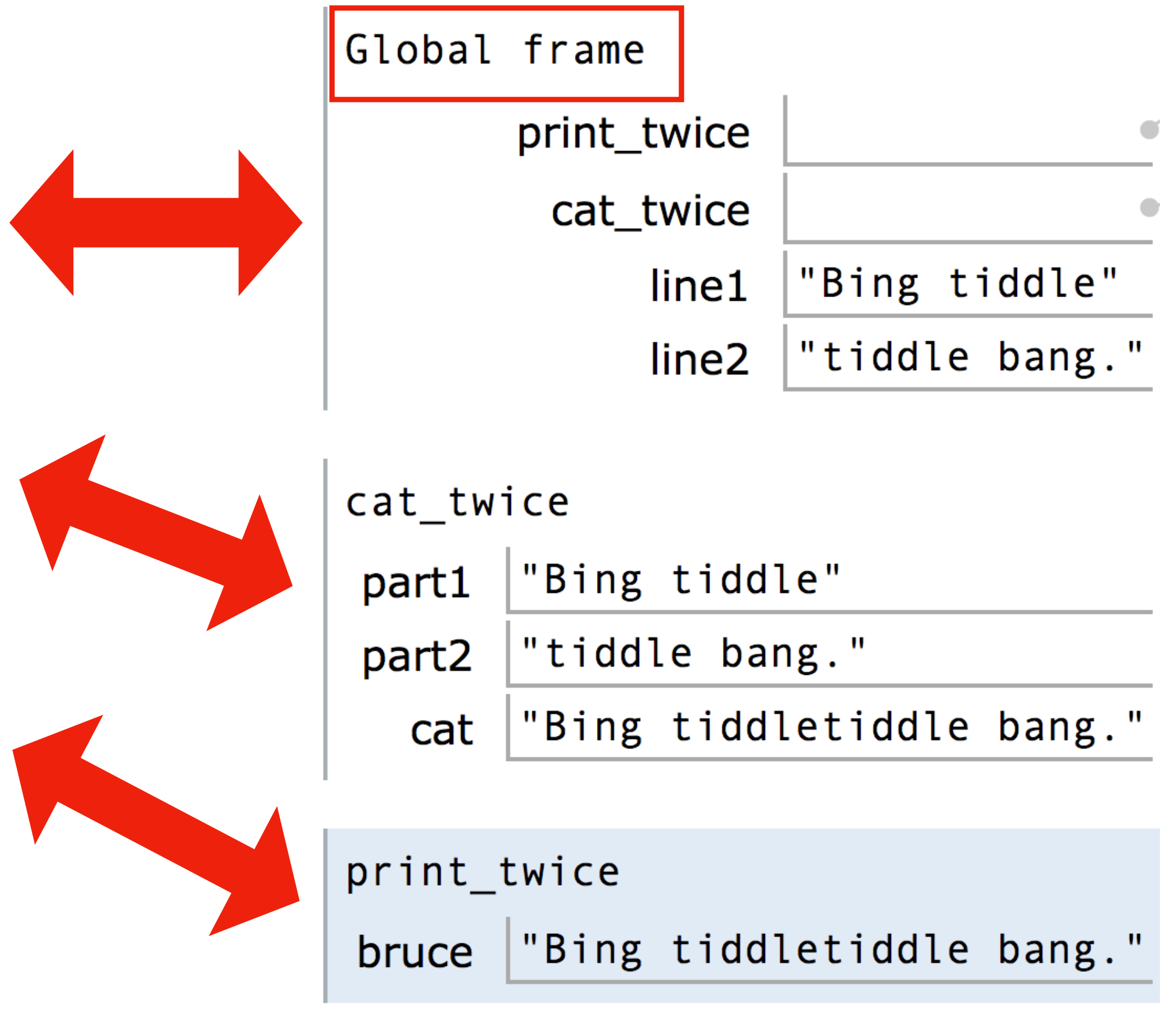

Difference 2: PythonTutor more clearly indicates the global frame

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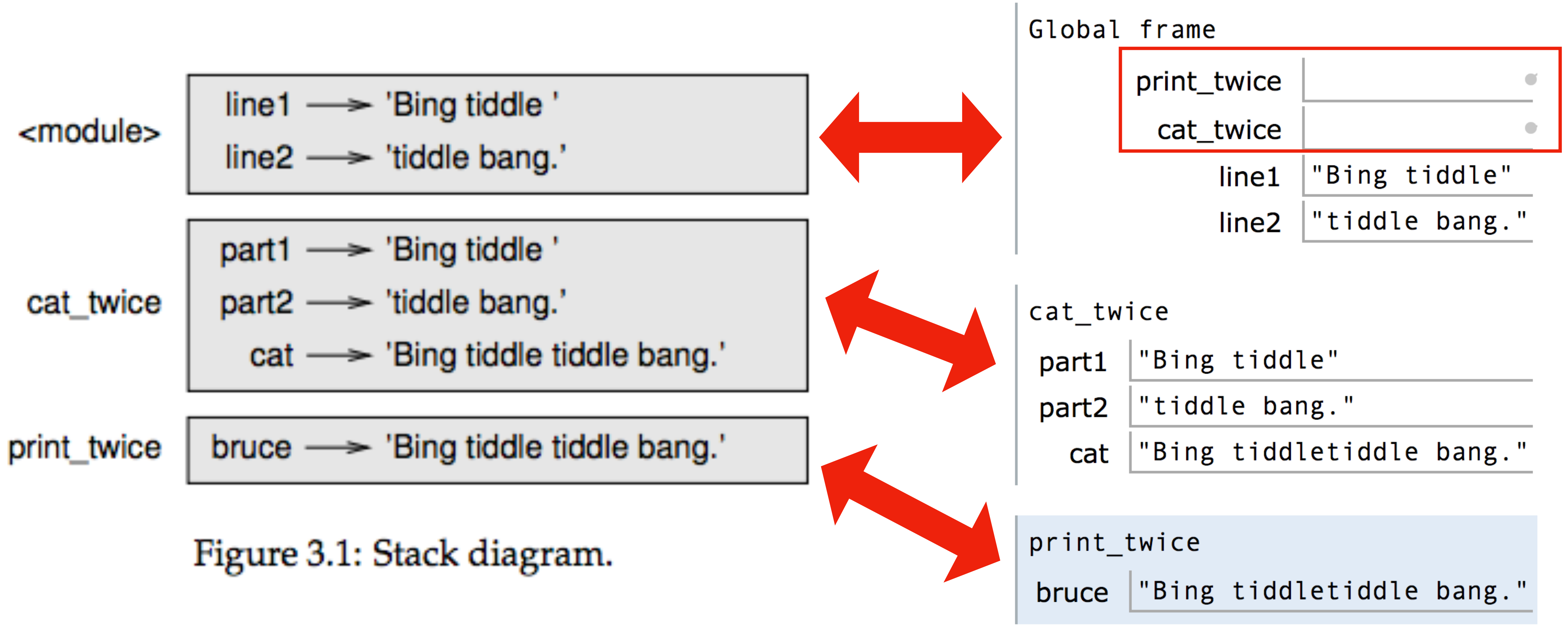
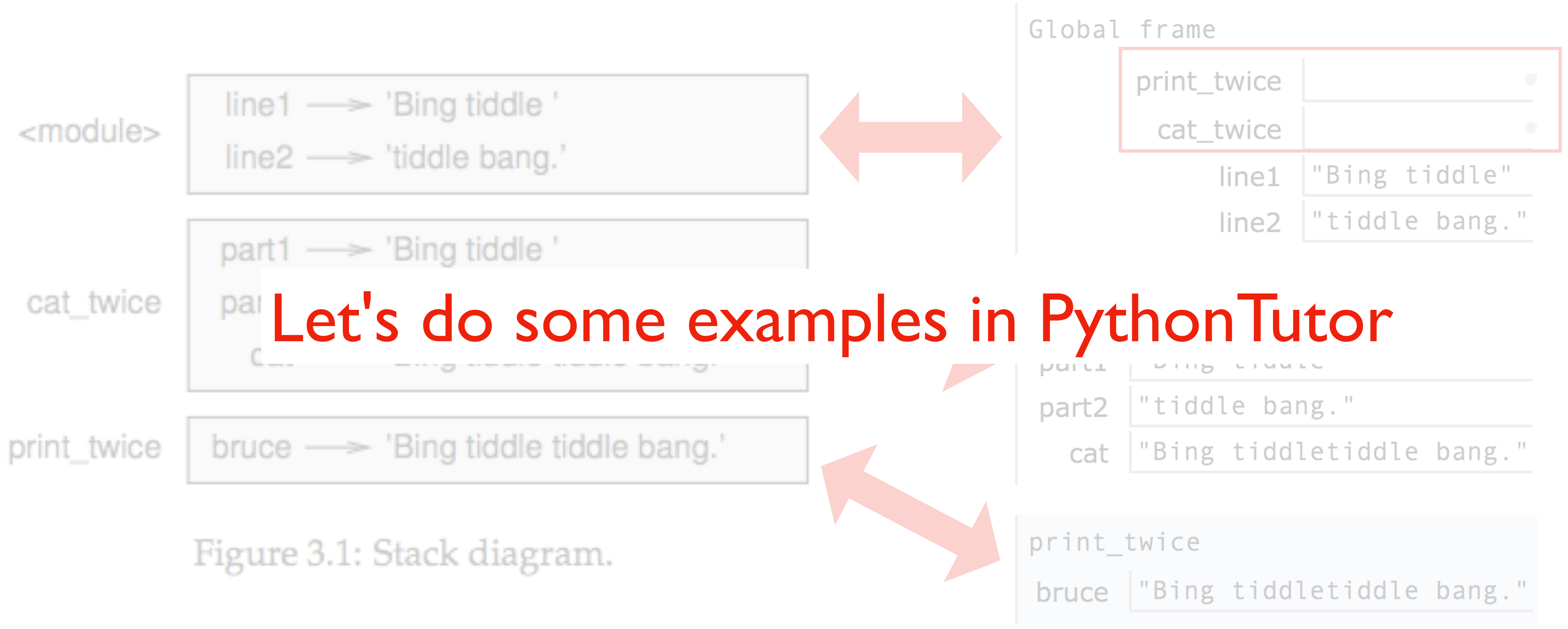


Figure 3.1: Stack diagram.

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

```
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

```
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

```
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 global variable with the same name

Lessons about Global Variables

```
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

```
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