Little Tricky Logic:
Misconceptions in the Understanding of LTL

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VardiFest

RQ. In **what ways** is LTL tricky, and **what can we do** about it?

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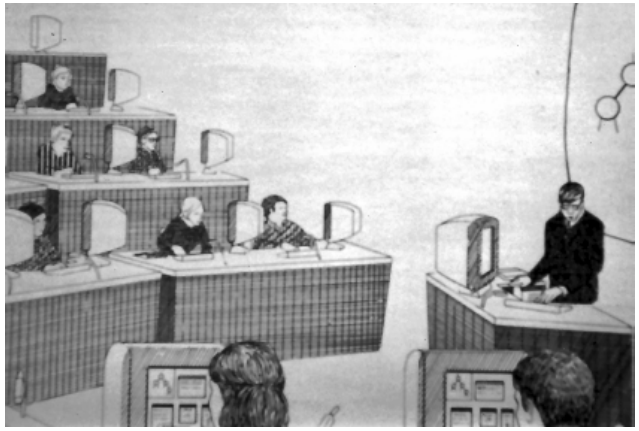
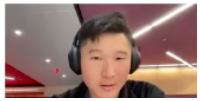
+2 years of studies with researchers and students





qualtrics

Quiz Time!

Part 1:

Formulas vs. Traces

Q. Do the traces below satisfy the formula?

`{eventually Red} and {eventually Green}`

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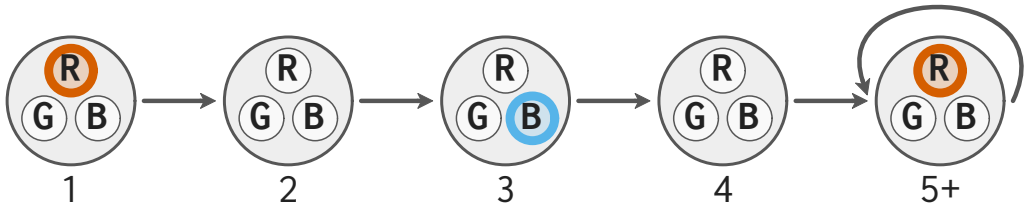

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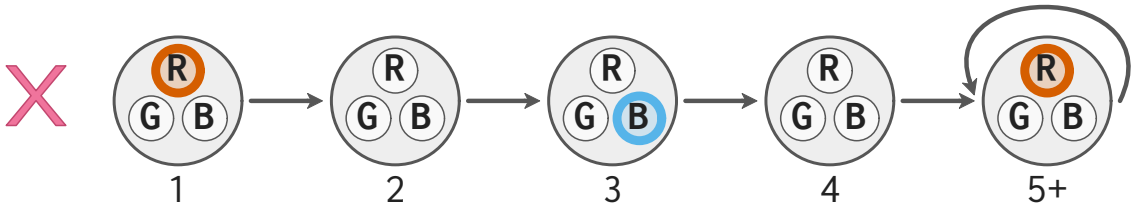

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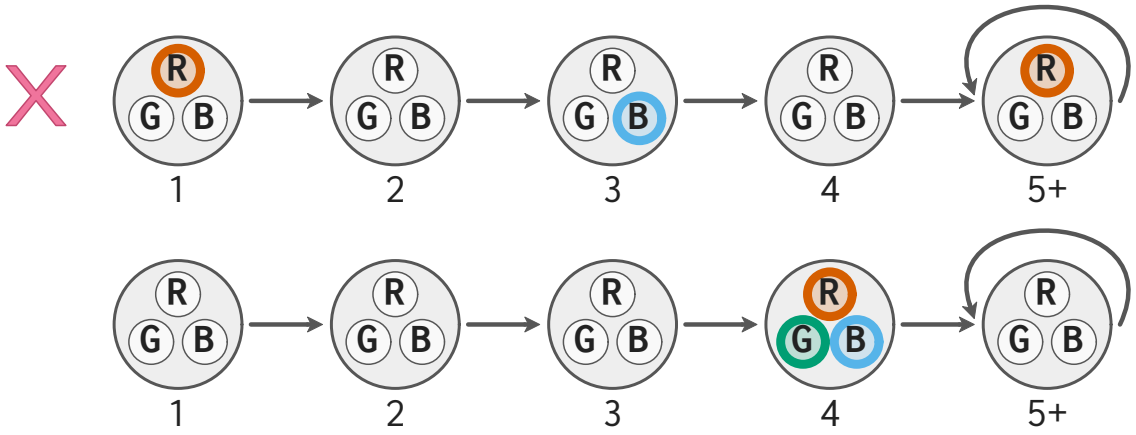

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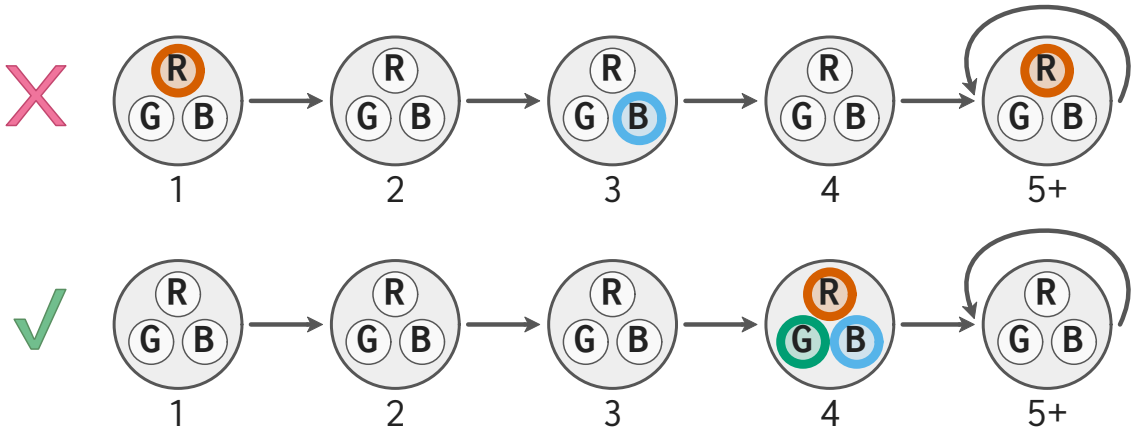

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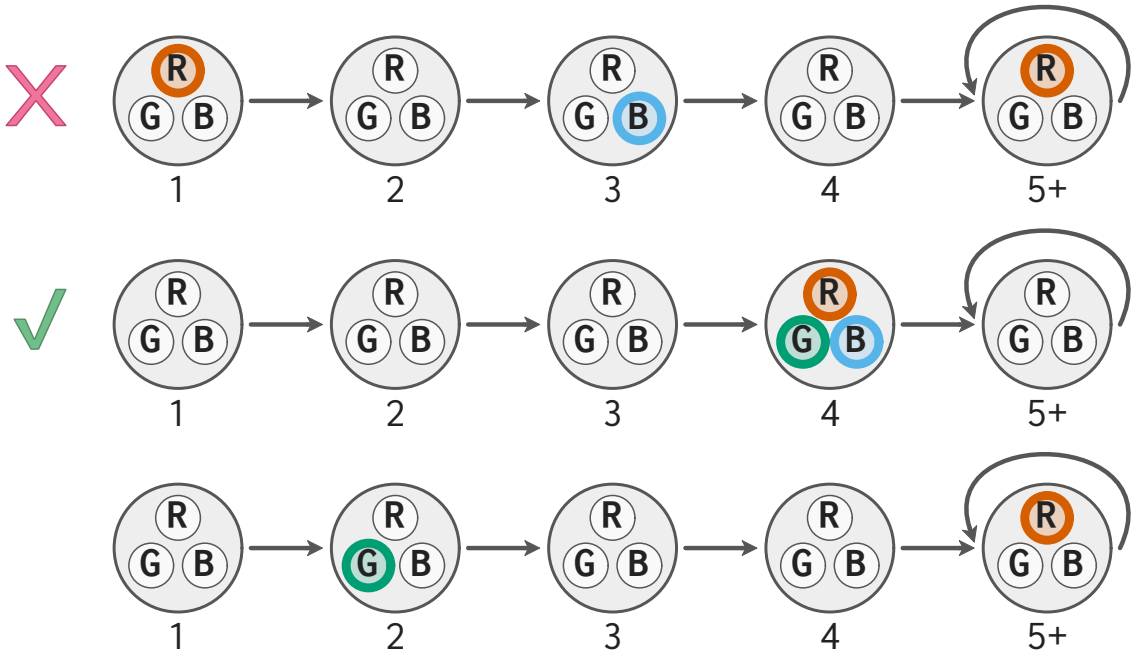

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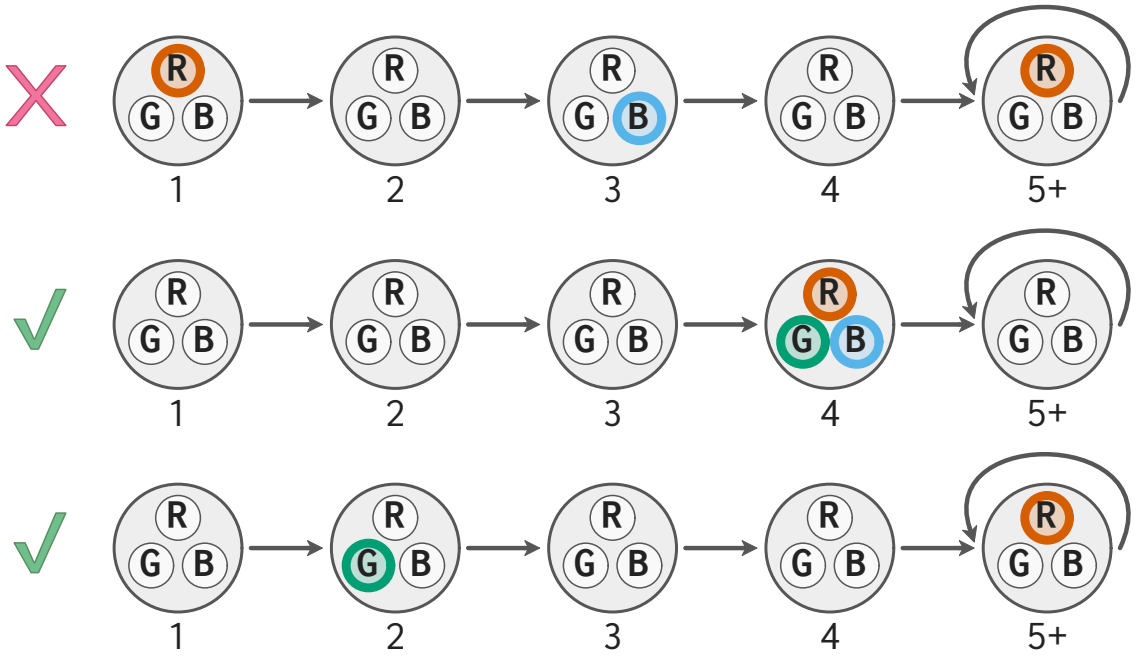

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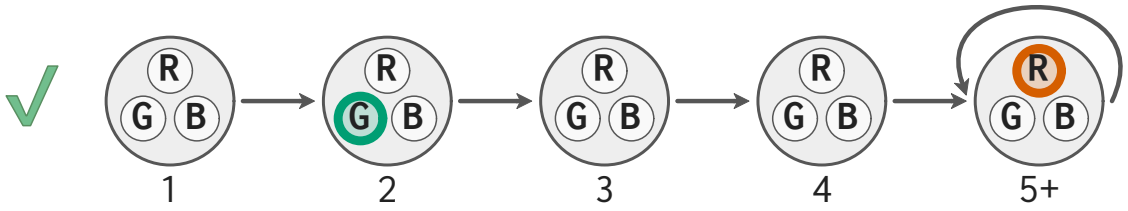
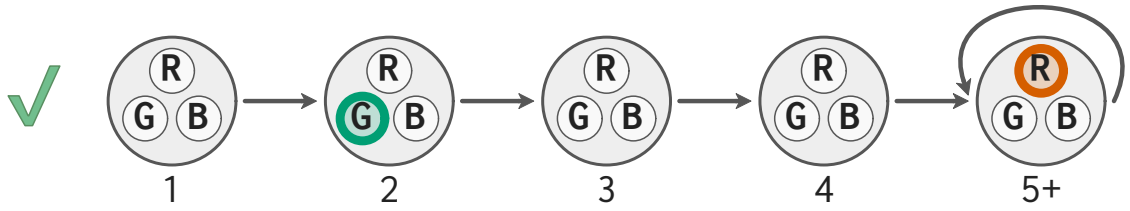


Q. Do the traces below satisfy the formula?

`{eventually Red} and {eventually Green}`

Not satisfied, because Green comes before Red

Bad `Prop` misconception



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Red

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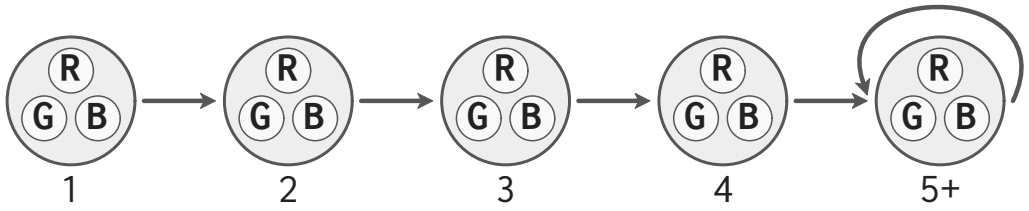

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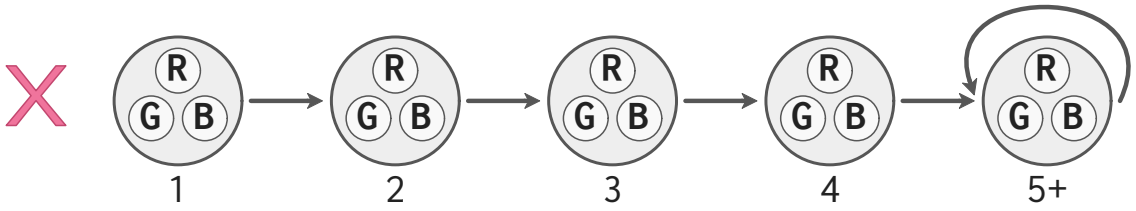

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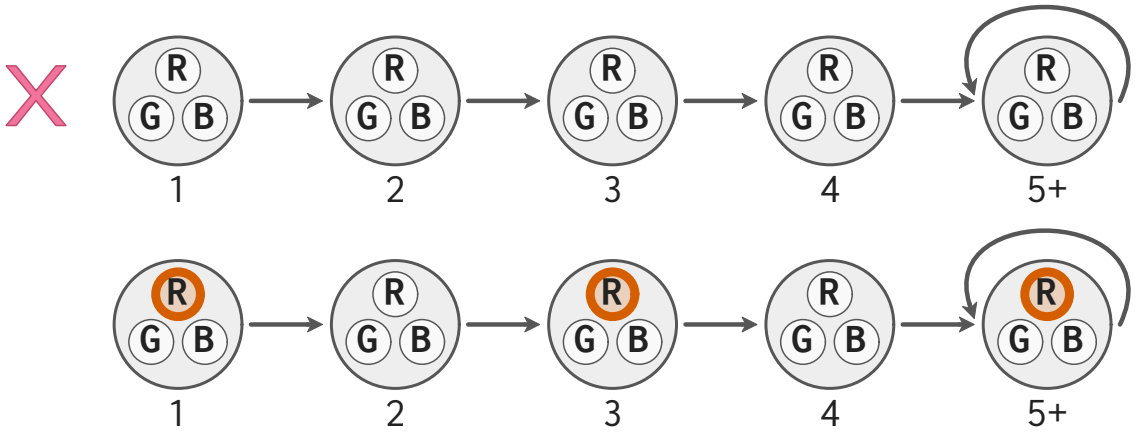

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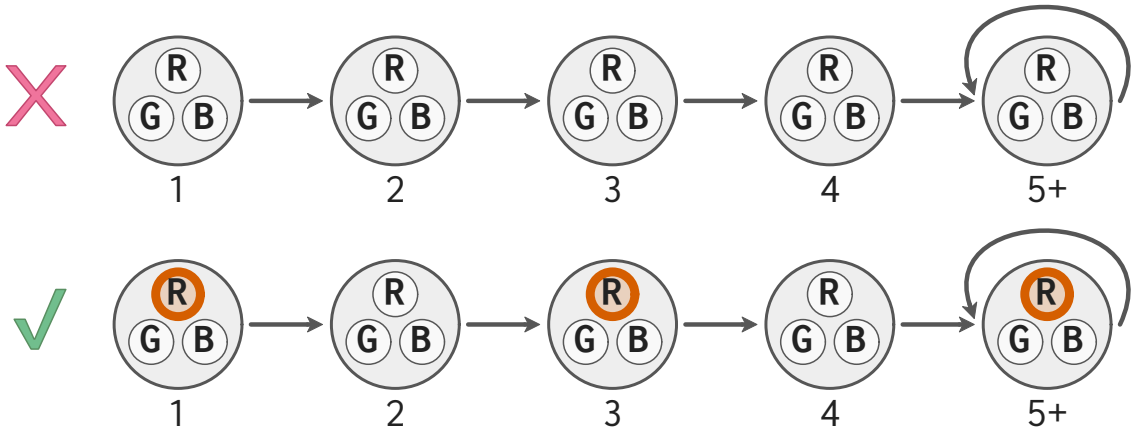

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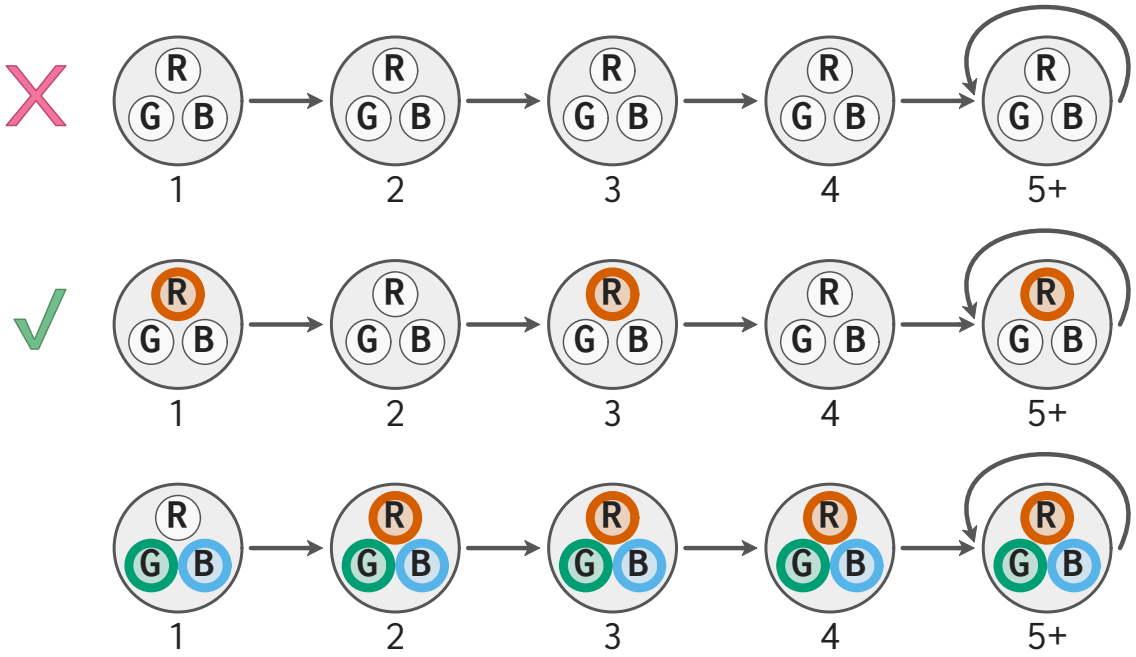

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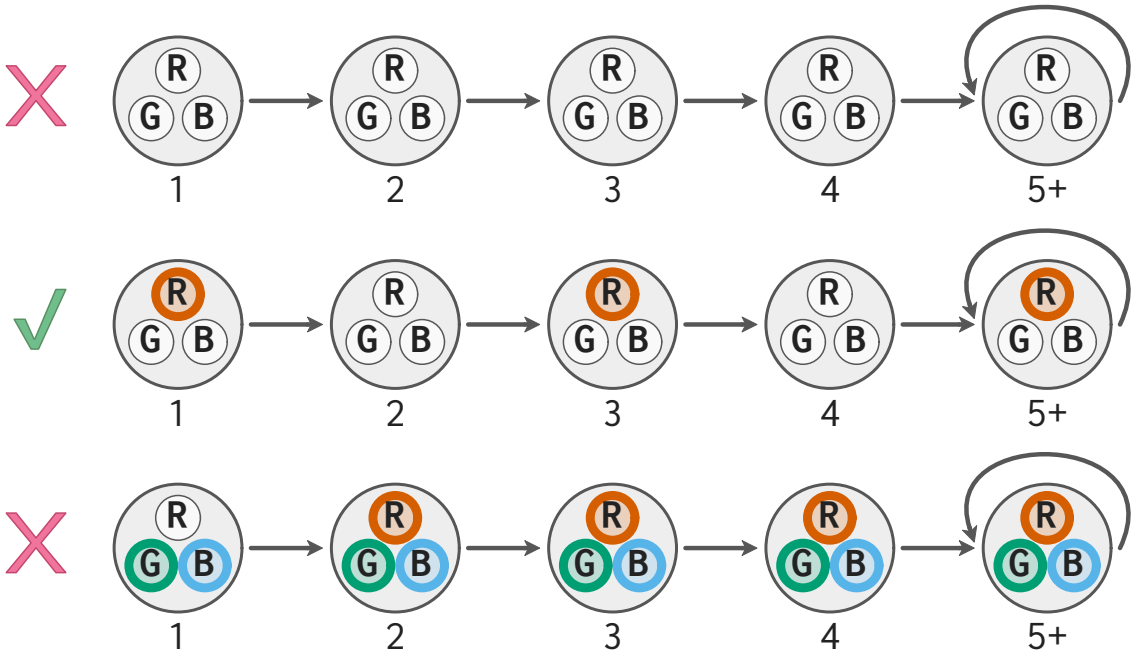

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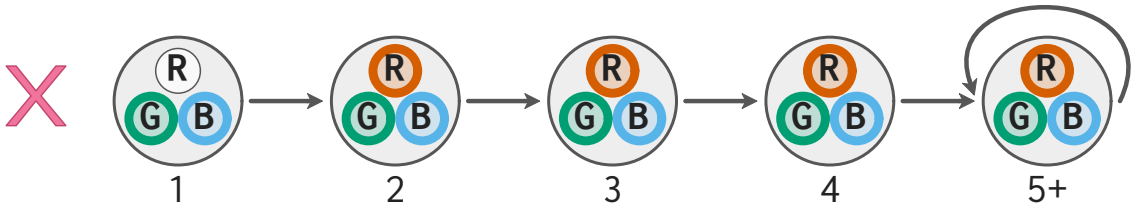
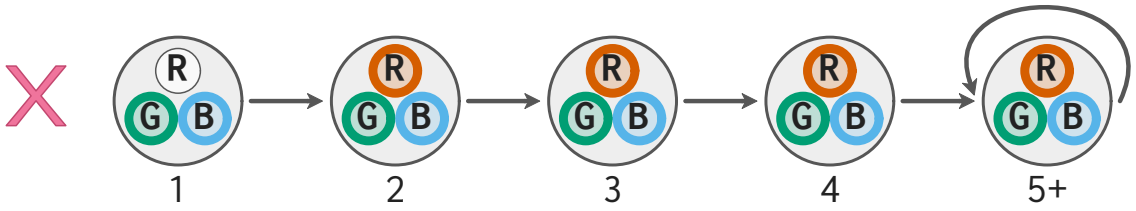


Q. Do the traces below satisfy the formula?

Red

Satisfied because Red is on at some point

`Implicit F` misconception



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`Red until Blue`

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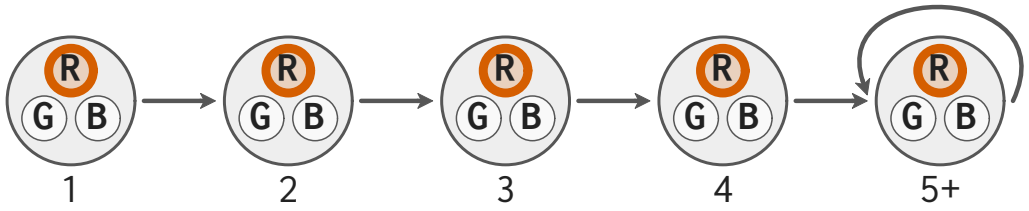

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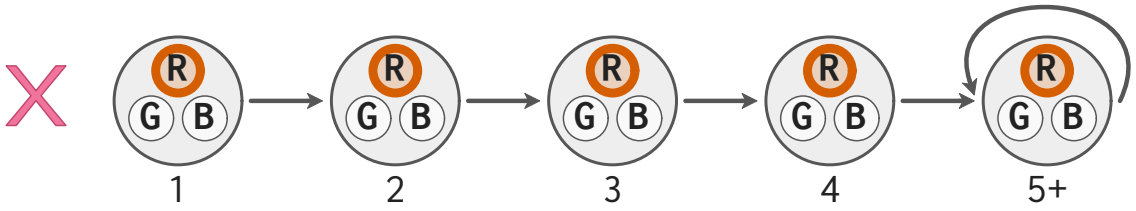

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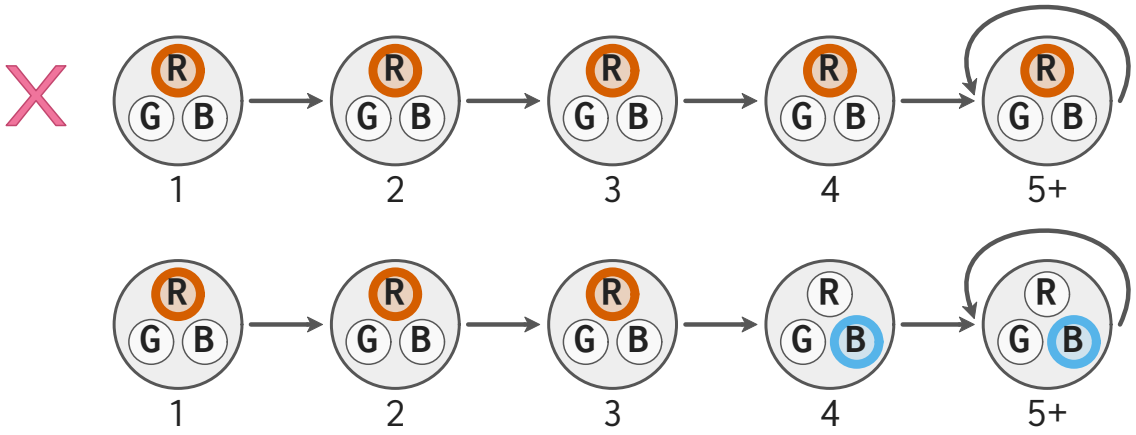

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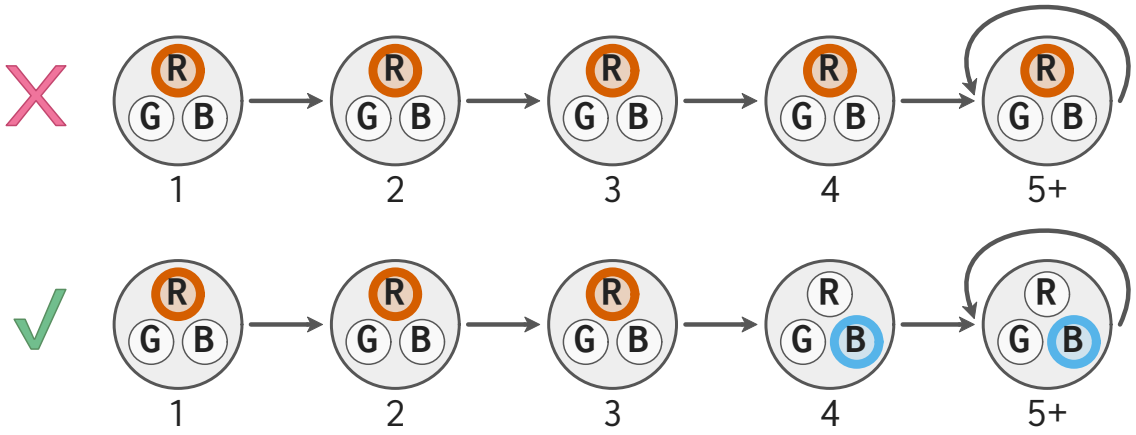

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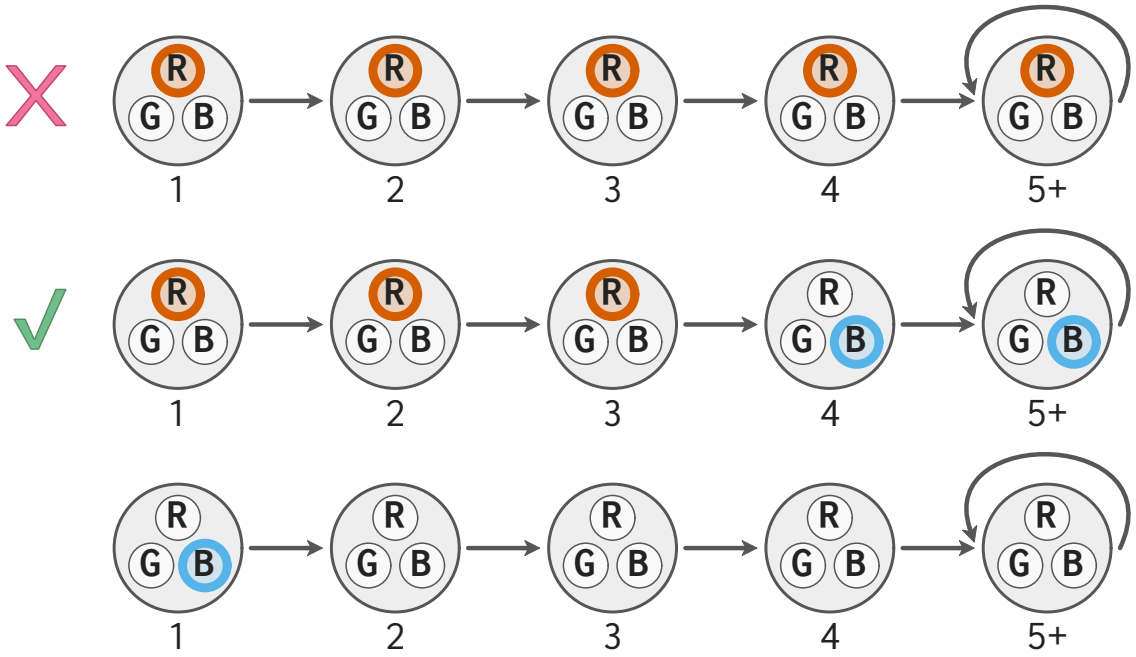

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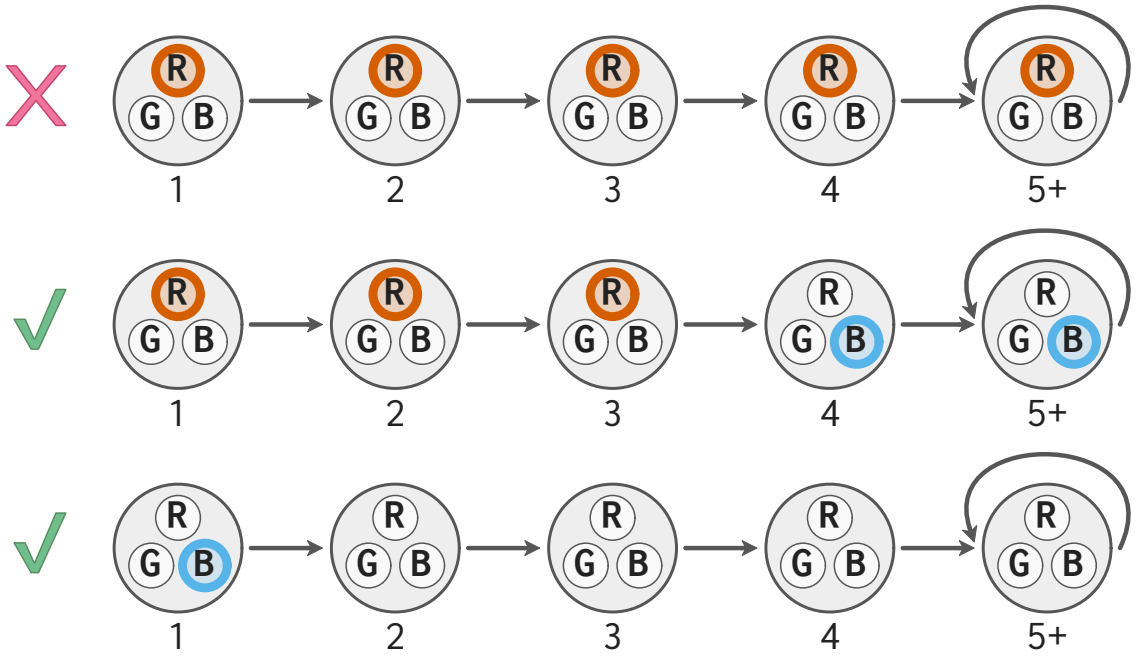

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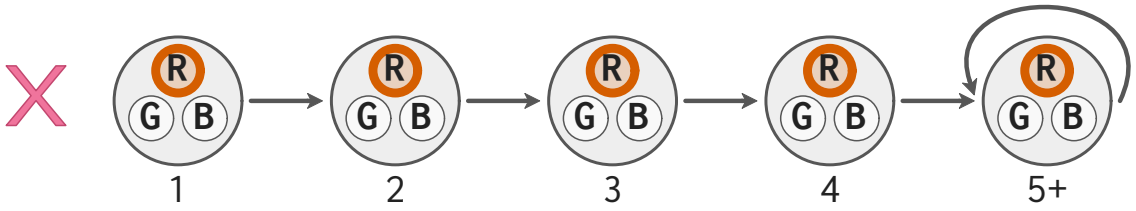

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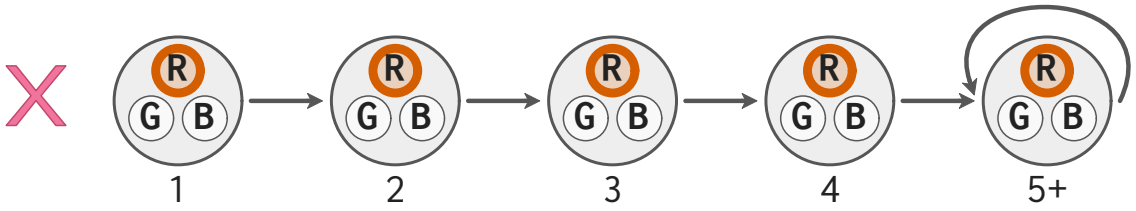

Satisfied because Blue may stay off

Even among researchers!

`Weak U` misconception

Part 2:

LTL to English

Q. Translate to English

{Red until Blue} and {always Red}

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{Red until Blue} and {always Red}

"Red is always on"

Q. Translate to English

{Red until Blue} and {always Red}

"Red is always on"

Q. Translate to English

{Red until Blue} and {always Red}

X "Red is always on"

"Red is always on and Blue is eventually on"

Q. Translate to English

{Red until Blue} and {always Red}

✗ "Red is always on"

✓ "Red is always on and Blue is eventually on"

Q. Translate to English

{Red until Blue} and {always Red}

✗ "Red is always on"

✓ "Red is always on and Blue is eventually on"

"This statement can never be satisfied"

Q. Translate to English

{Red until Blue} and {always Red}

✗ "Red is always on"

✓ "Red is always on and Blue is eventually on"

✗ "This statement can never be satisfied"

Q. Translate to English

{Red until Blue} and {always Red}

"This statement can never be satisfied"

Q. Translate to English

{Red until Blue} and {always Red}

When Blue turns on, Red **must** be off

`Exclusive U` misconception

"This statement can never be satisfied"

Q. Translate to English

{eventually Red} implies {always Blue}

Q. Translate to English

`{eventually Red} implies {always Blue}`

"if Red is ever on, then Blue is always on"

Q. Translate to English

`{eventually Red} implies {always Blue}`

✓ "if Red is ever on, then Blue is always on"

Q. Translate to English

`{eventually Red} implies {always Blue}`

✓ "if Red is ever on, then Blue is always on"

"Red is on at some point, after which Blue is on"

Q. Translate to English

`{eventually Red} implies {always Blue}`

✓ "if Red is ever on, then Blue is always on"

✗ "Red is on at some point, after which Blue is on"

Q. Translate to English

`{eventually Red} implies {always Blue}`

✗ "Red is on at some point, after which Blue is on"

Q. Translate to English

`{eventually Red} implies {always Blue}`

Red **will** turn on

`Bad Prop` misconception

"Red is on at some point, after which Blue is on"

Part 3:

English to LTL

Q. Translate to LTL

The Red light is on in exactly one state, but not necessarily the first state

Q. Translate to LTL

The Red light is on in exactly one state, but not necessarily the first state

Impossible!

Q. Translate to LTL

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`Impossible!`

Q. Translate to LTL

The Red light is on in exactly one state, but not necessarily the first state

```
Impossible!
```

```
{eventually Red} and {always {Red => always !Red}}
```

Q. Translate to LTL

The Red light is on in exactly one state, but not necessarily the first state

✗ `Impossible!`

✗ `{eventually Red} and {always {Red => always !Red}}`

Q. Translate to LTL

The Red light is on in exactly one state, but not necessarily the first state

✗ `Impossible!`

✗ `{eventually Red} and {always {Red => always !Red}}`

`{eventually Red} and {always {Red => after {always !Red}}}`

Q. Translate to LTL

The Red light is on in exactly one state, but not necessarily the first state

✗ `Impossible!`

✗ `{eventually Red} and {always {Red => always !Red}}`

✓ `{eventually Red} and {always {Red => after {always !Red}}}`

Q. Translate to LTL

The Red light is on in exactly one state, but not necessarily the first state

```
{eventually Red} and {always {Red => always !Red}}
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Q. Translate to LTL

The Red light is on in exactly one state, but not necessarily the first state

An implication constrains the **next state**

`Bad State Index` misconception

✗ `{eventually Red} and {always {Red => always !Red}}`

All Done!

Tricky?

Obvious?!

Expert Blind Spot?

Quiz Q's Based on 3 Instruments

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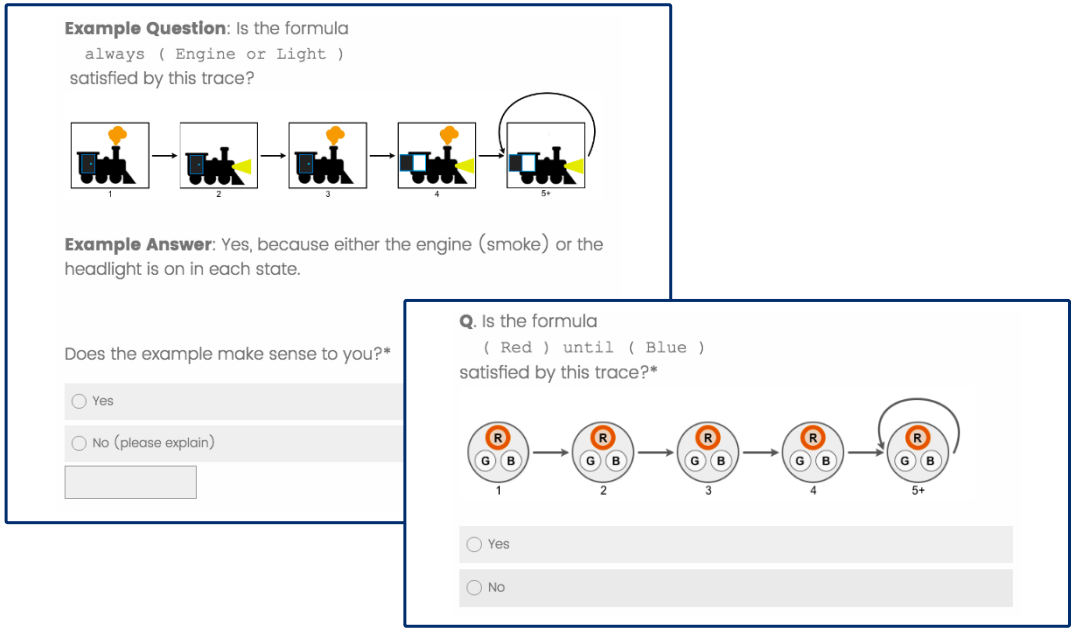
- LTL to English
- English to LTL
- Trace Satisfaction



Code Book for Analysis

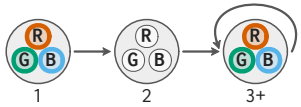
Code Book for Analysis

Bad Prop	Implicit F
Bad State Index	Implicit G
Bad State Quantification	Other Implicit
Exclusive U	Weak U

What Next?

What Next?

1. Teach Better



our instruments can help!

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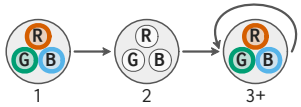

our instruments can help!

... but learners are everywhere
not just in classrooms

amazon Meta

NETFLIX

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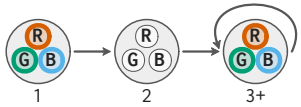

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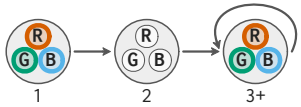

our instruments can help!

2. Build Tools

guard against misconceptions

What Next?

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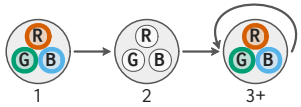

our instruments can help!

2. Build Tools

guard against misconceptions

3. Design Logics

Alloy 6 **Electrum**

our findings have inspired changes

Thank You!

benjamin.l.greenman@gmail.com