University of Sheffield

COM1001 *Introduction to Software Engineering* SPRING SEMESTER

Debugging

Professor Phil McMinn

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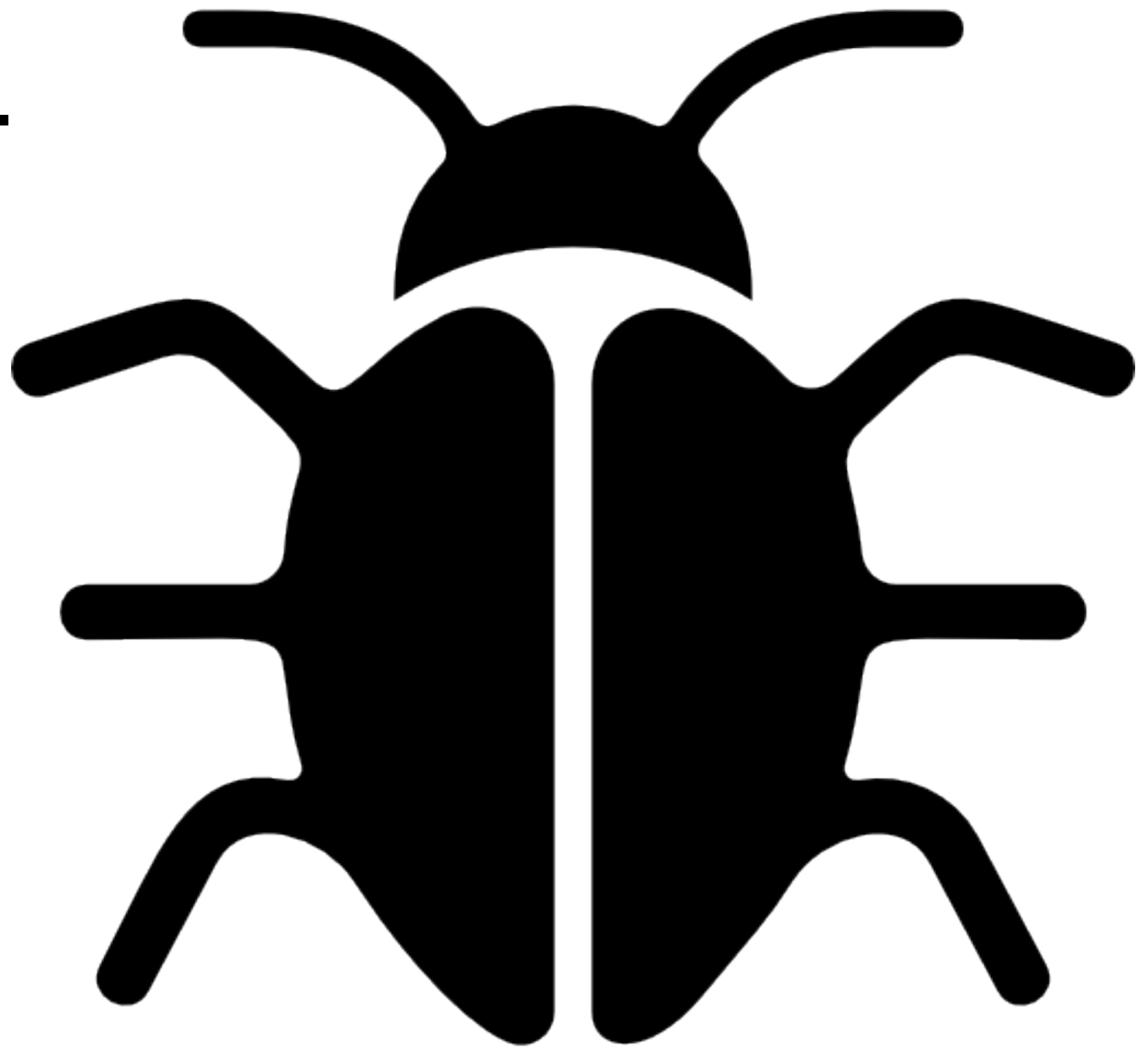
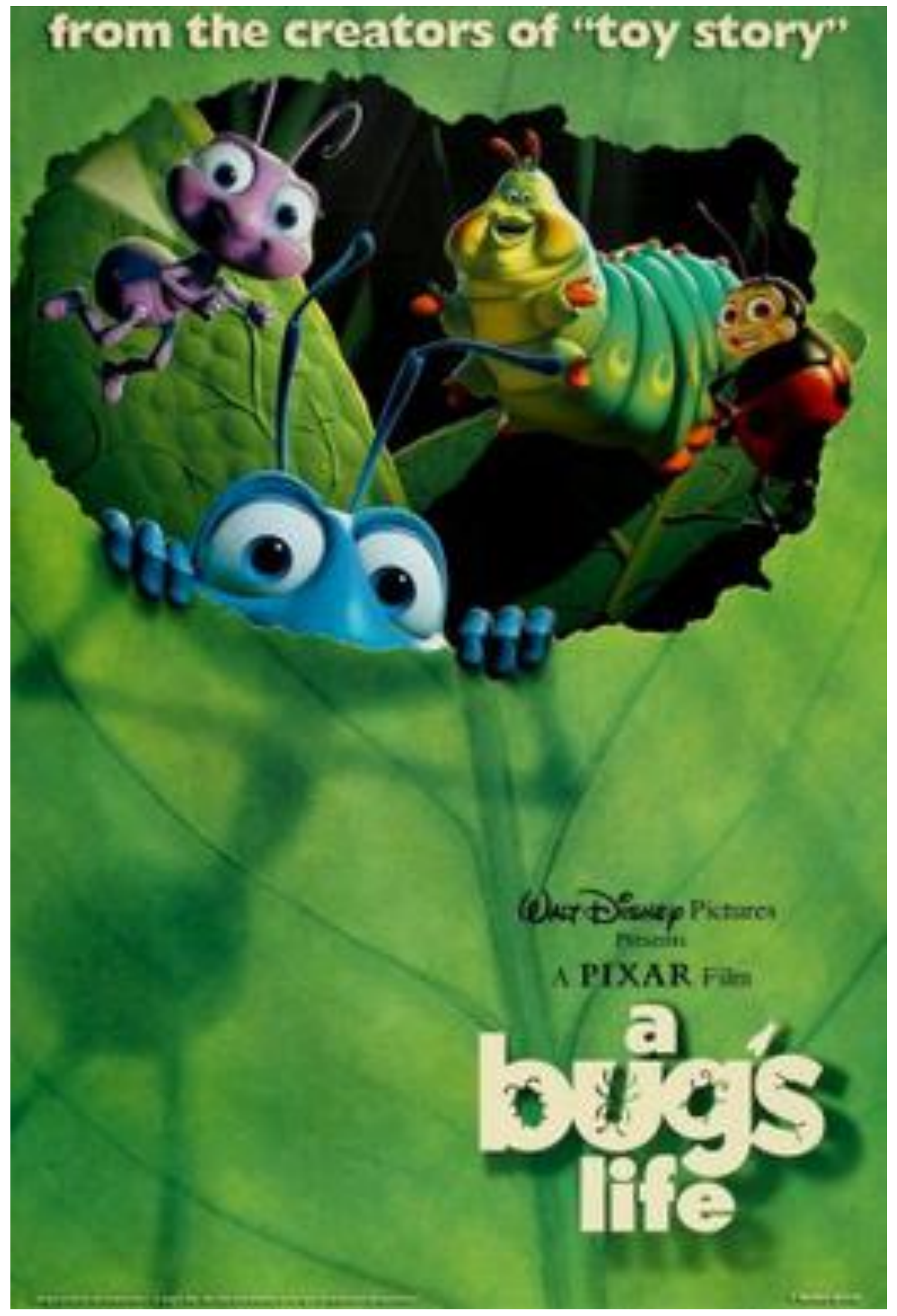


A Bug’s Life


from the creators of "toy story"
Walt Disney Pictures presents
A PIXAR Film
a bug's life

You’ve probably already learned to live with bugs.

You may even think that bugs are unavoidable
when it comes to software.

But as Computer Scientists and Software Engineers, we know that bugs do not creep out of “Mother Nature” and into programs.

At the beginning of any bug story stands a human who wrote the code in question…

I’m Writing a Method…

I want to find the index of the first character that differs between two strings, returning -1 if the strings are the same:

```ruby
def string_comparison(str1, str2)
  ...
end
```

But First, A Little Recap...

Strings in Ruby are a little bit like arrays of characters.

We can use array-like syntax to find out what character is at what position:

```
irb(main):001:0> str = "hello!"
=> "hello!"
irb(main):002:0> puts str[1]
e
```

0	1	2	3	4	5
h	e	l	l	o	!

```
irb(main):003:0> puts str[2]
l
```

0	1	2	3	4	5
h	e	l	l	o	!

If we try to index a character that does not exist, Ruby returns `nil`. "`nil`" is Ruby's way of saying "nothing". It's similar to `null` in Java.

```
irb(main):004:0> puts "is nil" if str[6].nil?
is nil
```

0	1	2	3	4	5	6	...
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Back to my method...

I want to find the index of the first character that differs between two strings, returning -1 if the strings are the same:

```ruby
def string_comparison(str1, str2)
  (1..[str1.length, str2.length].min).each do |i|
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debugging/string_comparison_buggy.rb

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If the loop terminates, my method hasn't found two different characters, otherwise it would have already have exited the method via the return statement in the loop body itself. So I return -1. Because it's the last line of the method doesn't require us to use the `return` keyword.

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Sometimes it works:

If I give it the arguments “`aardvark`” and “`aargh!`”, it gives me the answer **3**

Sometimes it doesn’t work:

If I give it the arguments “`sought`” and “`bought`”, it gives me the answer **-1**

Defects

My code contains a bug. Or more precisely, a **defect**.

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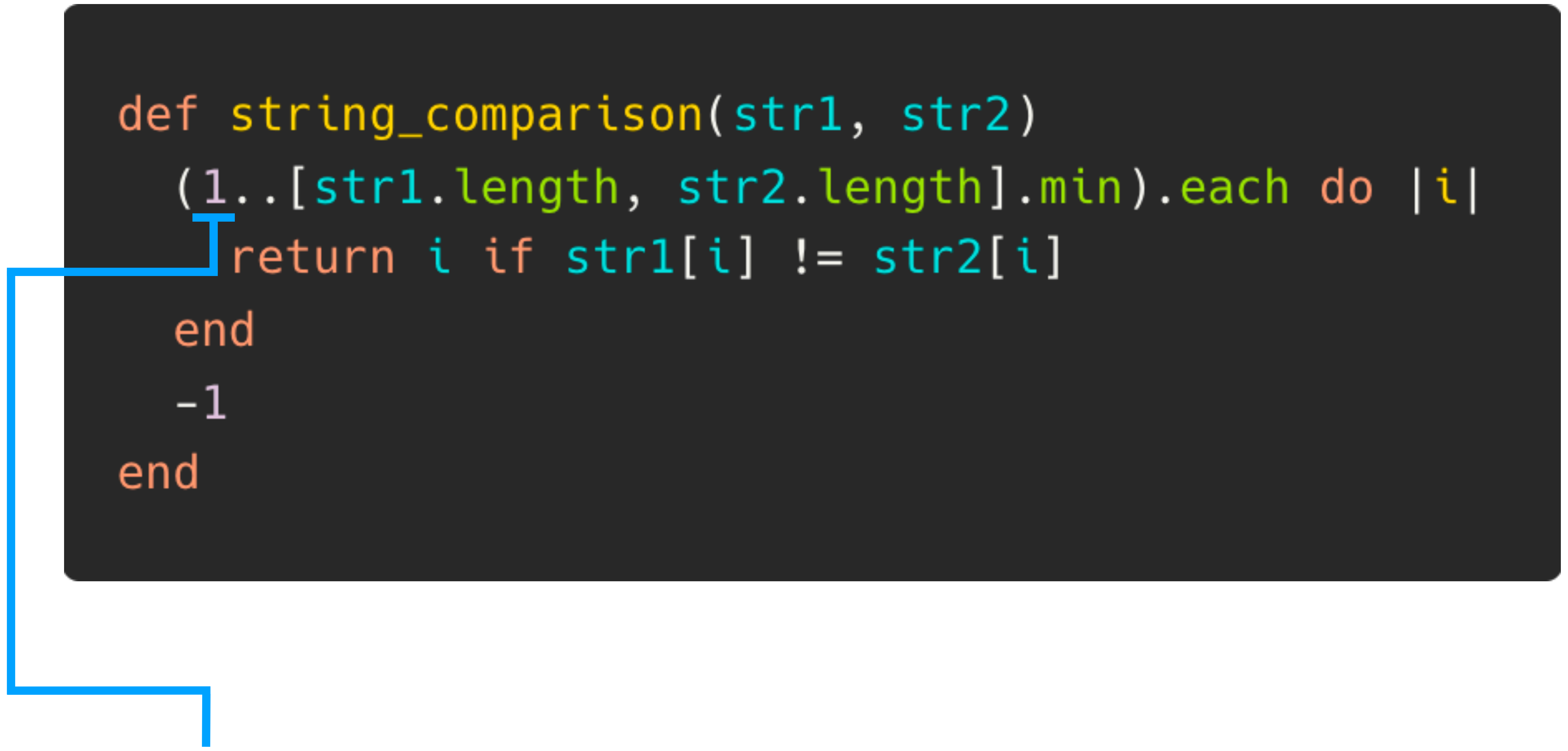

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Where is the **defect**?

How did it cause the method to fail?

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   The program, with the defect, is executed. The defect **infects** the intended state of the program.

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4. The infection causes a **failure**

   A failure is an externally observable error in the program’s behaviour.

Debugging Video

Debugging

Debugging is the process of tracing a **failure** back to the **defect** that caused it, and then fixing the defect.

We try to follow a failure backwards through the program, from the faulty output to the infected states of the program, to the program line(s) containing the defect that caused it.

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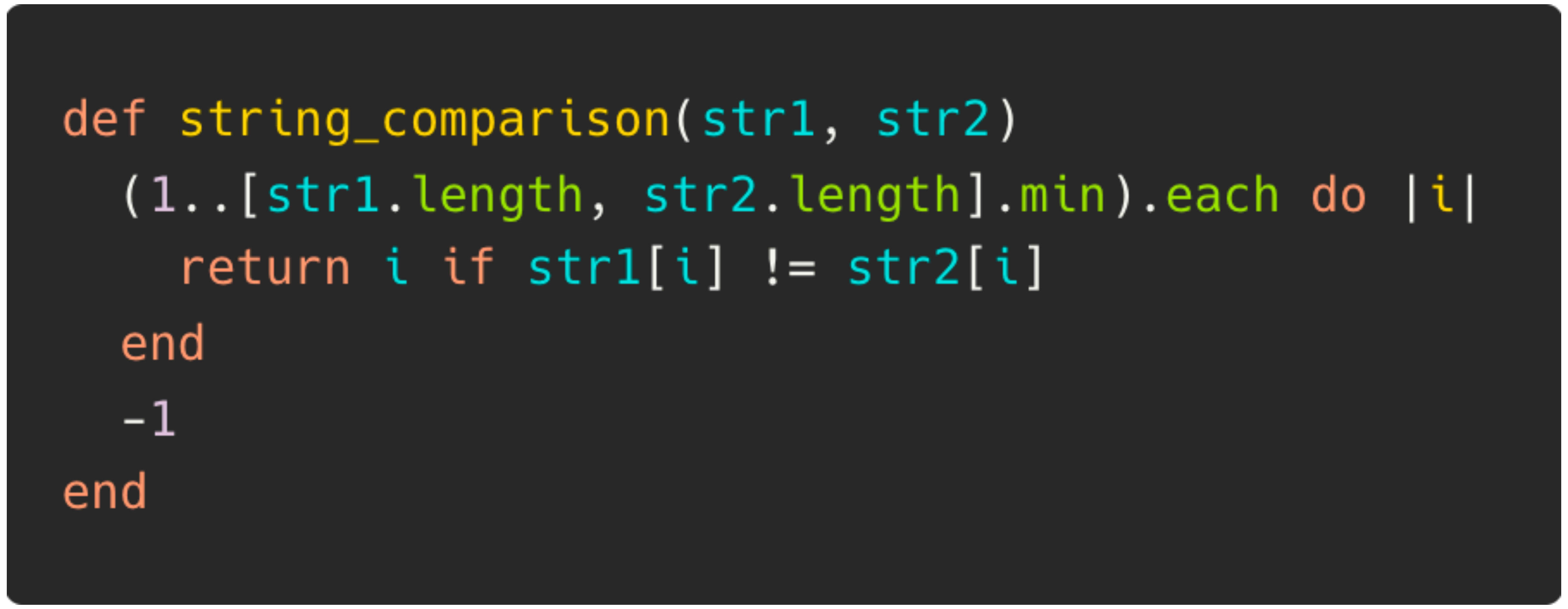
Debugging is mystery solving with a bit of time travel thrown in …

Step 1 – Reproduce the Failure

Easy in this case – we just give it the failing inputs again – “sought” and “bought”.

We call this failure-inducing inputs a **test case**.

Reproducing the failure is not always this easy.



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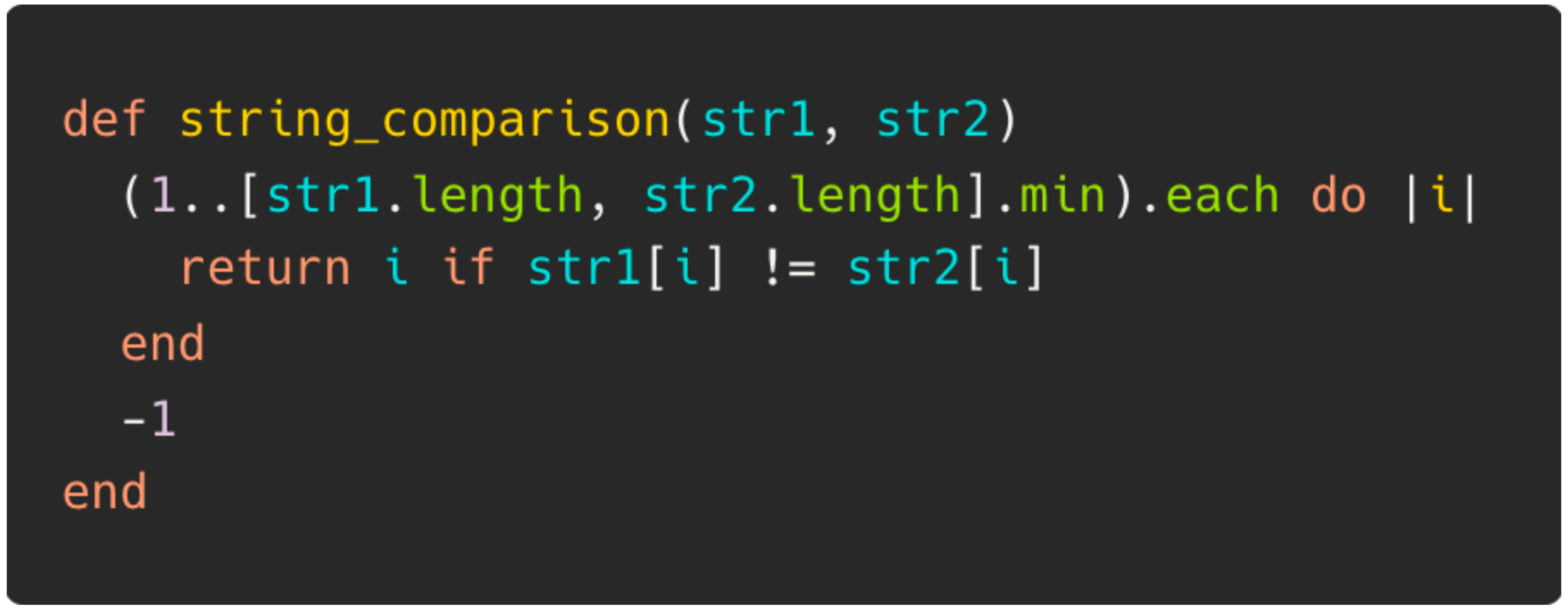
Step 2 – Simplify the Test Case

We can simplify “sought” and “bought” to “s” and “b” and we still get the wrong answer.



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Step 3 – Focus on the Likely Origins

We can do this by temporarily **instrumenting** the program code.

```ruby
def string_comparison(str1, str2)
  (1..[str1.length, str2.length].min).each do |i|
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debugging/string_comparison_buggy_instrumented.rb

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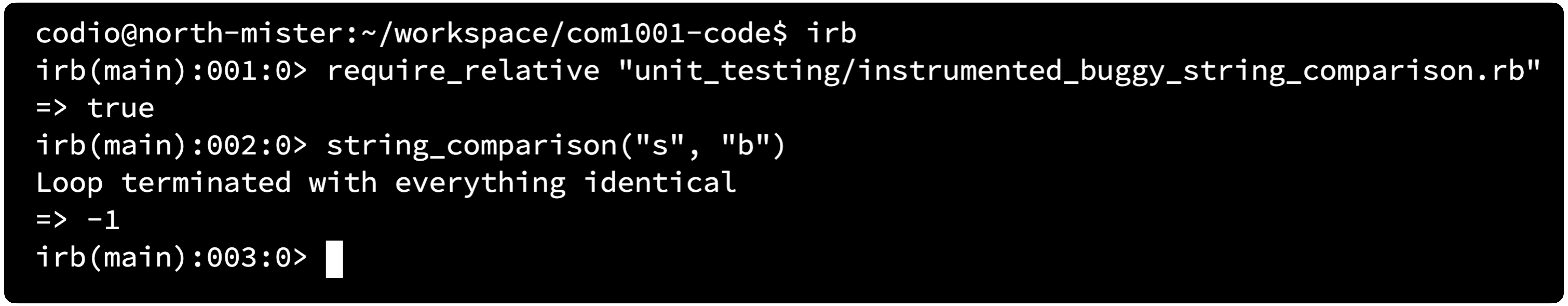
By printing out the values of variables we can **watch** them to see if they become **infected** with the wrong values

Step 4 – Understand How the Defect Came to Be



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irb(main):001:0> require_relative "unit_testing/instrumented_buggy_string_comparison.rb"
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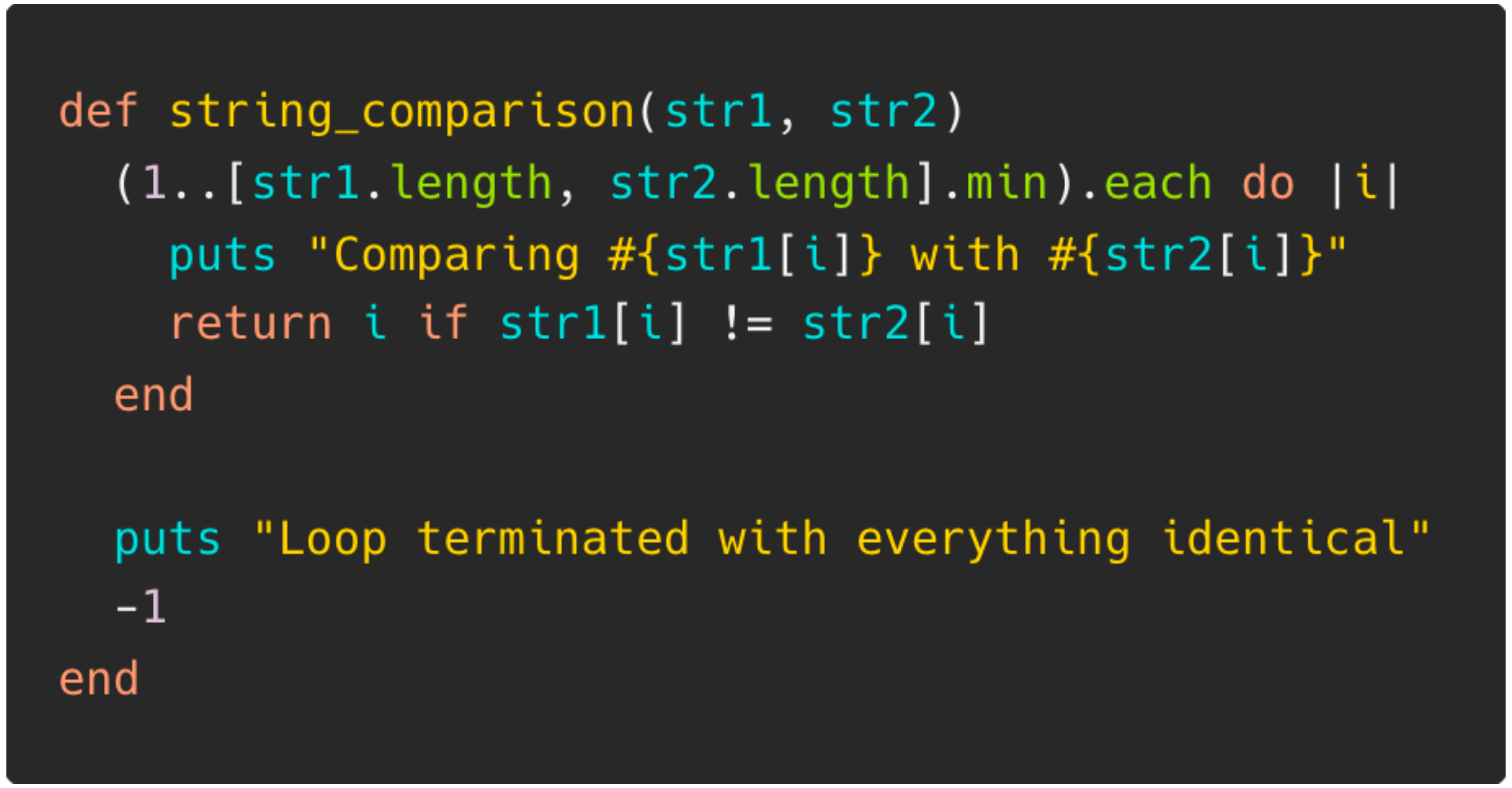

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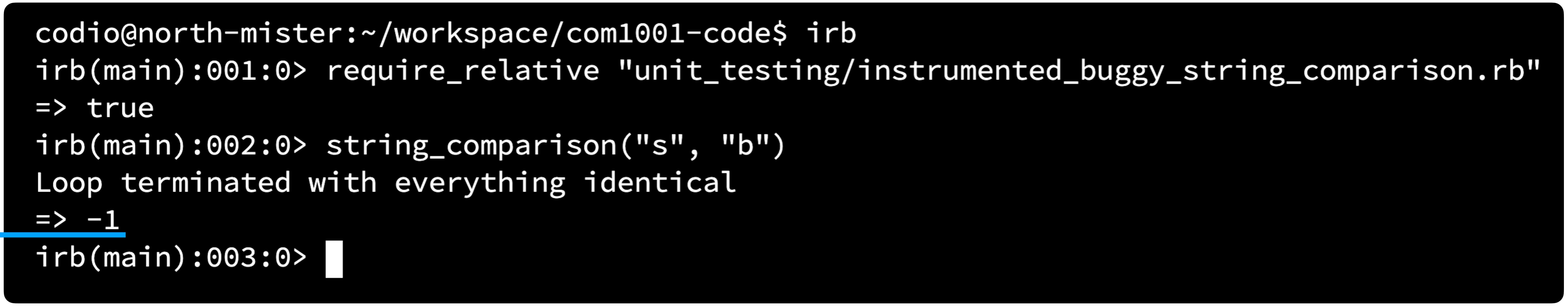

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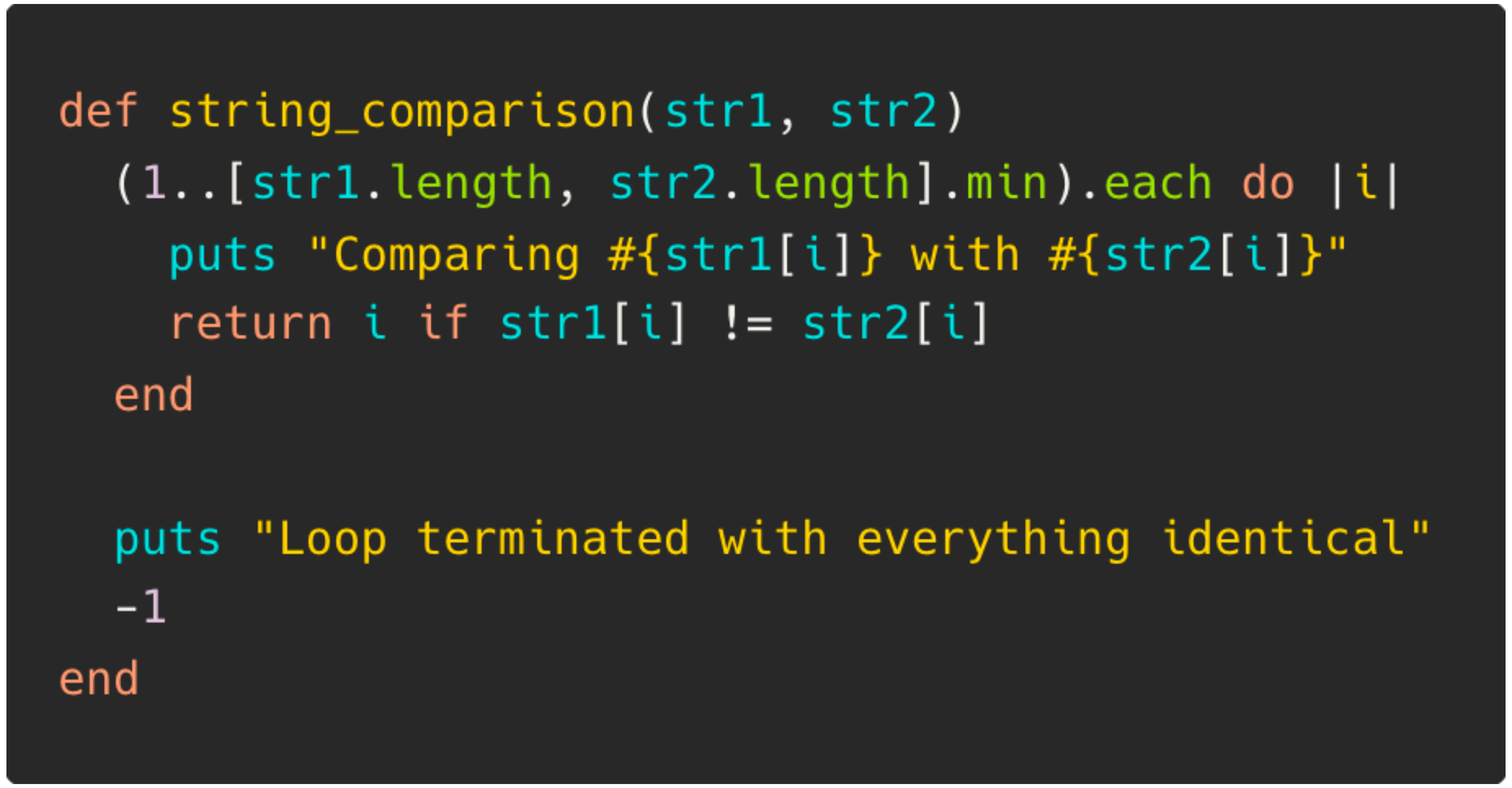

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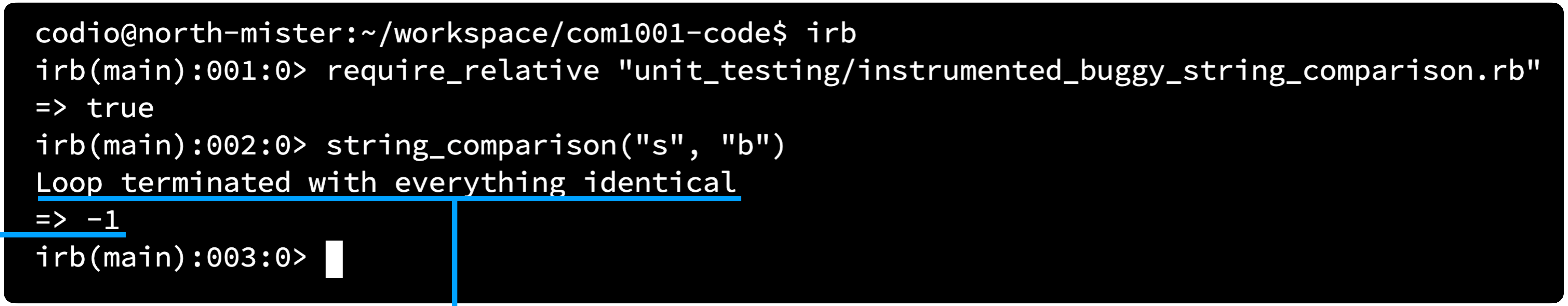

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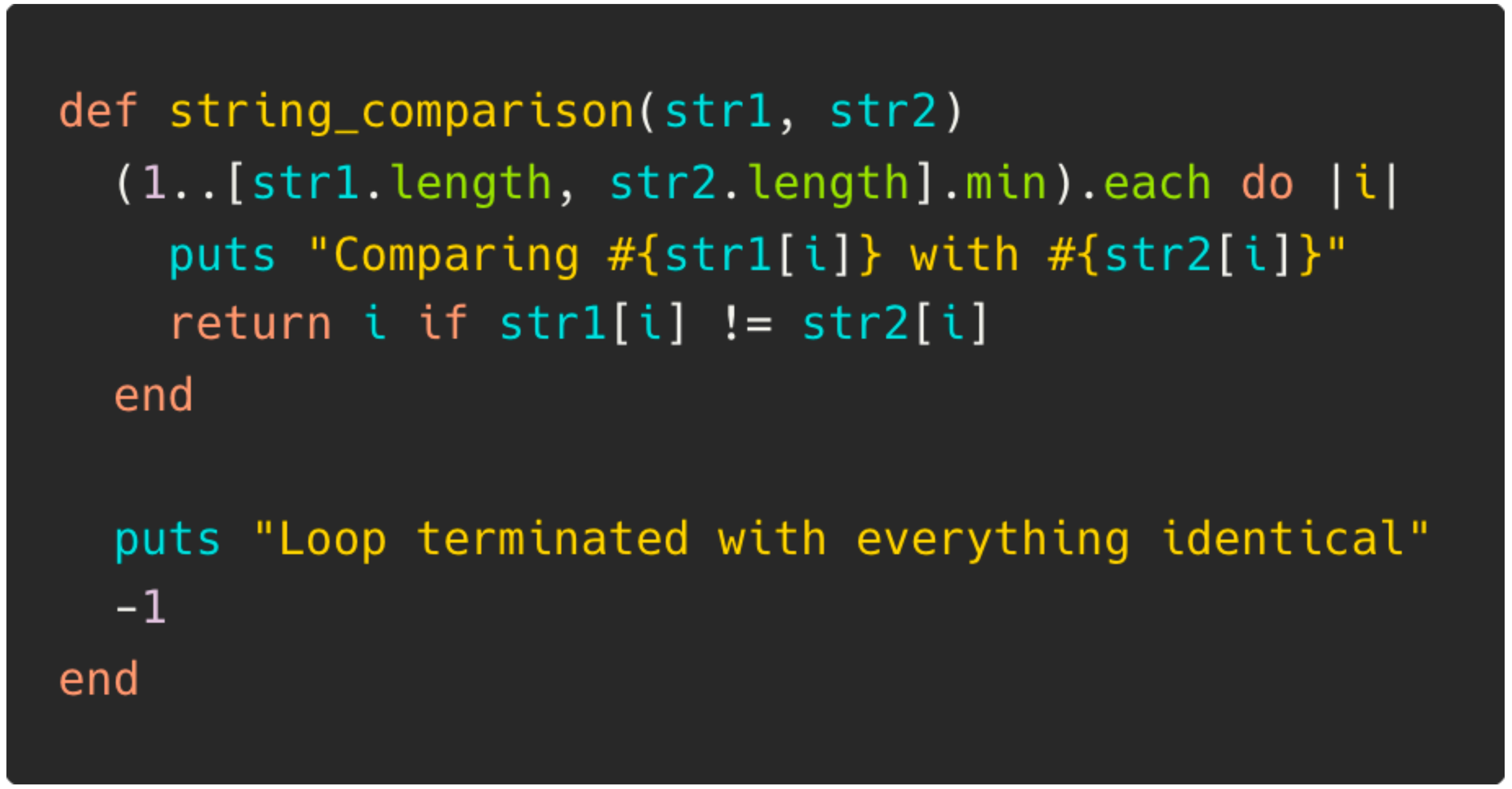

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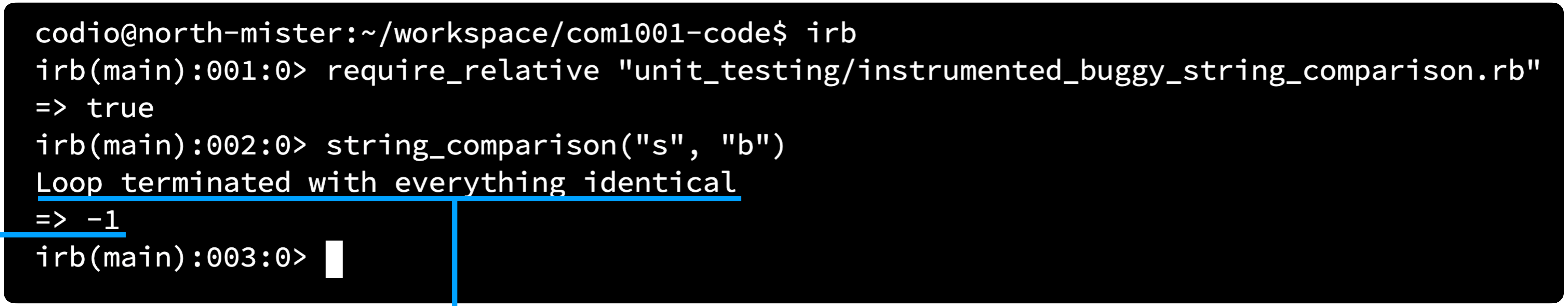

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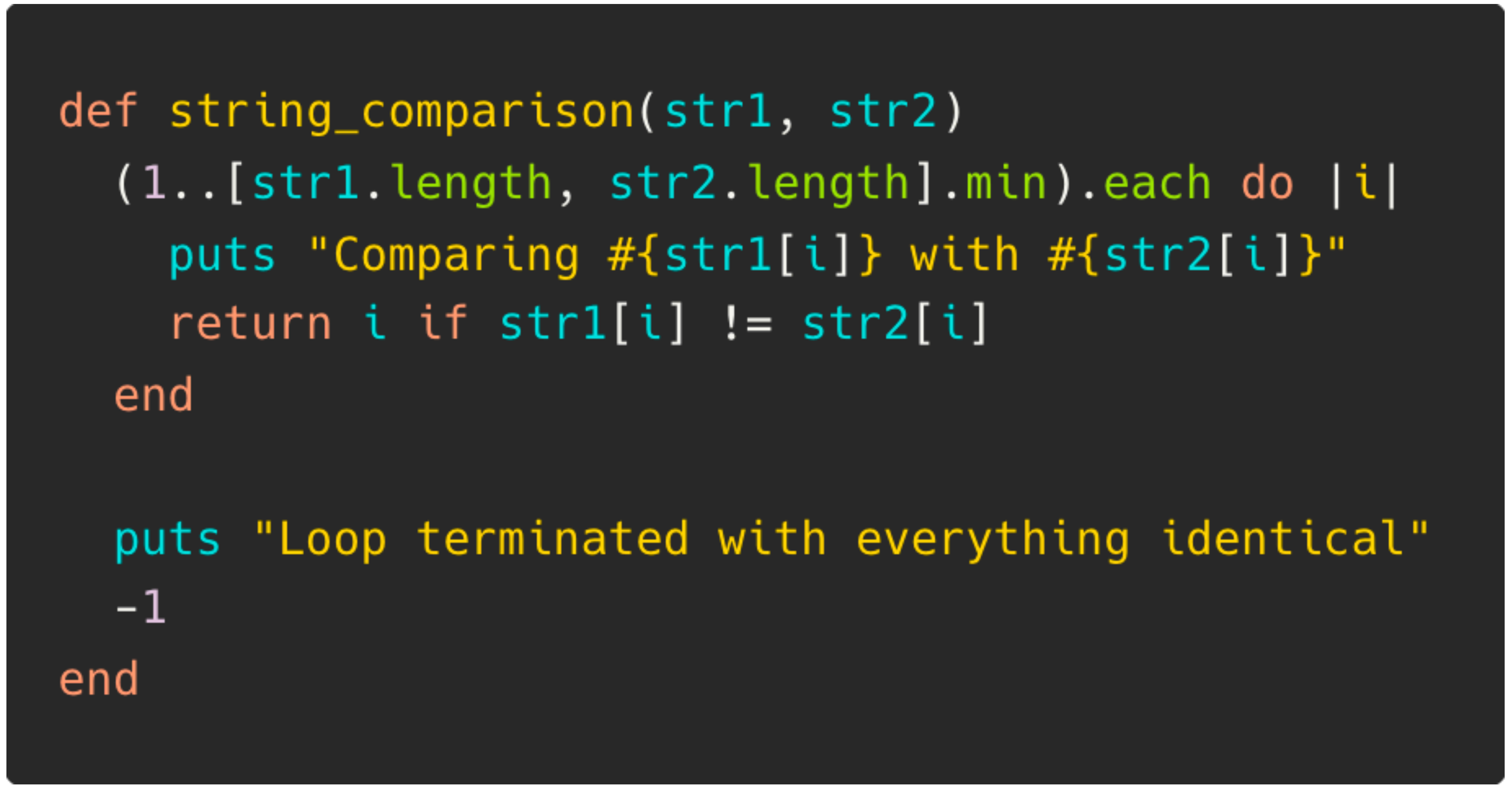
This is because the loop begins iterating from index 1, rather than 0. That is, the first character is not considered.



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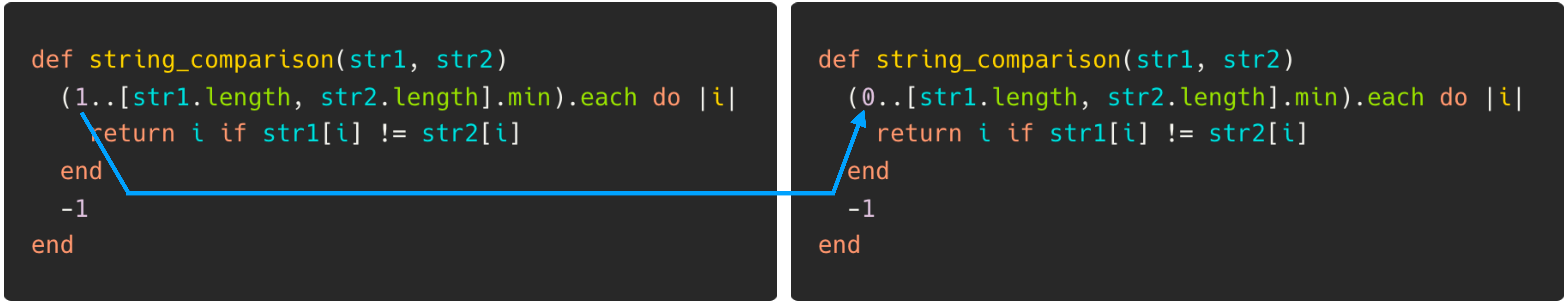

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