today we will be discussing diffusion

tensor imaging or dti

the white matter tissue of the brain

contains axons which form the

connections between neurons

making a map of these white matter

fibers allows for understanding which

areas in the brain are strongly

connected

consequently this gives an idea from

where to where information is flowing in

the brain

with a standard structural mri scan

white matter can be identified however

it is very difficult to actually see the

different connections and along which

direction different axonal bundles are

going

for that we need dti

as we already have seen in our

introductory video on mri an mri scanner

is great at picking up hydrogen atoms

so in a structural mri scan tissues with

more or less water content can be

distinguished

importantly hydrogen atoms don't stand

still but are constantly moving around

but they cannot just go anywhere they

want

for example within white matter hydrogen

atoms mostly move along the direction of

the axon similar to water moving through

a straw

now let's take a more detailed look at

how dti can detect the differences in

hydrogen atom movement in the brain

in the mri scanner hydrogen protons

align themselves to the magnetic field

and spin around their own axes all in

the same phase

first let's take a look at an example

where hydrogen atoms do not move

when performing a dti scan the gradient

is added to the magnetic field

as a consequence the synchronized

spinning of the protons is disrupted and

depending on the magnetic field some

protons spin faster and some others spin

slower

if we afterwards apply another magnetic

field gradient that is exactly opposite

to the first and is applied for the

exact same amount of time the effect of

the first gradient would just be

nullified

in other words at the end of the

application of the second gradient all

protons would be spinning in the same

phase again just as they did in the

beginning

now this example is only true if

hydrogen atoms wouldn't move but of

course in reality they do move

in that situation just as in the first

example the first gradient would cause

the protons to spin differently from

each other

but because the protons are moving the

second gradient will not have the same

effect as the first that means the

second gradient does not nullify the

effects of the first gradient

so that means that proteins will be in a

different location and spin in a

different phase and this will lead to a

decreased signal

therefore in places where protons can

move freely such as in the ventricles

the signal is very low but in other

places where protons are more restricted

in their movement such as gray matter

signal will be higher

everything we've explained up until now

describes diffusion-weighted imaging

it is used as a tool to find areas with

limited water diffusion which can be

indicative of neurological conditions

such as a stroke

but when thinking about diffusing tensor

imaging most people think of beautiful

pictures of rainbow spaghetti

to create this we need to do a few more

things

axons in the white matter resemble tubes

or tunnels

this means that hydrogen protons in the

axons can move freely along the

direction of the axon but are much more

restricted from side to side

this is what we call an isotropic

movement and to measure it we need to

observe all three dimensions of a 3d

space

let's look at an example where the axon

follows the z direction of the 3d space

in the x and y direction there is not a

lot of hydrogen movement going on but in

the z direction there is

since we are interested in all these

directions x y and z we need multiple

magnetic field gradients for different

directions

in that way we can capture in which

direction hydrogen protons move the most

the value that represents protons moving

more in one direction than in the other

is called fractional anisotropy

put everything together and we get our

spaghetti brain image showing all the

white matter tracks of the brain

as a final touch we can give the image

some colors which represent different

directions of the 3d space

now that's it

we hope you enjoyed our explanation

about dti

if you did consider giving this video a

like

and as always we hope to see you the

next time

you