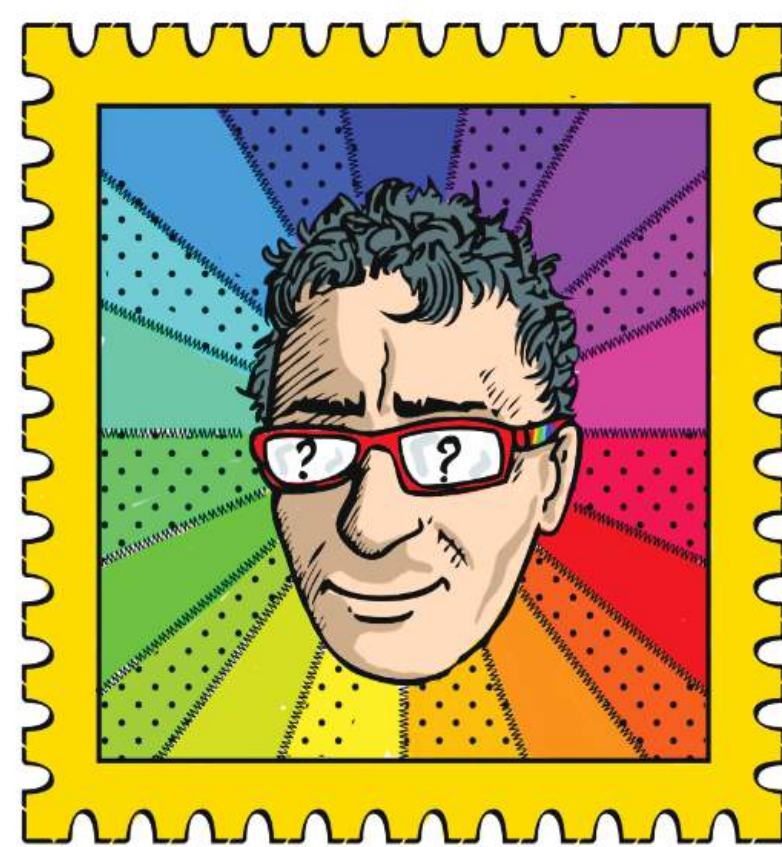


WHAT AND WHERE

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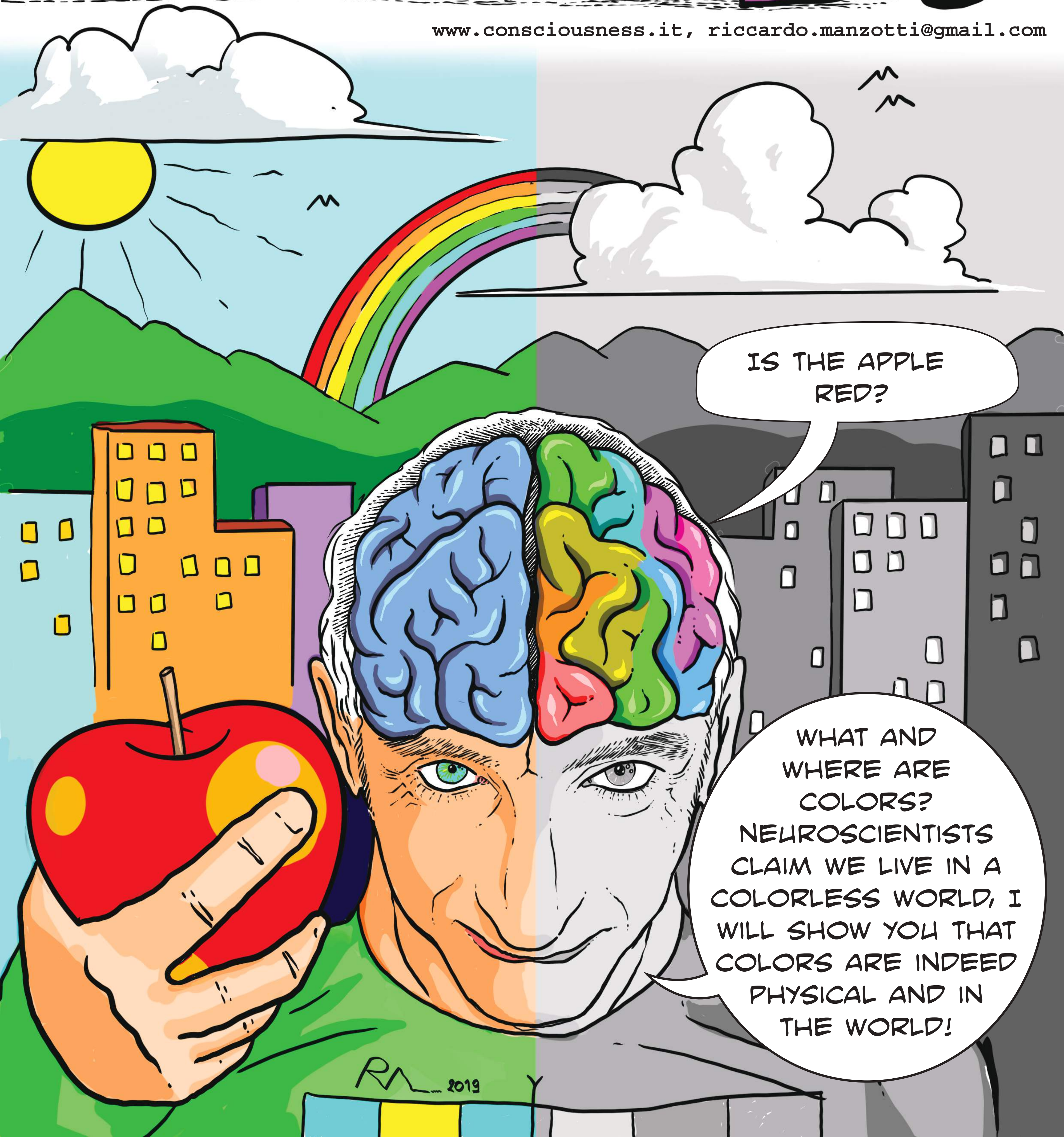


ARE

COLORS?



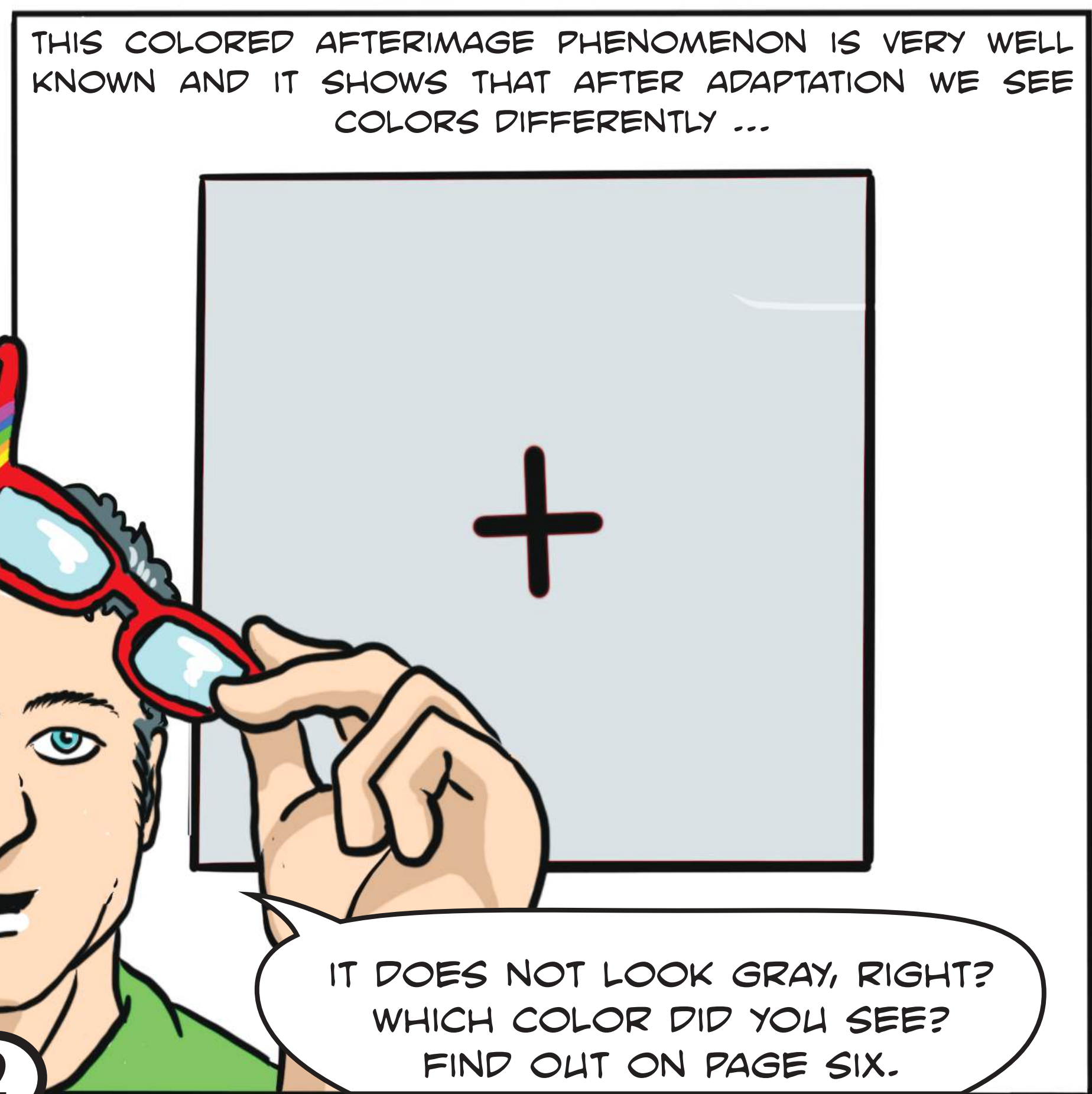
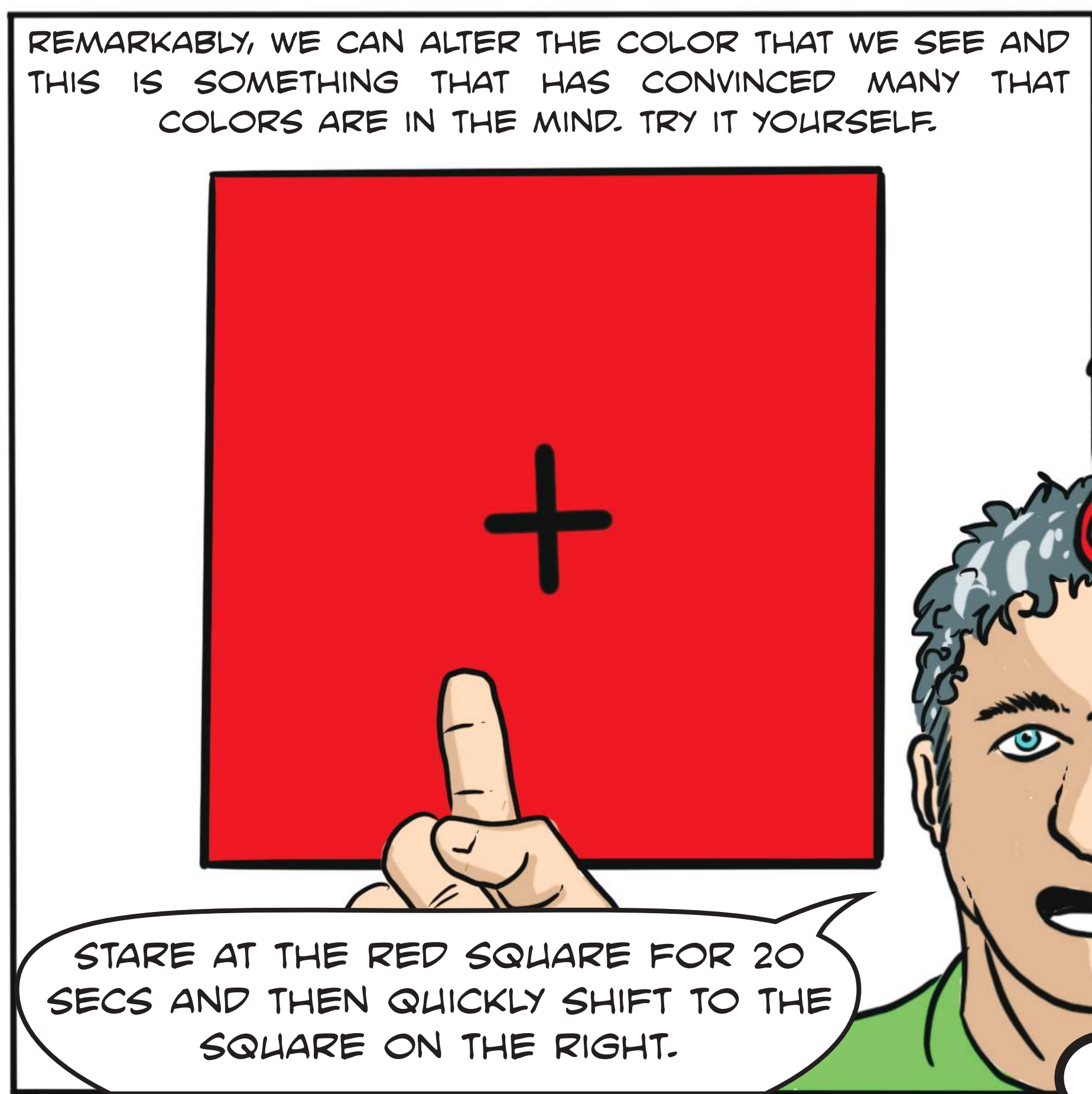
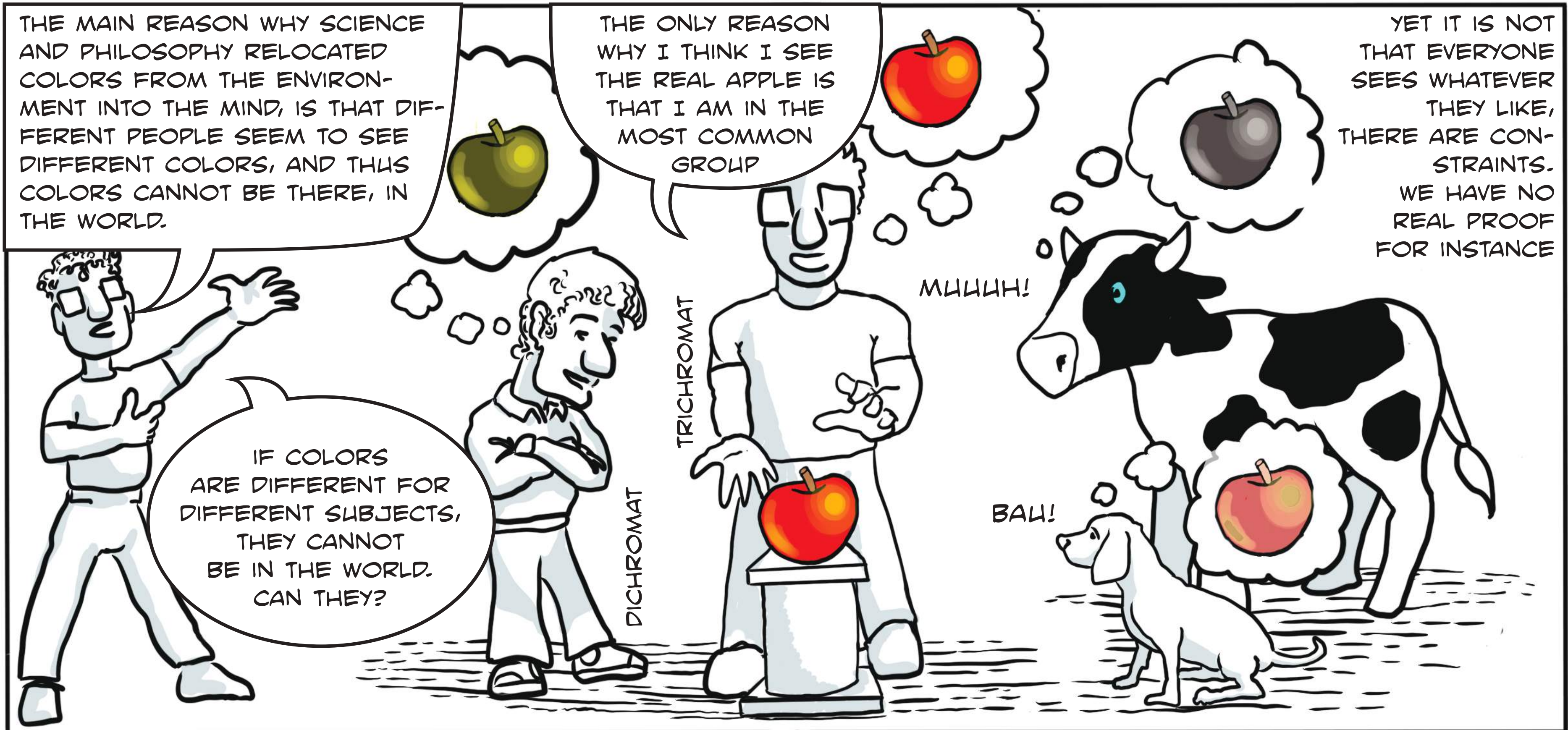
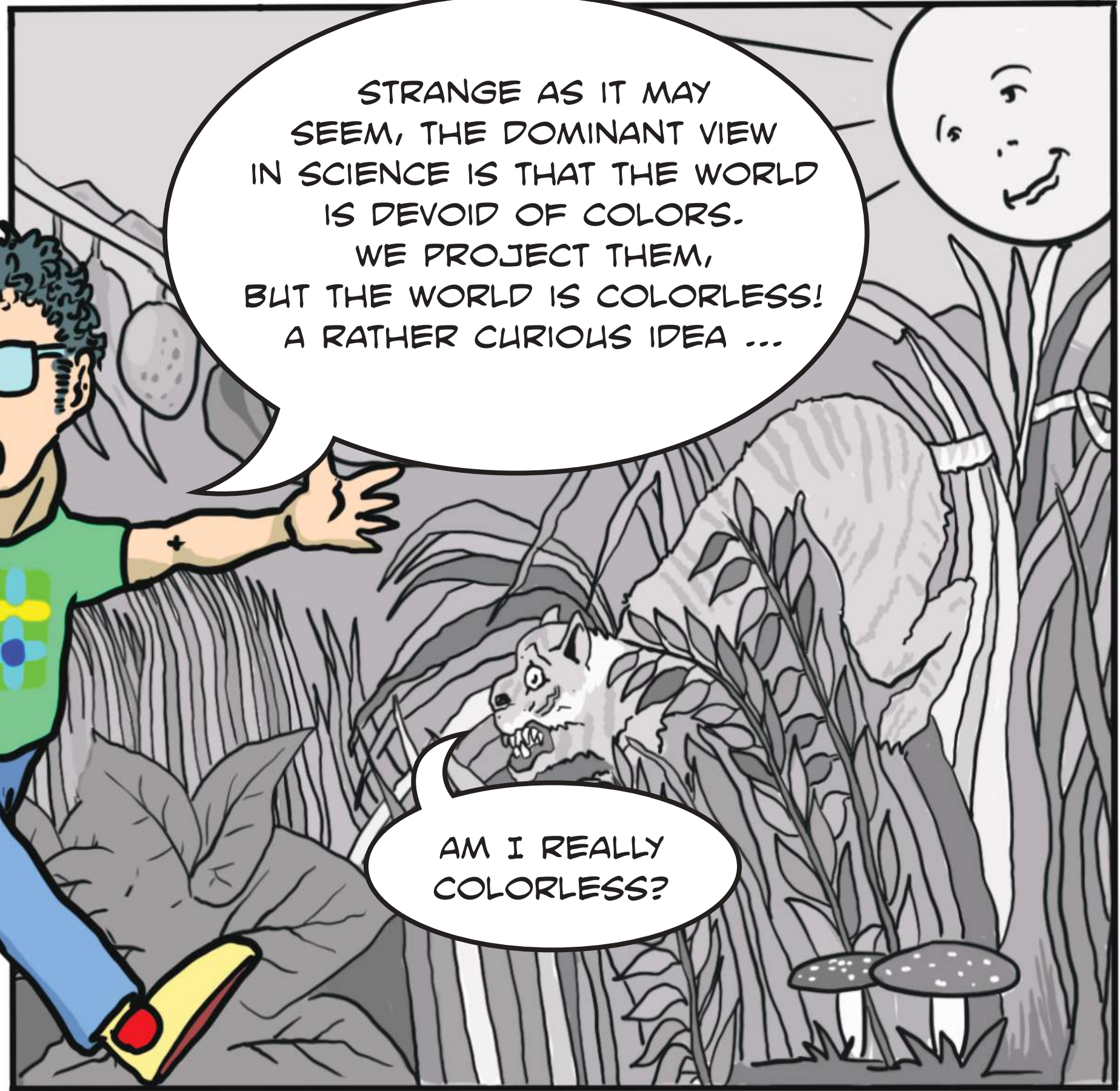
www.consciousness.it, riccardo.manzotti@gmail.com



IS THE APPLE
RED?

WHAT AND
WHERE ARE
COLORS?
NEUROSCIENTISTS
CLAIM WE LIVE IN A
COLORLESS WORLD, I
WILL SHOW YOU THAT
COLORS ARE INDEED
PHYSICAL AND IN
THE WORLD!

RM 2019



IF THAT'S THE CASE, LET'S START A JOURNEY FROM THE OBJECT TO OUR HEAD, TO SEE WHETHER COLORS ARE SOMEWHERE TO BE FOUND.

THE FIRST STEP IS THE MEDIUM, THAT IS, THE LIGHT. CAN COLORS BE IN THE LIGHT?

OR THEY MAY BE CREATED IN THE EYES! AFTER ALL, COULD WE SEE COLORS WITHOUT EYES?

WHAT ABOUT THE BRAIN? DON'T WE HAVE A COLOR CORTEX?

MANY PEOPLE BELIEVE THAT COLORS ARE IN THE LIGHT!

OR BY THE PERIPHERAL NERVES AND THE NEURAL GANGLIA

SO MANY OPTIONS CANNOT ALL BE TRUE. LET'S START WITH LIGHT.

ISAAC NEWTON
1642 B.
1727 D.

DID I HEAR THE WORD 'LIGHT'? THEN, LET ME STEP IN! I AM VERY LIKELY THE GUY WHO IS THE MOST RESPONSIBLE FOR THE IDEA THAT COLORS ARE IN THE LIGHT. I AM ISAAC NEWTON! BUT DON'T BLAME ME FOR SUCH A SILLY IDEA. LIGHT IS SIMPLY NOT COLORED!

I AM SURE THEY TAUGHT IN HIGH SCHOOL THAT LIGHT IS COLORED. DON'T THEY ALWAYS SHOW A COLOR SPECTRUM NEXT TO LIGHT FREQUENCY? BUT THIS CONCLUSION IS WRONG!

COLOR SPECTRUM

450 LIGHT FREQUENCY (λ) 750

1

THE SPACE OF COLORS IS (NEARLY) CLOSED! ITS EXTREMES ARE VERY SIMILAR

2

SO, ISAAC, WHY IS LIGHT NOT COLORED? ACTUALLY, IT IS A PRETTY COMMON IDEA. CAN YOU RECAP AN EXPLANATION?

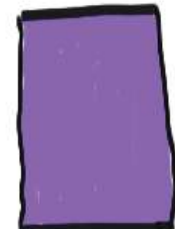
CERTAIN COLORS (BROWN, GOLD) DO NOT EXIST AMONG THE FREQUENCIES OF LIGHT

3

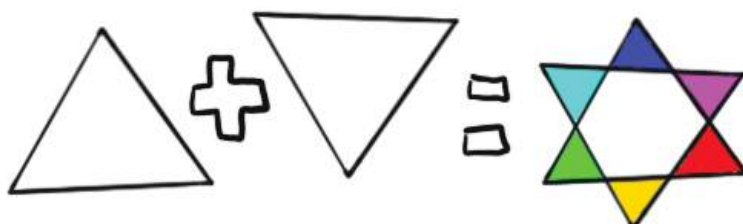
YES, OF COURSE! IT ALL BOILS DOWN TO THE FACT THAT COLORS AND LIGHT HAVE DIFFERENT PROPERTIES AND THUS THEY CANNOT BE THE SAME.

COLORS ARE NOT CONTINUOUS. IN FACT, WE SEE BANDS IN THE RAINBOW. BUT FREQUENCY IS WHOLLY CONTINUOUS.

IN CONTRAST, THE SPACE OF LIGHT IS NOT CLOSED. ITS EXTREMES ARE COMPLETELY DIFFERENT!



$$3 + 3 = 6$$



RED
ORANGE
YELLOW
GREEN
BLUE
VIOLET

6
COLORS

SO MUCH THE WORSE
FOR MY WHIM!

I'M SORRY, ISAAC,
BUT IN THE EYE THERE
ARE NO COLORS!
THERE ARE ONLY CELLS
CALLED CONES THAT
CAPTURE LIGHT AND
RELEASE RHODOPSIN
TO TRIGGER NEURAL
IMPUSES.

WE
MIGHT BE TEMPTED TO
THINK THAT SIGNALS GET THEIR
COLOR FROM THE NERVE AS
JOHANNES MÜLLER
SUGGESTED IN 1835!
HE CLAIMED THAT NERVES
HAVE A SORT OF "SPECIFIC ENERGY".
BUT OF COURSE THIS IS NOT TRUE!
NEURAL SIGNALS
HAVE NO COLOR AND
ARE ALL THE SAME!

WE
MIGHT BE TEMPTED TO
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BUT OF COURSE THIS IS NOT TRUE!
NEURAL SIGNALS
HAVE NO COLOR AND
ARE ALL THE SAME!

TOWARDS THE BRAIN

WE STARTED FROM THE APPLE AND HAVEN'T FOUND ANY COLOR YET. THE LAST POSSIBILITY IS THE BRAIN. IF THAT FAILS, WE WILL HAVE TO GO BACK TO SQUARE ONE AND REVISIT OUR ASSUMPTIONS.

NEUROSCIENCE CIRCUS

IS SOMETHING UTTERLY MYSTERIOUS? NO PROBLEM! NEUROSCIENCE HAS A SOLUTION FOR EVERYTHING?!?

IT'S ALL IN THE BRAIN AND A BRAIN CAN DO IT ALL! YOU NEED COLOR? THE BRAIN CREATES IT! BUT HOW? WELL, NOBODY KNOWS!

YET, THE IDEA THAT THE BRAIN CREATES THE COLORS WE SEE (WHICH DO NOT EXIST IN THE WORLD) IS JUST SILLY. THERE IS NO INNER WORLD INSIDE THE BRAIN. NO ONE BELIEVES IN AN INNER PROJECTOR!

NOBODY HAS EVER EXPLAINED WHY, WHERE AND HOW THE BRAIN TRANSFORMS SIGNALS INTO COLORS!

IF THE PHYSICAL IS DEVOID OF COLORS, HOW CAN A BRAIN, WHICH IS JUST AS PHYSICAL, HAVE OR PRODUCE THEM?

JUST A BIT OF LOGIC!

BRAIN \in PHYSICAL
 COLOR \notin PHYSICAL
 COLOR \notin BRAIN

TAKE A NEURON. DOES IT HAVE ANY COLOR? NO.

OR A NEURAL SIGNAL IN THE BRAIN. CODING DOES NOT CREATE COLOR.

INFORMATION HAS NO COLOR. BITS ARE COLORLESS.

THE SAME HOLDS TRUE INSIDE A COMPUTER. THE COLOR CODES ARE JUST NUMBERS

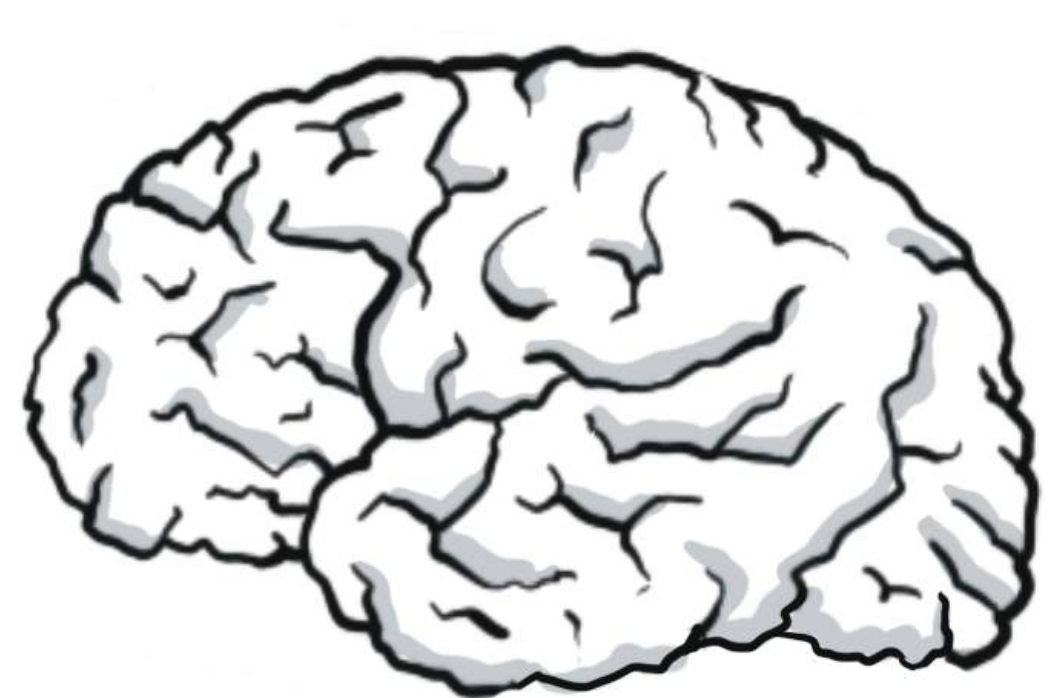
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THE ASSOCIATION BETWEEN COLORS AND INFORMATION IS ARBITRARY AND CONVENTIONAL

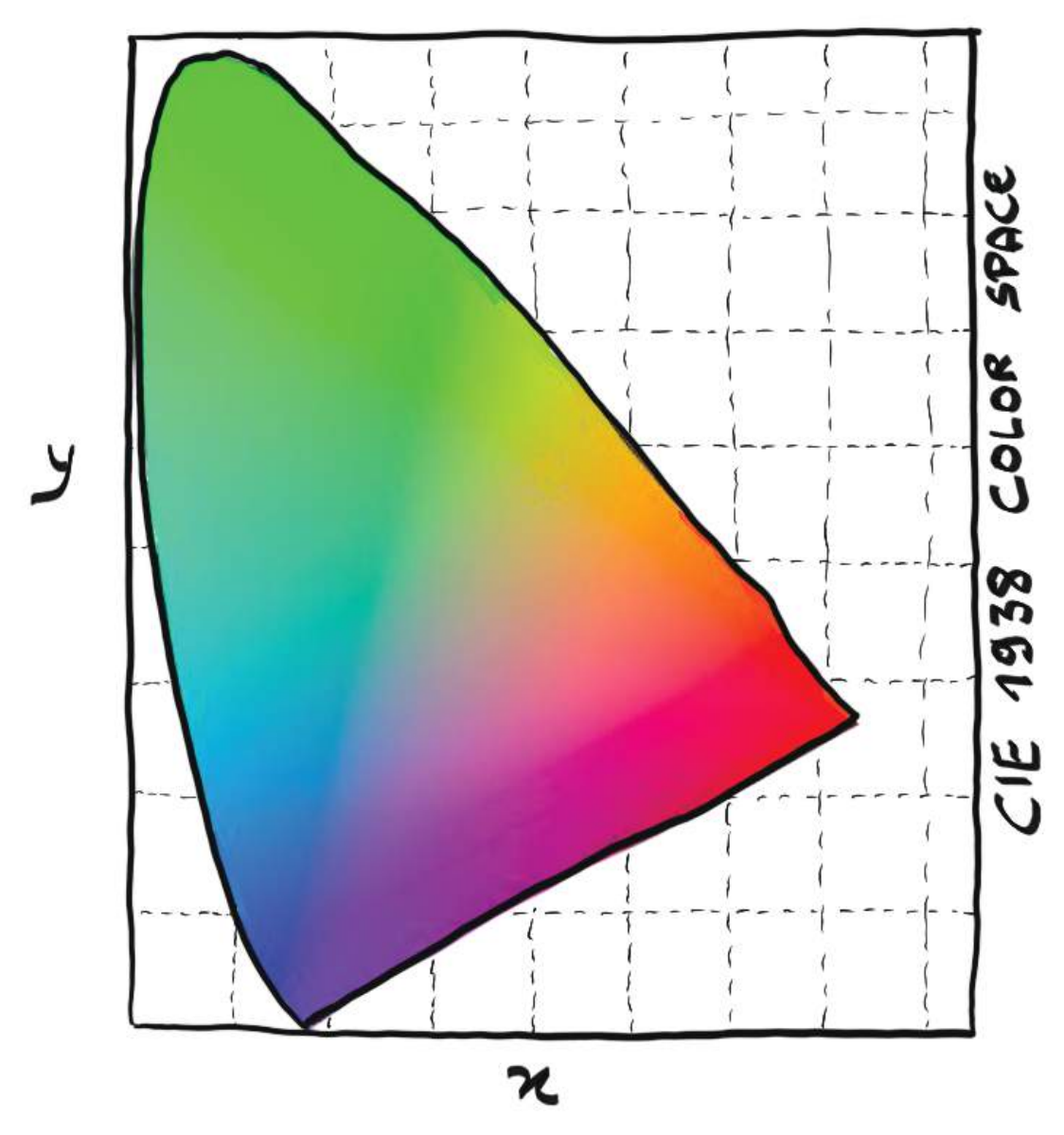
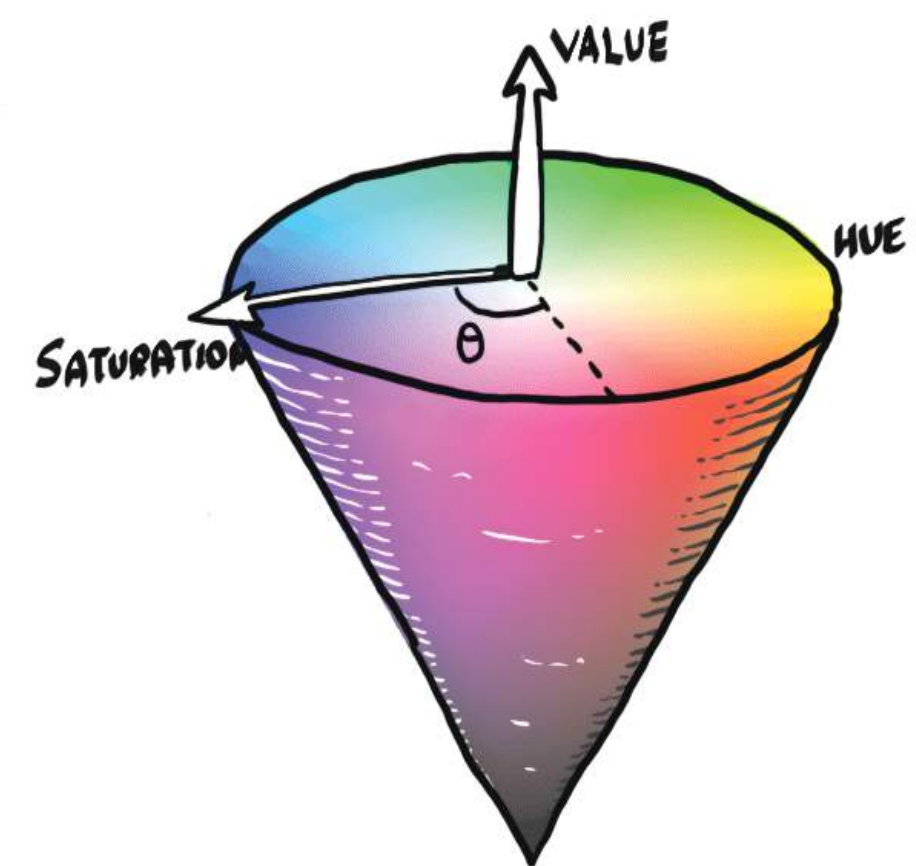
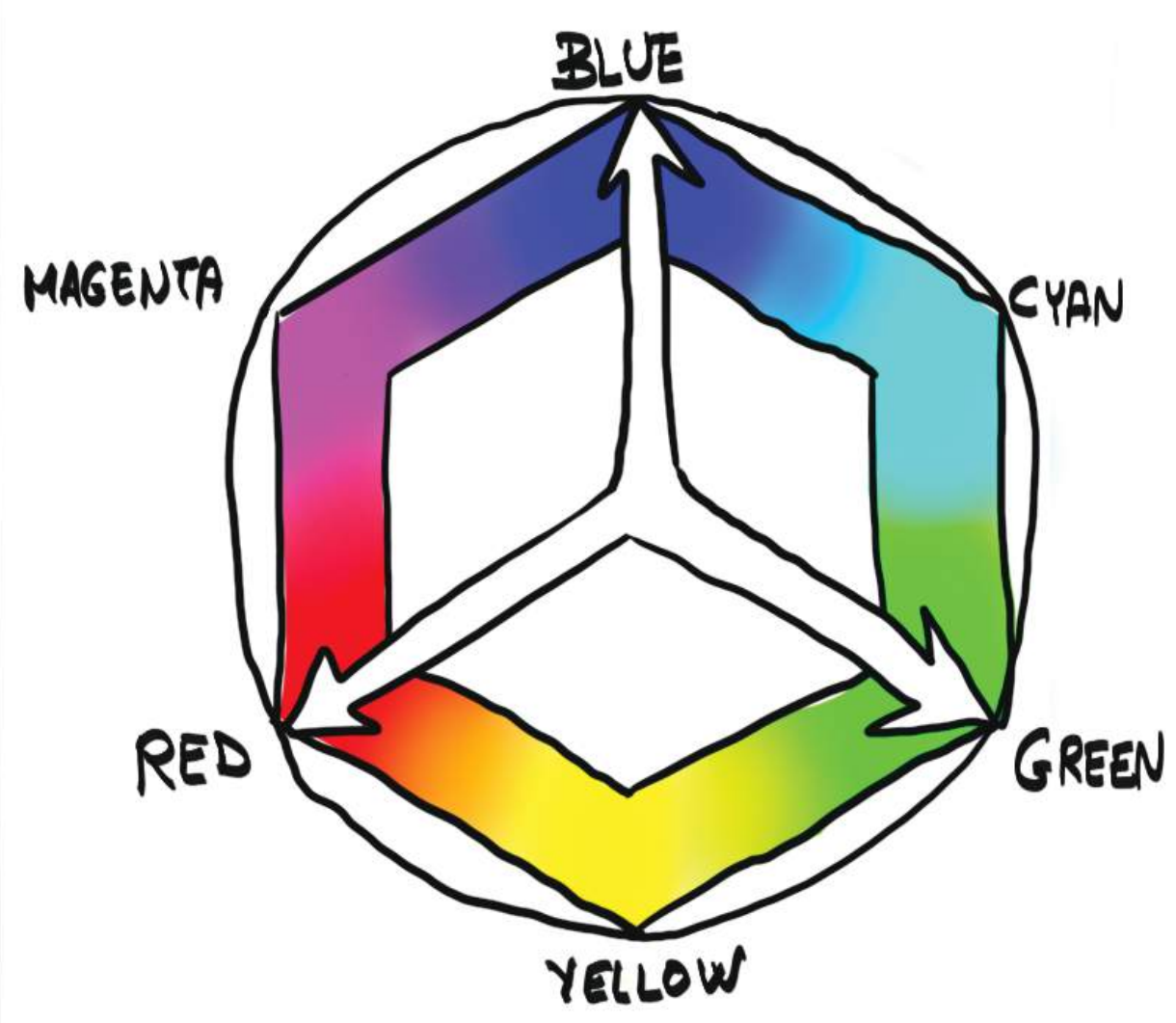
CONVINCE YOURSELF BY CONSIDERING VIRTUAL REALITY. ARE THERE ANY VIRTUAL COLORS INSIDE THE DEVICE? NO, JUST PHYSICAL COLORS. A PURE VIRTUAL RED, SO TO SPEAK, DOESN'T EXIST! THERE ARE ONLY TINY LCD SCREENS!

THE RED I SEE IS A PHYSICAL RED! IT IS NOT A VIRTUAL RED!

THE IDEA THAT THE BRAIN HAS A COLOR SPACE HAS LED MANY TO MODEL COLOR IN GEOMETRICAL SPACES. THEY ARE ACCURATE AND USEFUL TOOLS, BUT THEY ARE NOT REAL PHYSICAL SPACES.



COLOR SPACES ARE SIMPLY WAYS TO ORGANIZE COLORS IN AN EFFICIENT WAY. YET THEY ARE NOT ... INSIDE THE BRAIN!



THE MORE COGNITIVE AND COMPUTER SCIENTISTS SPEAK OF COLOR SPACES AS THOUGH THEY WERE REAL, THE MORE THEY CONCEIVE OF COLOR AS AN ABSTRACT ENTITY MADE OF PURE INFORMATION. BUT LOOK AT THEIR EQUATIONS AND YOU WON'T FIND ANY COLOR IN THEM!

MMM... WE'VE COME FULL CIRCLE SINCE NEWTON. IF COLORS ARE NEITHER IN THE EYE NOR IN THE BRAIN, MAYBE WE WERE TOO HASTY! AFTER ALL THE APPLE REALLY LOOKS RED! WHAT IF COLORS WERE IN THE EXTERNAL WORLD?

I'M RED!
I'M RED!

WHY DON'T YOU SEE ME!

I'M HERE!

LOOK AT ME!
I CAN DO TRICKS!
CAN'T I?

LET'S TAKE A STEP BACK. IN THE 1850S A WAR RAGED BETWEEN TWO GIANTS IN COLOR SCIENCE! ON ONE HAND, HELMHOLTZ BELIEVED THAT COLORS ARE PHYSICAL QUANTITIES, WHILE ON THE OTHER, HERING CLAIMED THAT COLORS ARE MENTAL OPPONENT QUANTITIES!

H. HELMHOLTZ
1821-1894

K. HERING
1834-1918

L. HURVICH
1910-2009

COLORS ARE IN THE WORLD!

COLORS ARE IN THE MIND!

ONE IDEA IS THAT THE WORLD CONTAINS QUANTITIES (RED, GREEN AND BLUE) THAT OUR BODY PICKS UP, BUT THEY ARE THERE ...

THESE QUANTITIES MAY INDEED BE EXTERNAL PHYSICAL QUANTITIES

THE OTHER IDEA IS THAT THERE IS NOTHING IN THE WORLD AND THAT OUR BODY CREATES COLORS IN SOME MENTAL SPACE ...

OPPONENT COLORS ARE JUST MENTAL

LUCKILY THERE IS A WAY TO SOLVE THE PROBLEM! LET'S GO BACK TO THE AFTERIMAGE ON PAGE TWO. WHAT DO YOU REALLY SEE?

DID YOU SEE THE COLOR ON THE LEFT OR THE COLOR ON THE RIGHT?

CYAN OR GREEN?

CYAN OR GREEN

THE TRADITION STATES THAT WE OUGHT TO SEE GREEN. BUT WE DON'T! WE SEE CYAN!

DEAF PHILOSOPHER

BLIND PHILOSOPHER

SCHOLARS READ WHAT THEY OUGHT TO SEE. BUT THEY RARELY CHECK WHAT THEY SEE WITH THEIR OWN EYES!

ISN'T IT SURPRISING THAT MOST PHILOSOPHERS AND SCIENTISTS HAVE NEVER DONE THE TEST THEMSELVES? THEY HAVE READ THAT YOU SEE GREEN AFTER RED, BUT THEY HAVE NOT SEEN IT WITH THEIR OWN EYES!

BUT PEOPLE DON'T SEE GREEN, THEY SEE CYAN! THIS IS AN EMPIRICAL FACT! SO WE CAN BEGIN TO ENVISAGE A DIFFERENT EXPLANATION THAT WILL TAKE COLORS BACK IN THE REAL WORLD, ALBEIT WITH SOME IMPORTANT DIFFERENCE!

FIRST, YOU STARE AT A RED PATCH FOR 20 SECS, DURING WHICH YOU LOOSE SENSITIVITY FOR THE PROPERTY YOU CALL RED.

THE GRAY PATCH ON PAGE TWO HAS ALL COMPONENTS, BUT YOU CANNOT SEE THE RED ONE! SO YOU SEE WHAT IT IS LEFT: BLUE AND GREEN

THE ADAPTATION MAY HAPPEN IN MANY WAYS, BUT, FOR THE SAKE OF THE EXAMPLE, LET'S SUPPOSE THAT ONE TYPE OF CONE BECOME ALMOST BLIND.

I PICK BLUE! I PICK GREEN! NOBODY WANTS RED!

YOU ARE LEFT WITH CYAN, BECAUSE IT'S THE COLOR, INSIDE GRAY, YOU CAN NOW SEE.

THE PATCH IS BOTH CYAN AND WHITE AND MANY OTHER RELATIVE COLORS! THE WORLD IS RELATIVE AND COLORS ARE RELATIVE TOO!

I SEE A CYAN SQUARE!

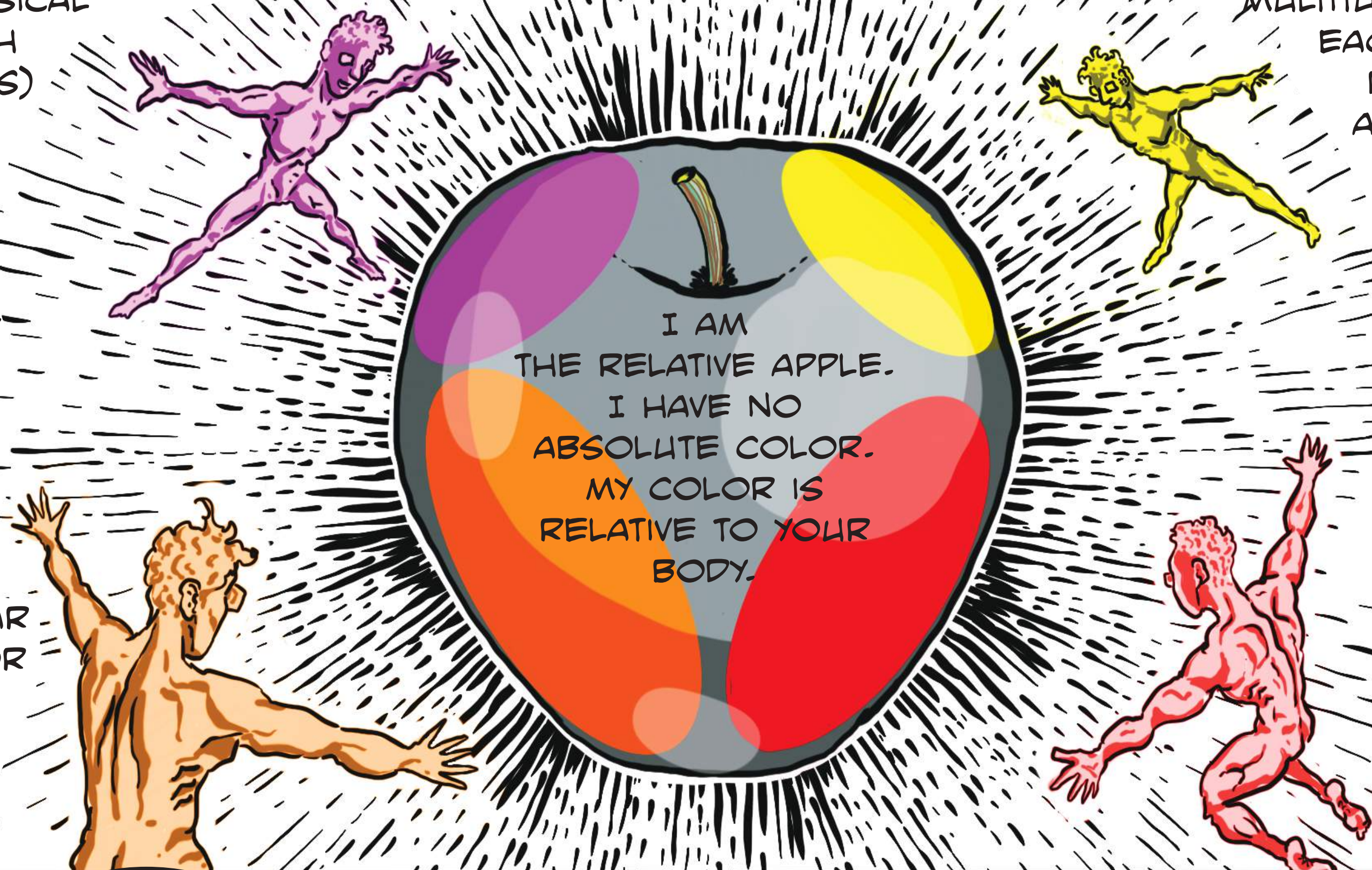
I SEE A WHITE SQUARE!

LIKewise, A TRUCK IS BOTH STILL AND MOVING. IT CAN HAVE UMPTTEEN RELATIVE VELOCITIES!

ANY OBJECT HAS AS MANY RELATIVE VELOCITIES AS THERE ARE OTHER OBJECTS. LIKEWISE, CAN AN OBJECT HAVE AS MANY RELATIVE COLORS AS OTHER PHYSICAL SYSTEMS AROUND? YES OF COURSE!

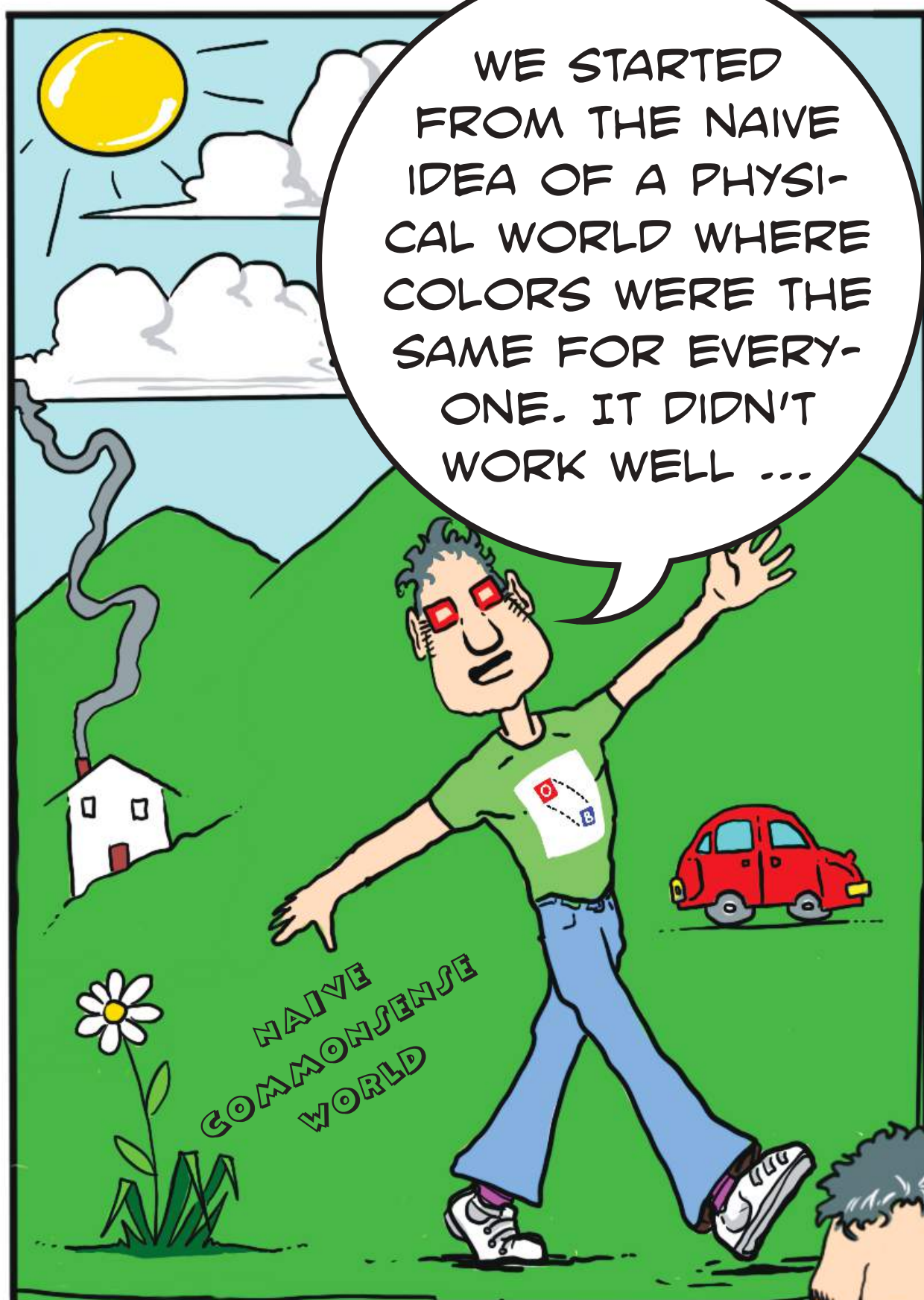
$\vec{v}_1 < \vec{v}_2$

SO IF COLORS ARE RELATIVE TO OTHER PHYSICAL SYSTEMS (SUCH AS OUR BODIES) THE PROBLEM WE STARTED WITH HAS BEEN SOLVED. ANY OBJECT HAS UMPTTEEN RELATIVE COLORS. EACH BODY BRINGS INTO EXISTENCE ONE PARTICULAR RELATIVE COLOR AT A TIME, BUT THE OBJECT HAS ALL OF THEM.



SO, THE APPLE HAS A MULTITUDE OF COLORS. EACH OF US HAS A DIFFERENT BODY AND SO EACH OF US BRINGS INTO EXISTENCE A DIFFERENT APPLE (WITH A DIFFERENT COLOR). THE WORLD IS RICHER BUT THERE ARE NO MENTAL COLORS. ALL THE COLORS WE SEE ARE IN THE WORLD. EVERYTHING IS PHYSICAL.

WE STARTED FROM THE NAIVE IDEA OF A PHYSICAL WORLD WHERE COLORS WERE THE SAME FOR EVERYONE. IT DIDN'T WORK WELL ...



WE THEN SWITCHED TO THE SCIENTIFIC PICTURE OF THE WORLD WHERE THERE ARE NO COLORS. BUT THAT DIDN'T WORK EITHER

COLORLESS SCIENTIFIC WORLD



BUT, THANKS TO THE RELATIVE OBJECT, THE RAINBOW BREAKS INTO OUR WORLD AGAIN! EVERYTHING IS LIKE A RAINBOW! EVERYTHING HAS ALL THE COLORS DIFFERENT SUBJECTS SEE IT HAVING. BECAUSE COLORS EXIST RELATIVE TO OTHER PHYSICAL SYSTEMS, LIKE EVERYTHING ELSE, ALL IS RELATIVE!

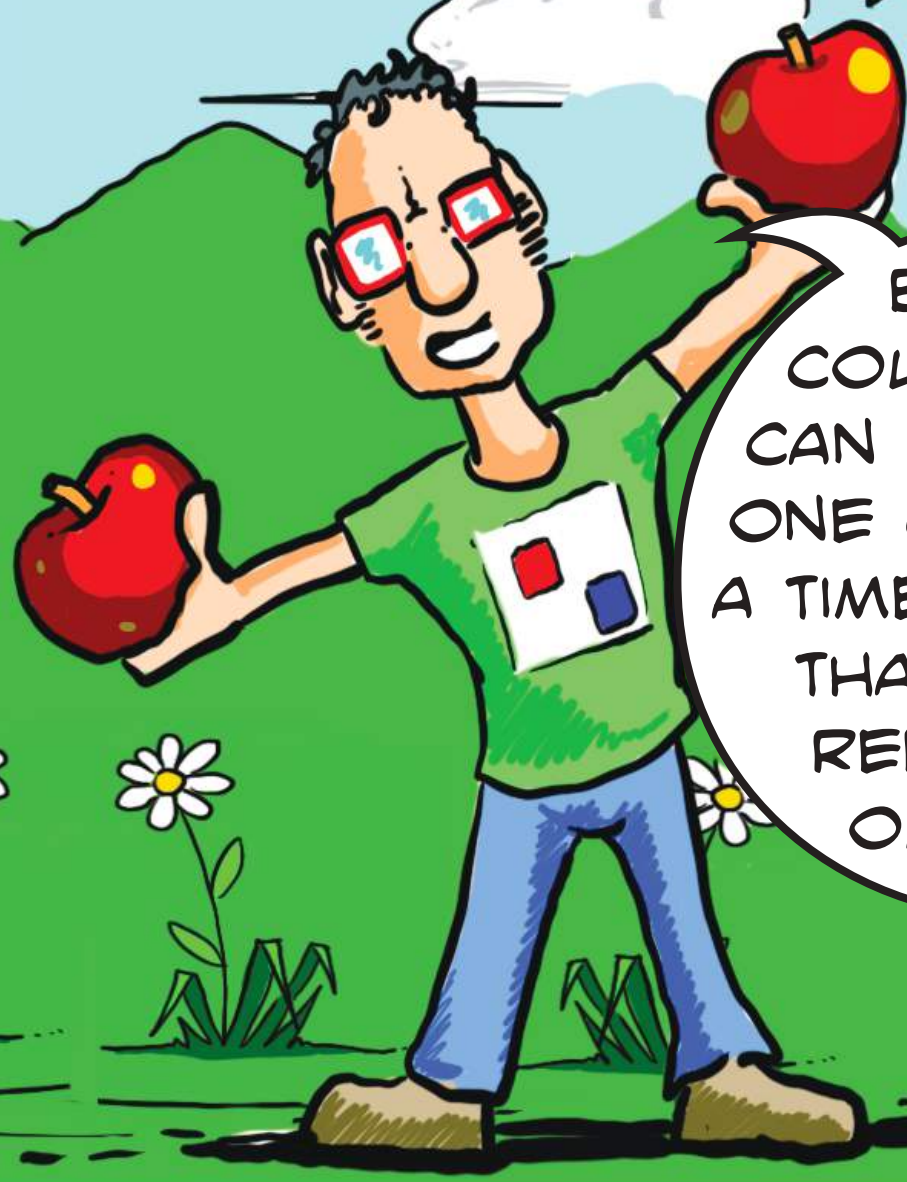
WORLD BEYOND THEORIES



THE WORLD IS A "RAINBOW WORLD". EVERYTHING HAS UMPTTEEN RELATIVE COLORS!

IN A RAINBOW WORLD, COLORS ARE BACK IN THE WORLD! THEY ARE NO LONGER A CREATION OF THE MIND!

THANKS TO MY FRIEND GREGORY OWCARZ FOR HIS HELP!



BUT OF COURSE, WE CAN SEE ONLY ONE COLOR AT A TIME. THE ONE THAT EXISTS RELATIVE TO OUR BODY.