# Twisty Puzzles

Greg d'Eon
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or,

Rubik's Cubes Probably Seem Tough To Solve,

But They're Actually Not That Hard,

But People Are Still Really Good At Them

This Talk

2 ideas:

1. Rubik's cubes **aren't that hard** to solve
2. ...but people are still **really good** at them

A Brief History of Rubik's Cubes
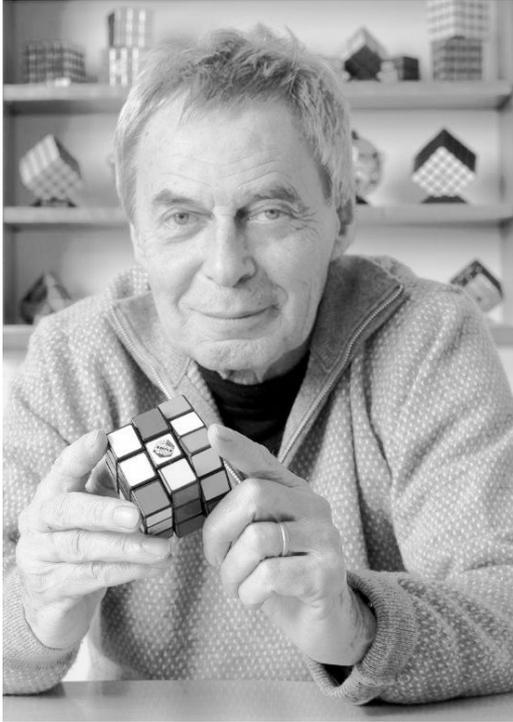
Solving Rubik's Cubes Isn't That Hard,
## But People Are Really Good At It

Really, It Isn't

"43 quintillion combinations!"
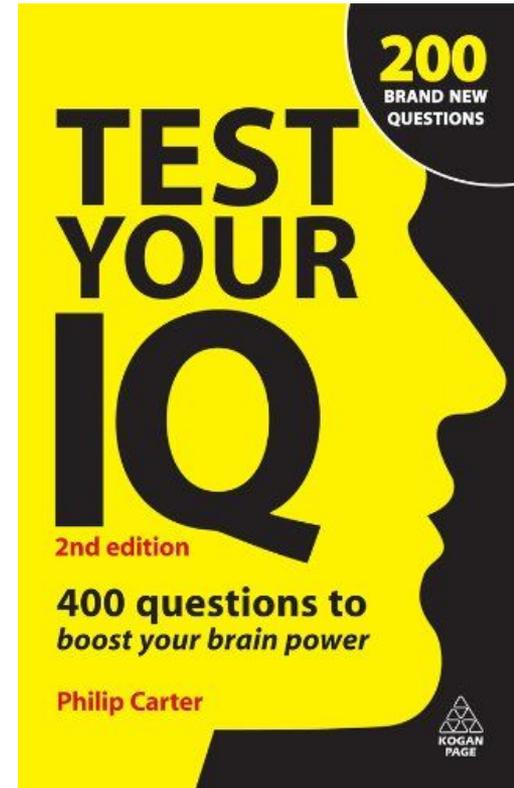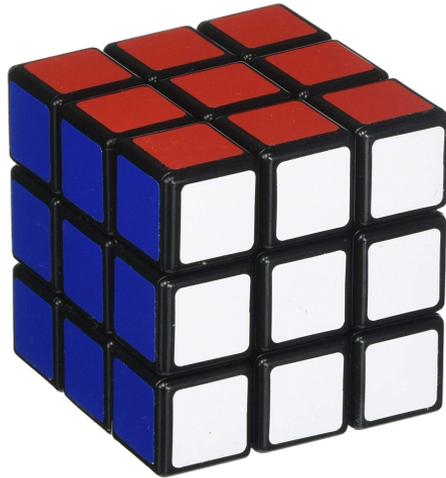
Really, It Isn't
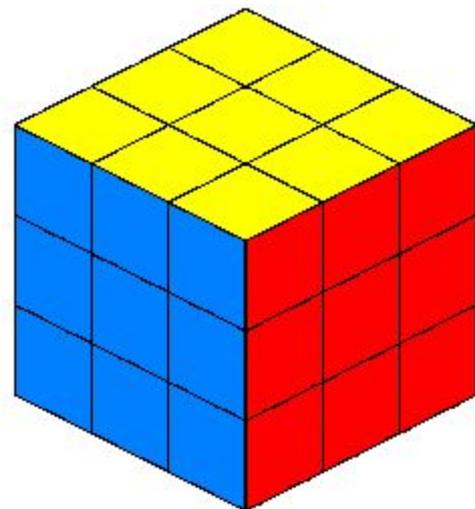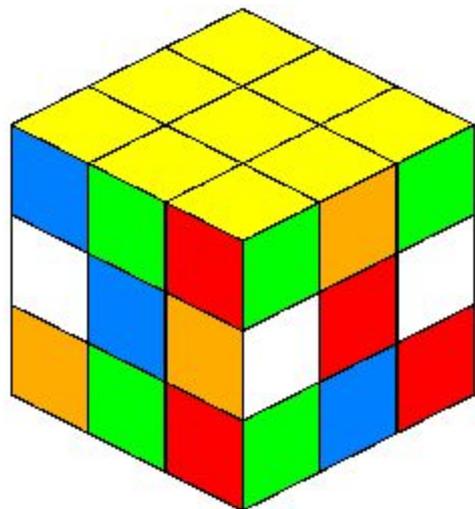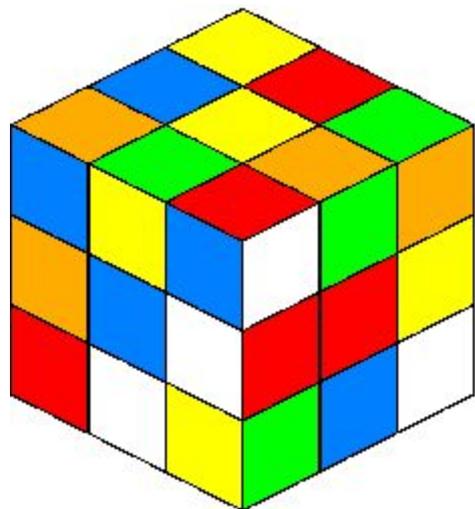
Rubik's Cubes for Beginners

Think **pieces**, not **stickers**

corner (3 colors)

edge (2 colors)

center (1 color)
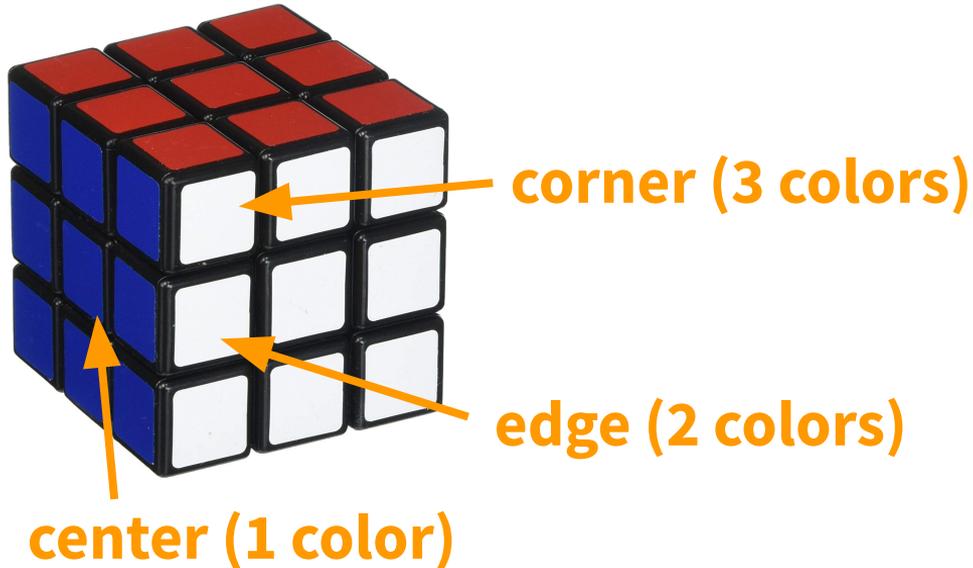
"Algorithms"

Just a sequence of moves

- **R**ight, **U**p, **F**ront, **L**eft, **D**own, **B**ack
- R (clockwise), R2 (180 degrees), R' (counter-clockwise)

Fast!

- F (R U' R' U') (R U R' F') (R U R' U') (R' F R F')

# Rubik's Cubes for Beginners
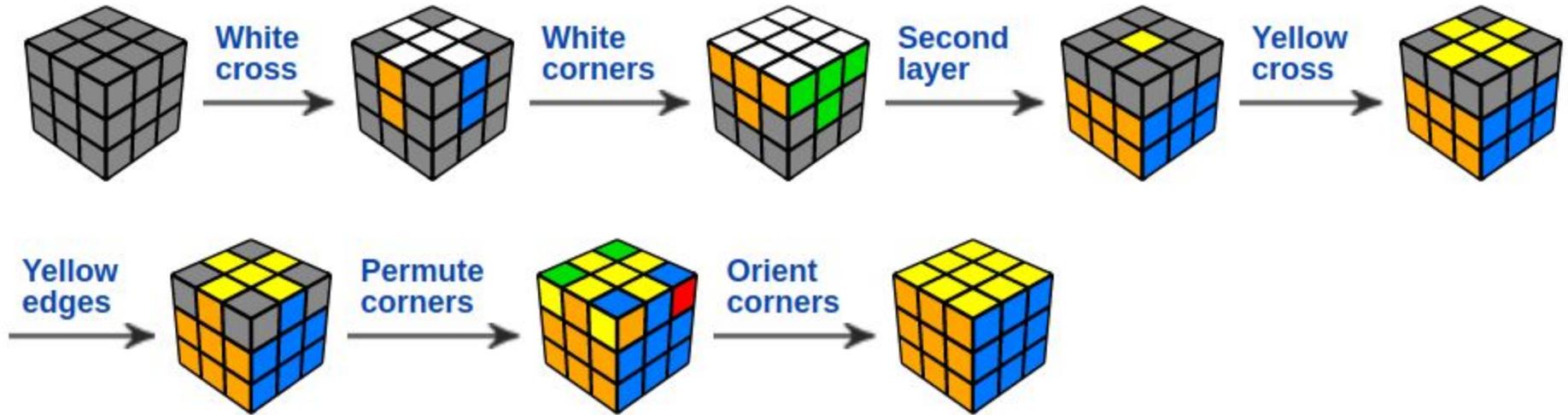
Step 1: White Cross

Easy: just try for a while

Step 2: White Corners

Pretty easy: a couple of tricks to help

- Example: R' D' R
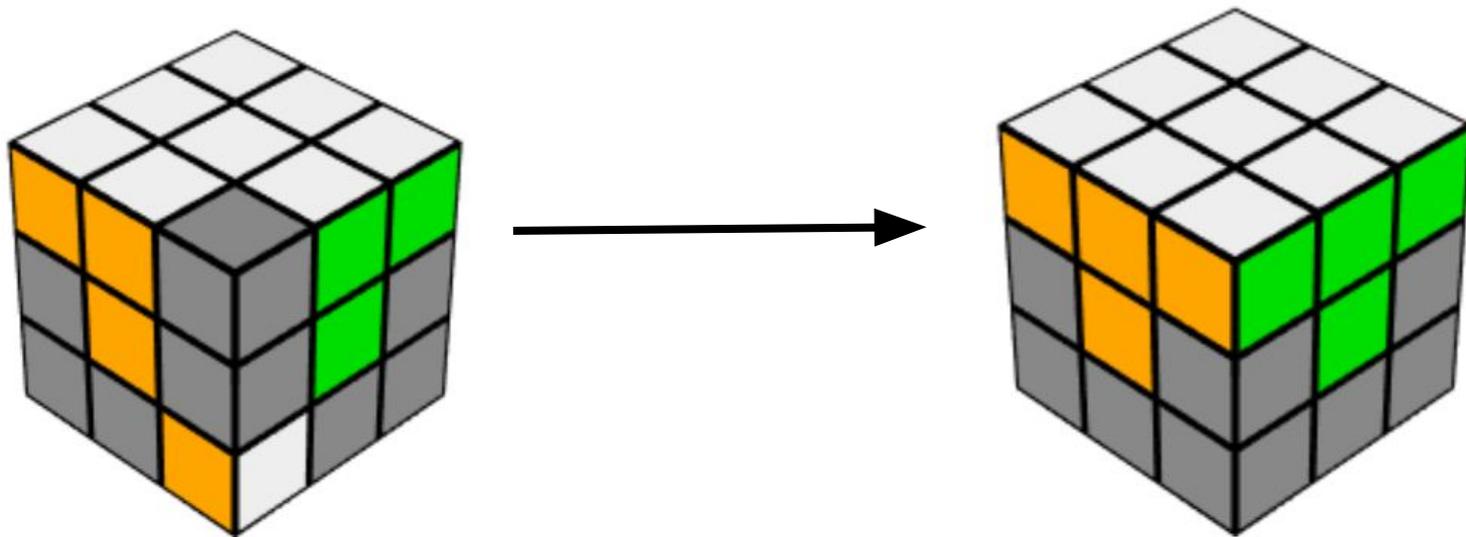
Step 3: Middle Layer

Algorithm: insert one edge

- (U R U' R') (U' F' U F)
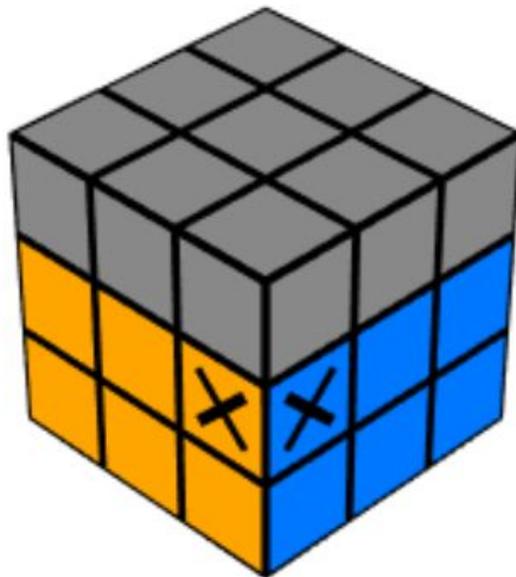
Step 4: Orient Edges

Algorithm: flip two edges

- F (R U R' U') F'
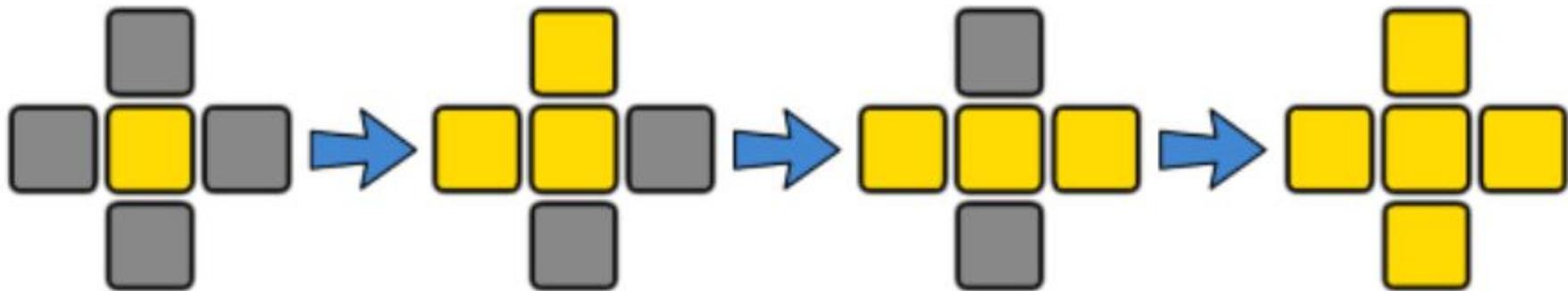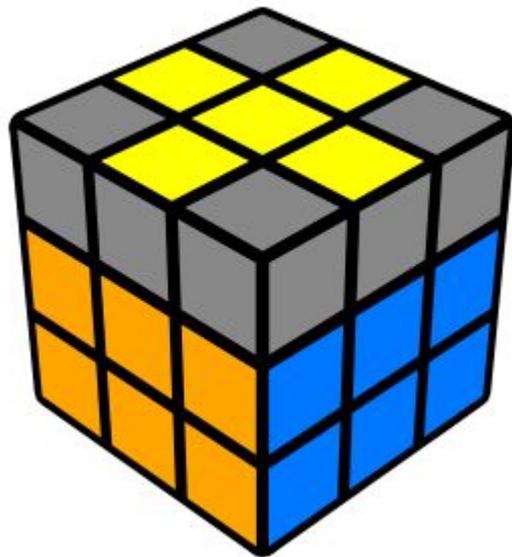
Step 5: Permute Edges

Algorithm: swap two edges

- R U R' U R U2 R' U

Step 6: Permute Corners

Algorithm: cycle three corners

- (U R U' L') (U R' U' L)
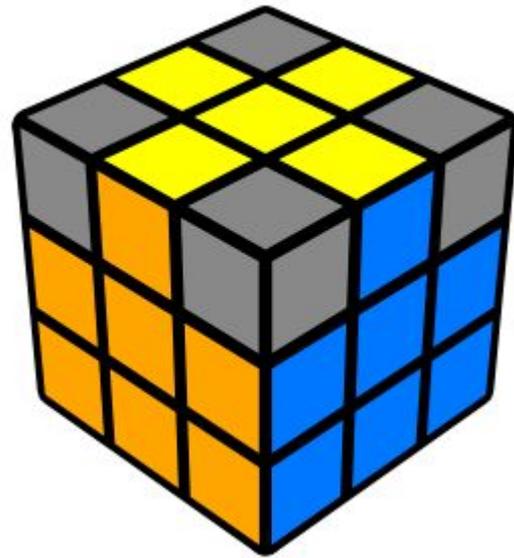
Step 7: Orient Corners

Algorithm: spin corners until cube is solved

- R' D' R D to solve one corner, then U for next corner
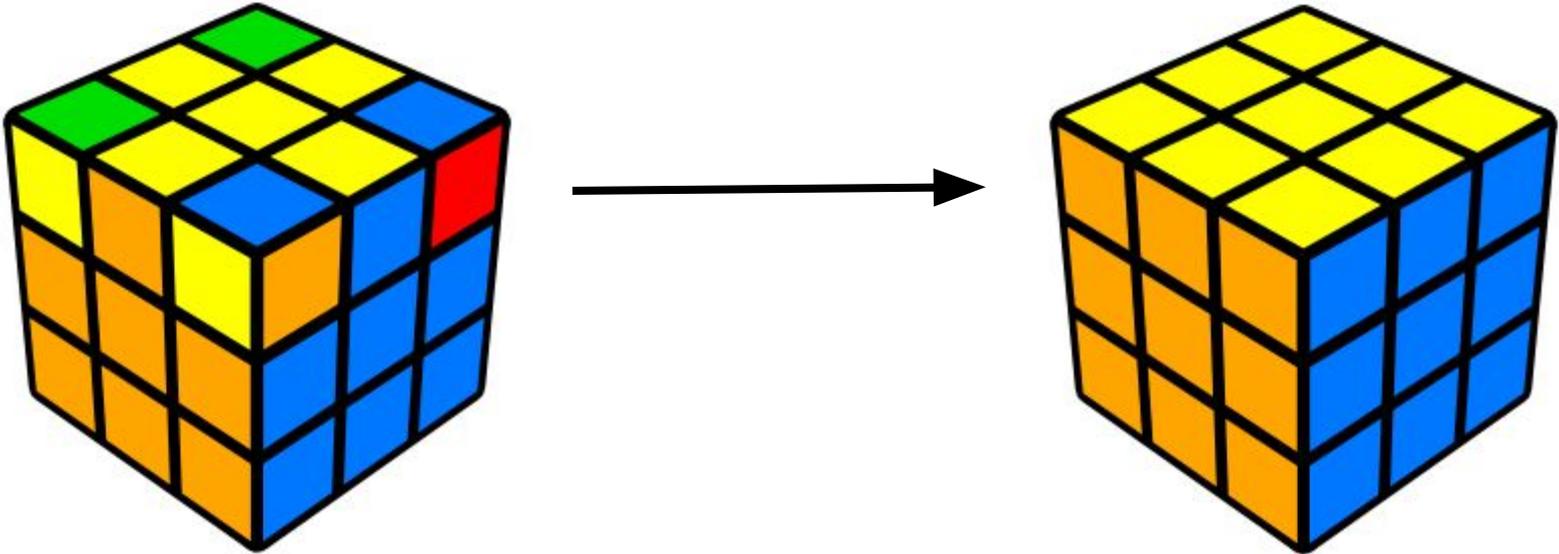
That's It!

7 steps and **5 algorithms**; just takes practice

- White cross & corners: intuitive
- Middle layer: (U R U' R') (U' F' U F)
- Orient edges: F (R U R' U') F'
- Permute edges: (R U R' U) (R U2 R' U)
- Permute corners: (U R U' L') (U R' U' L)
- Orient corners: R' D' R D

Solving Rubik's Cubes Isn't That Hard, But People Are Really Good At It

Faster Methods

Beginner method: **60 seconds**

Better: the **Fridrich method** (aka: CFOP)

- **C**ross
- **F**2L ("first two layers")
- **O**LL ("orient last layer")
- **P**LL ("permute last layer")

Jessica Fridrich: CFOP can get **13 seconds**

Step 2: F2L

F2L: **combine** white corners and middle layer

- ~41 different cases
- Still uses **intuition**
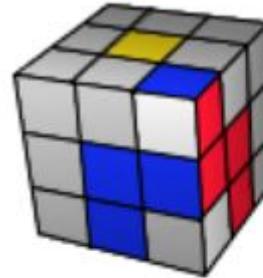
(U' R U' R') (U' R U2 R')

Step 3: OLL

OLL: orient yellow corners and edges at the **same time**

- "2 look OLL": **9 algorithms**
- Full OLL: **57 algorithms**
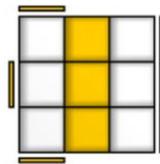
R' U' y L' U L' y' L F L' F R
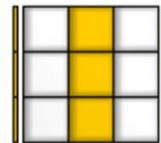
R U' y R2 D R' U2 R D' R2 d R'
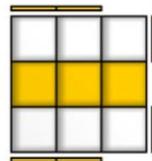
F U R U' R' U R U' R' F'
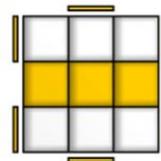
L' B' L U' R' U R U' R' U R L' B L

Step 4: PLL

PLL: permute yellow corners and edges at the **same time**

- Full PLL: **21 algorithms**
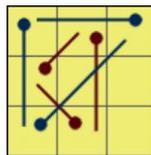
G 4:

[R U R'] y' R2 u' R U' R' U R' u R2
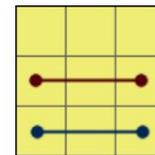
F:

[R' U2 R' d'] [R' F'] [R2 U' R' U] [R' F R U' F]
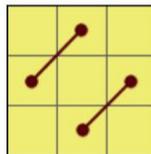
Z:

M2 U M2 U M' U2 M2 U2 M' U2
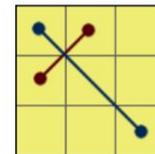
Y:

F R U' R' U' [R U R' F'] {[R U R' U'] [R' F R F']}

More?

ZBLL: with edges oriented, solve the last layer in **1 step**

- **493 algorithms**
- Impossible to recognize which one to use
- Why do people do this to themselves

Speedcubing
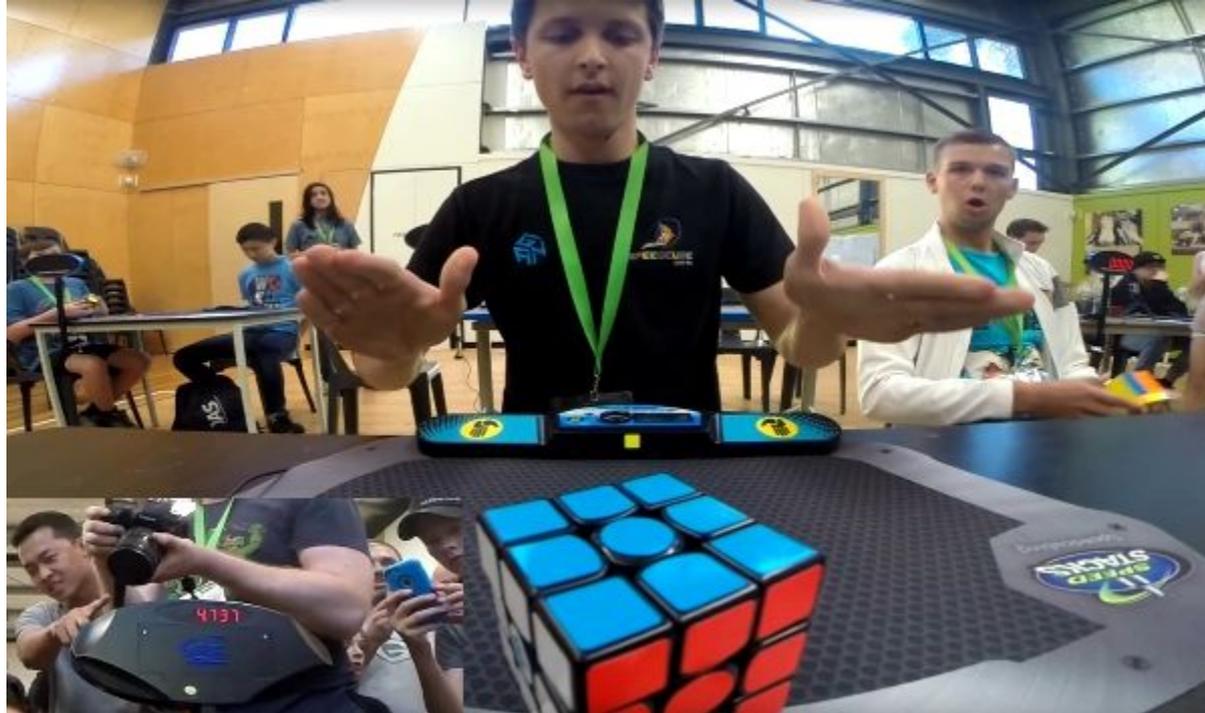
Speedcubing

Regulation solves:

- Judges apply **random scramble**
- 15 seconds **inspection time**
- **+2** for 1 turn away; **DNF** for more

Records for **single solve** or **Bo5**

People Are Really Good At It

People Are Really Good At It

Big
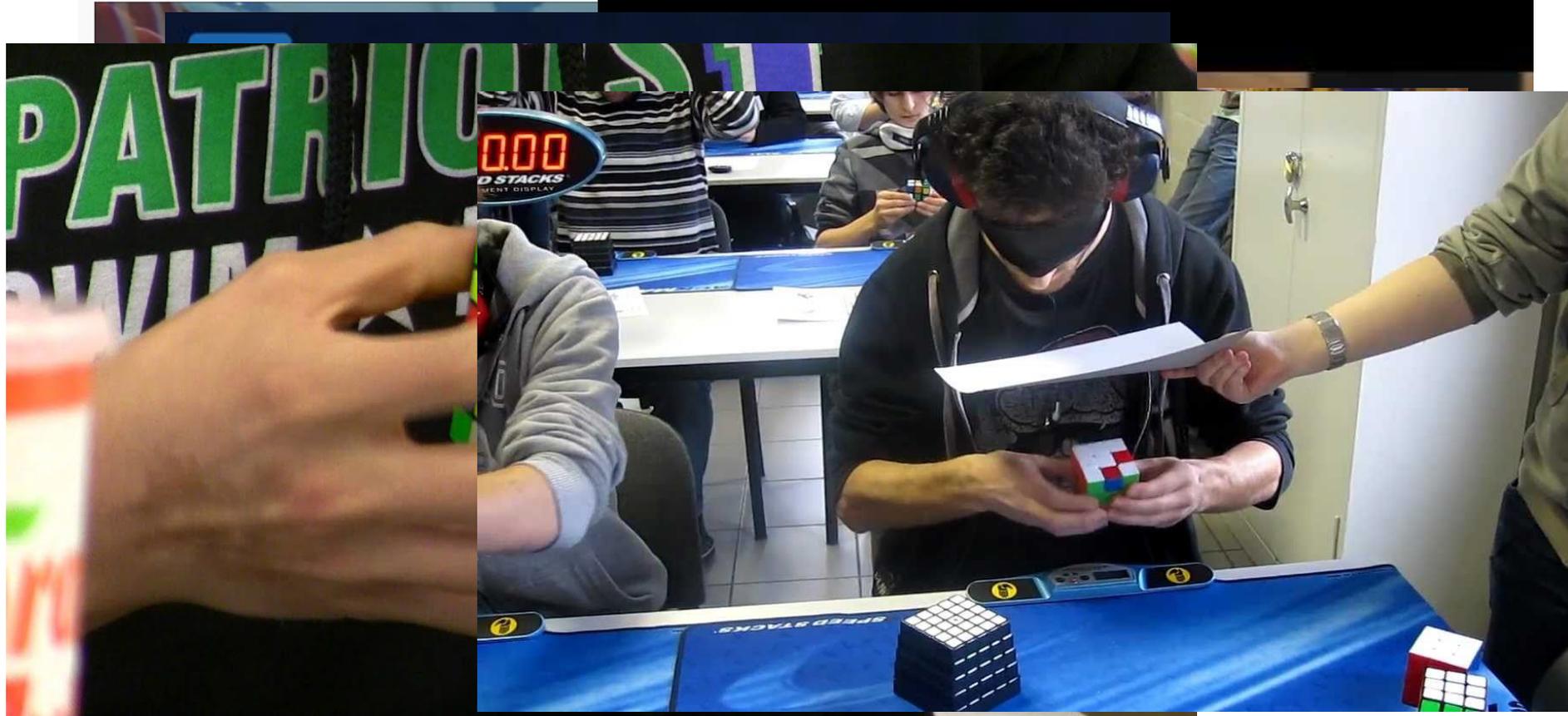
Solving Rubik's Cubes Isn't That Hard,
## But People Are Really Good At It

# Beyond 3x3

Other Rubik's cubes
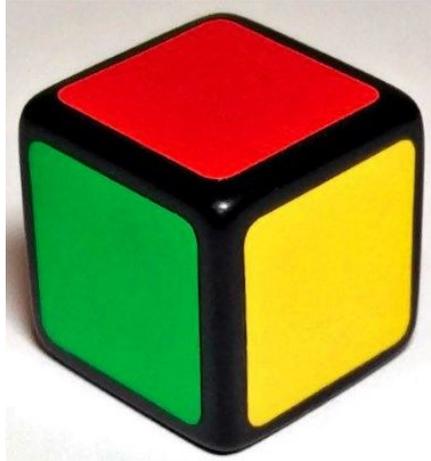
Beyond 3x3
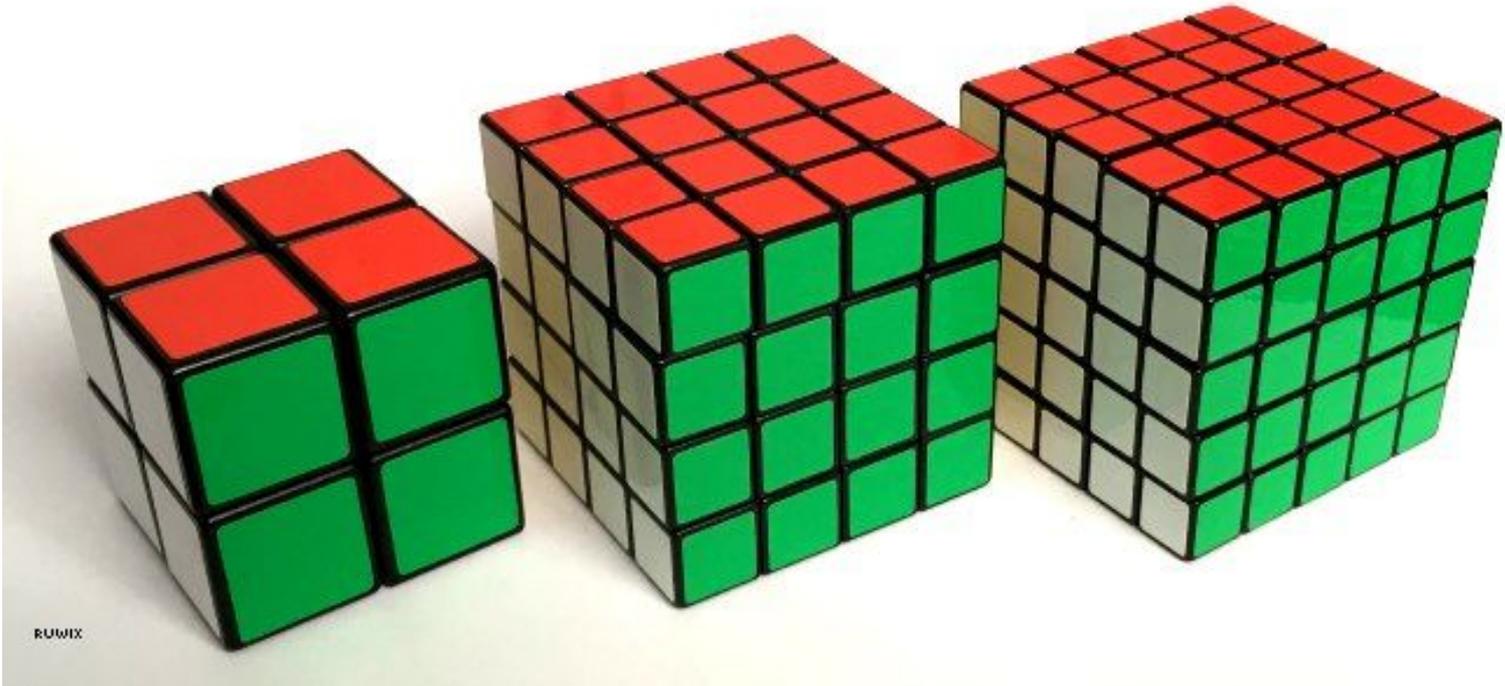
Other Rubik's cubes

Beyond 3x3

Other Rubik's cubes
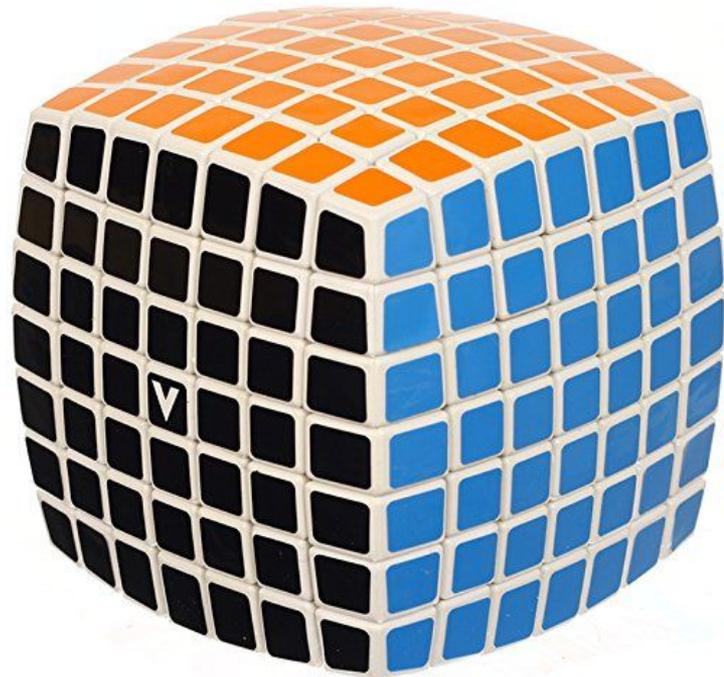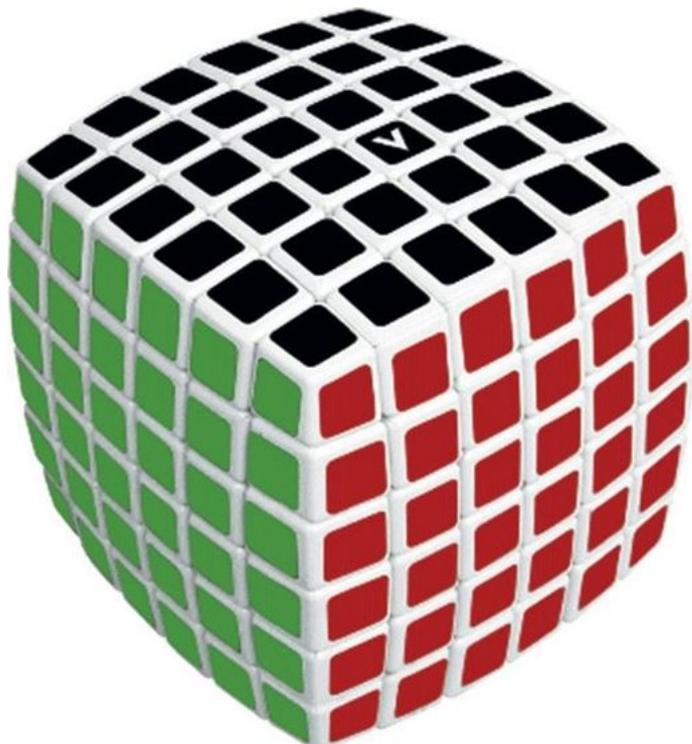
More Pieces = More Difficulty?

Not much harder than 3x3, and **4x4 is biggest difficulty jump**

Solution:

1. Build **centers**
2. Build **edges**
3. Pretend it's a 3x3

Step 1: Build the Centers

Pretty easy to do **intuitively**
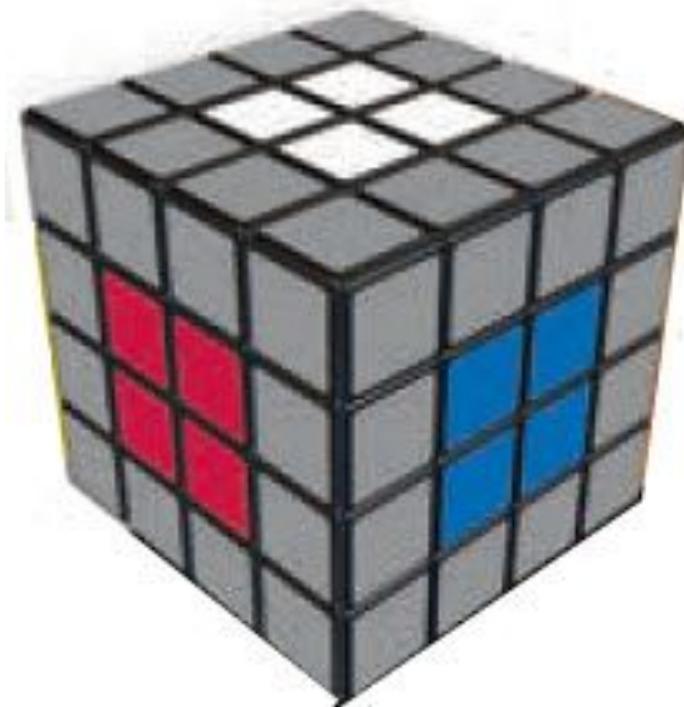
Step 2: Build the Edges

Takes a **bit more thought**, but **no algorithms**
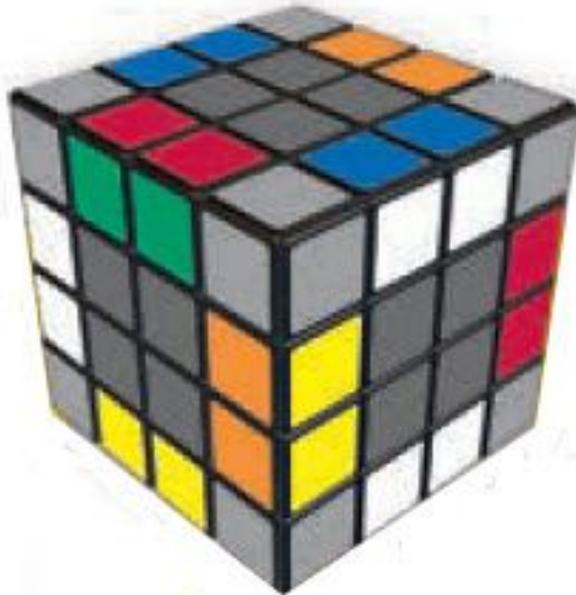
Step 3: Pretend it's a 3x3
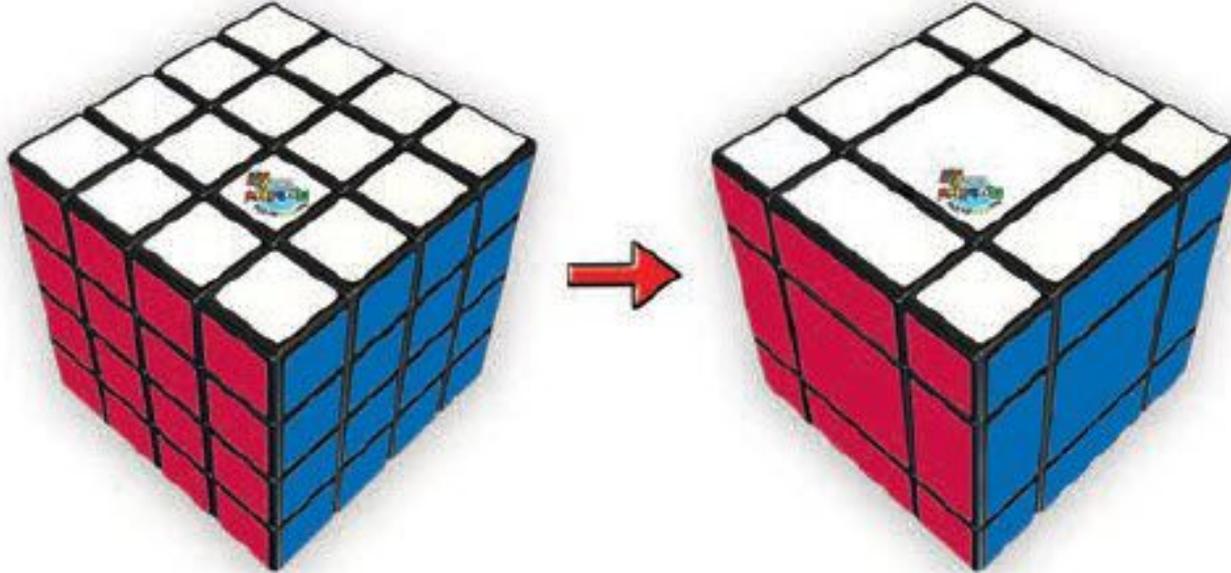
Step 3.5: Except When It's Not A 3x3

(edge **parity**)
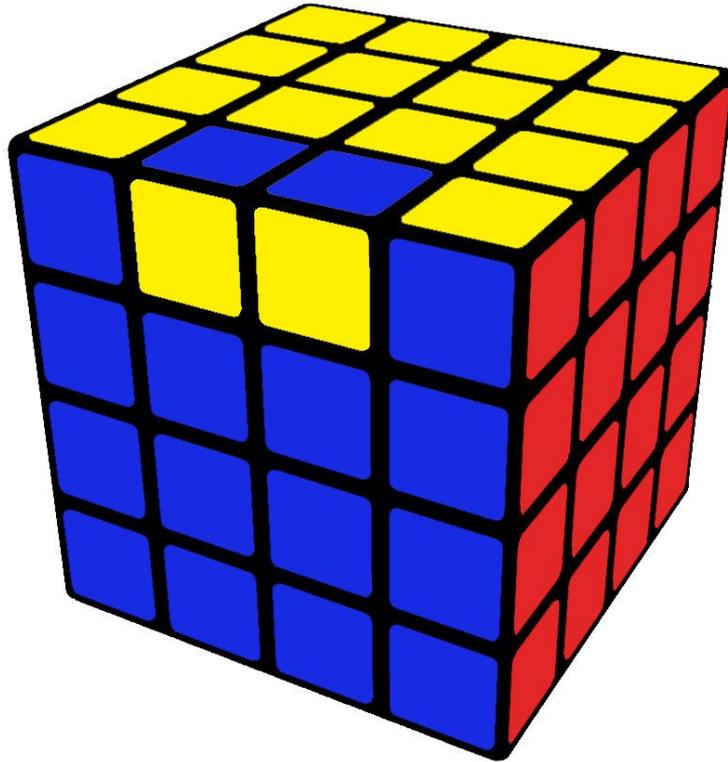
Big

Solving Rubik's Cubes Isn't That Hard,
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People Are Really Good At It

Records for other sizes:

- 2x2: 0.49
- 4x4: 17.42
- 5x5: 36.06
- 6x6: 1:13.82
- 7x7: 1:40.89

...most of the time

Solving Rubik's Cubes Isn't That Hard,

Blindfolded ↓

But People Are Really Good At It

This one can't be serious, right?

How can you **remember all of the stickers?**

How do you **keep track of them** when you turn the cube?

This must take a **photographic memory**, right?

The BLD Secret

Use **PLLs** to make **small changes**
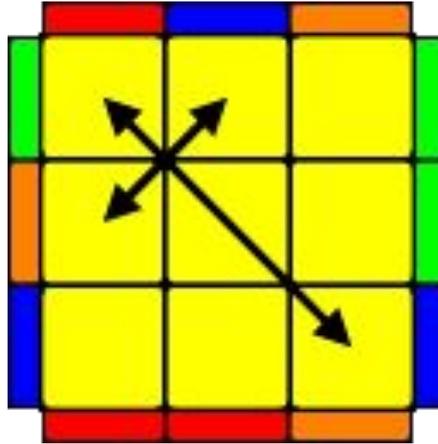
(F (R U' R' U') (R U R F') (R U R' U') (R' F R F'))

How to Memorize a Rubik's Cube

Only need to remember a **chain** of pieces

- Piece 1 belongs in spot 2…
- …which belongs in spot 3…
- …
- …which belongs in spot 1!

To solve:

- Swap 1 and 2
- Swap 1 and 3
- …
- Done!

Corners and edges are **separate**!

How to Memorize a Rubik's Cube

Remember the **chain** with a **memory palace**

- **Label each piece** with a letter
- Turn chain into a **sequence of letters**
- Imagine objects in your house, office, commute, …
- **Crazy = memorable!**

How to Memorize a Rubik's Cube

How much memory does it take?

- Usually 6-8 corners, 10-12 edges
- Total: 16-20 letters
- Like remembering **two phone numbers** for a few minutes
- **Executing accurately** is the harder part

Blindfolded

Solving Rubik's Cubes Isn't That Hard,

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BLD Cubing

Different rules for blind solves

- No **inspection**
- Timing **includes memorization**

People Are Really Good At It

Blindfolded WR: **15.50 s**

- < 7 second memorization!

People Are Really Good At It

Big cubes

Mike Hughey solves 7x7x7 cube blindfolded

People Are Really Good At It


59/60 59:46 Multi-Blind World Record -- Graham Siggins

Other Things Like

Solving Rubik's Cubes Isn't That Hard,
But People Are Really Good At It

Other Twisty Puzzles

Other Twisty Puzzles
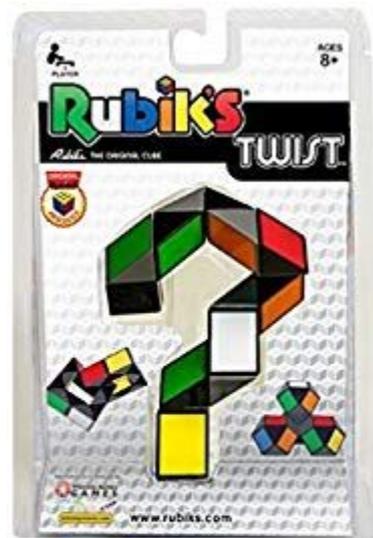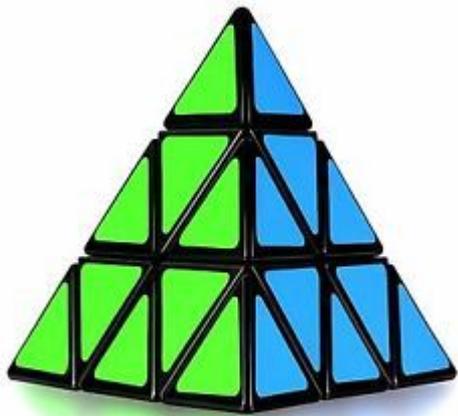
Make cool shapes!

Other Twisty Puzzles
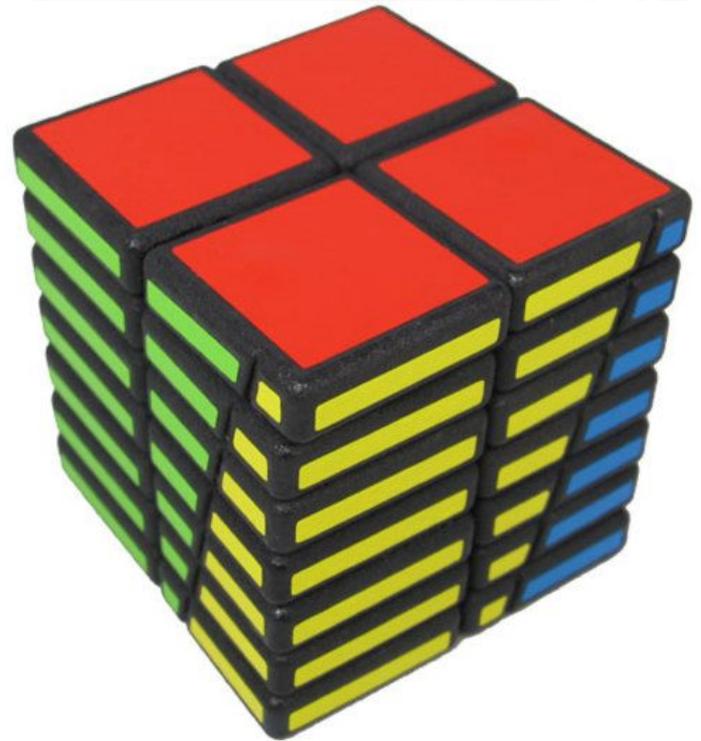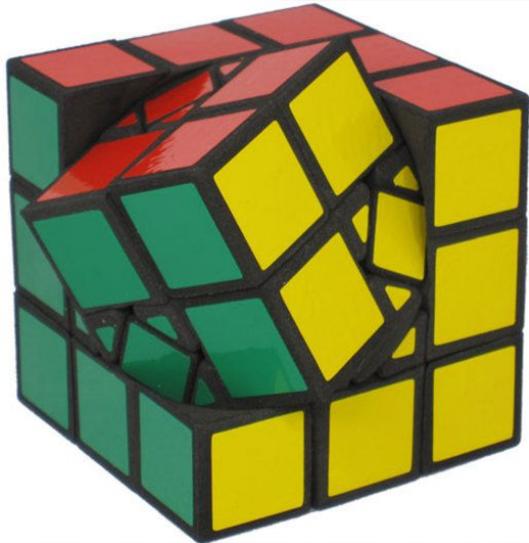
"But Rubik's Cubes Are Mathematical!"

Rubik's cubes are related to **group theory**

- Rubik's cube group: permutations of the pieces
- Interesting fact: only **1/12 of arrangements are possible**

Solving Rubik's Cubes

Speedsolving is about **practice**, not **genius**

- Algorithms come from **computers**
- **Muscle memory** from (hundreds of) thousands of solves

...but the results are still mind-blowing

Twisty Puzzles

Greg d'Eon
UDLS, January 2020