Â determined by the past, exceptÂ for random quantum jumps which no one canÂ Â
0:05
control. Causes have causes have causes, andÂ they go back all the way to the Big Bang.Â Â
0:11
Does that mean we have no free will? PeopleÂ often ask me that. I find the question stunninglyÂ Â
0:17
uninteresting. Of course we donâ\200\231t have freeÂ will. Ok, then, how do we make decisions? DoÂ Â
0:23
we make decisions? Did the Big Bang make me doÂ this video? Thatâ\200\231s what weâ\200\231ll talk about today.
Has Physics Ruled Out Free Will?
0:34
I already made a video about free will aÂ few years ago. But Iâ\200\231ve noticed recentlyÂ Â
0:38
that a lot of people think free will isÂ relevant for addressing climate change.Â Â
0:42
And because I donâ\200\231t believe in freeÂ will Iâ\200\231ve suddenly become a problem.Â Â
0:47
This is complete nonsense. ButÂ letâ\200\231s start at the beginning.
0:51
And we begin of course with physics. EverythingÂ in the universe is made of 25 particles that,Â Â
Physics FTW!
0:57
for all we currently know, are not themselvesÂ made of any smaller constituents. We collectÂ Â
1:02
them in whatâ\200\231s called the standard modelÂ of particle physics. Thatâ\200\231s everythingÂ Â
1:07
in the universe, except possibly darkÂ matter, but thatâ\200\231s a different story.
1:11
Most of those particles are unstable andÂ decay very quickly. How can it be thatÂ Â
1:16
a particle which isnâ\200\231t made of anything canÂ decay? Thatâ\200\231s a question I get so frequently,Â Â
1:21
I made a video about that specifically.
1:24
For now, letâ\200\231s stick with the particles that areÂ stable. Those are the ones that we are made of,Â Â
1:30
electrons, up and down quarks,Â and photons and gluons to holdÂ Â
1:34
them together. And good thing theyâ\200\231reÂ stable because otherwise youâ\200\231d be moreÂ Â
1:39
radiant than a nuclear fuel rod.Â Youâ\200\231d also be dead very quickly.
1:43
Ok, so humans are one big collection ofÂ particles. What the particles do is describedÂ Â
1:49
by the mathematics of the standard model. Itâ\200\231sÂ a lot of maths, and you need that maths if youÂ Â
1:55
want to answer difficult questions like whatâ\200\231sÂ going on in LHC collisions. For simple questions,Â Â
2:01
like whether free will exists, we donâ\200\231t need toÂ know much about the maths. Relevant is just that,Â Â
2:08
ultimately, what you and I do isÂ also described by the standard model.
2:12
And yes, that means that we knowÂ the equations for human behaviour.Â Â
2:16

We can write them down. In practice,Â thatâ\200\231s a completely useless statement,Â Â
2:20
because we canâ\200\231t solve the equations forÂ all these 10 to the 30 or so particles thatÂ Â
2:25
humans are made of. Not even the biggestÂ supercomputer in the world could do that.
2:29
But we donâ\200\231t need to solve the equations toÂ draw conclusions from their properties. For theÂ Â
2:36
purposes of this video, the most relevant propertyÂ of these equations is that they are deterministic,Â Â
2:42
which means that if you know the propertiesÂ and motions of the particles at one time,Â Â
2:47
you can calculate what happens at any later time. Ok, it isnâ\200\231t quite as simple. Because this isÂ Â
2:54
quantum physics, so on top of this deterministicÂ behaviour, thereâ\200\231s an occasional quantum jumpÂ Â
2:59
which happens randomly whenever you makeÂ a measurement. Yâ\200\231all know that I donâ\200\231tÂ Â
3:04
believe this stuff with the quantum jumps.Â But today Iâ\200\231ll stick with the most generallyÂ Â
3:09
accepted theory. So, we have particles thatÂ behave deterministically plus random jumps.
3:15
In quantum mechanics we use wave-functions toÂ describe the particles, and this implies thatÂ Â
3:22
there are some quantities, like positionÂ and momentum, whose values you canâ\200\231t knowÂ Â
3:27
precisely at the same time. But the wave-functionÂ still changes deterministically. If you want,Â Â
3:35
you can include gravity, but that is just aÂ deterministic theory. A non-quantum theory,Â Â
3:41
or a â\200\234classicalâ\200\235 theory as physicists say. So,Â gravity just adds some more determinism on top.
3:47
And thatâ\200\231s how the universe works,Â for all we currently know. Itâ\200\231s oneÂ Â
3:51
big wave-function that contains allÂ those particles. Its change in timeÂ Â
3:56
is deterministic with the occasional randomÂ jump. The deterministic part is fixed by theÂ Â
4:02
past. The random jumps cannot be influencedÂ by anything because thatâ\200\231s what it means forÂ Â
4:08
them to be random. And thatâ\200\231s it. Please donâ\200\231tÂ blame me for this. I swear it wasnâ\200\231t my idea.

Emergence

4:14
Physics is great, but it doesnâ\200\231t tell you muchÂ about human anatomy, other than possibly thatÂ Â
4:20
flapping your arms wonâ\200\231t make you fly. Thatâ\200\231sÂ because if you combine many particles, thenÂ Â
4:26
things get very complicated very quickly. You getÂ new, â\200\234emergentâ\200\235 behaviour as itâ\200\231s often called.
4:32
You donâ\200\231t even need to look at difficult thingsÂ like human beings to see that.

If you do as muchÂ Â
4:38
as combine atoms to big chunks called metalsÂ you get new behaviour, like the ability to Â Â
4:44
conduct electricity. Or being very shiny. OrÂ being very painful if they fall on your foot.Â
4:50
Emergent properties donâ\200\231t existÂ on the level of the constituents,Â Â
4:54
they arise from the properties andÂ interactions of the constitution. AÂ Â
4:59
single electron doesnâ\200\231t have a conductivity.Â That just doesnâ\200\231t make sense. ConductivityÂ Â
5:05
is a property that only makes senseÂ for large collections of electrons.
5:10
It doesnâ\200\231t make sense to talk about theÂ conductivity of an electron for the same Â Â
5:14
reason it doesnâ\200\231t make sense to ask whetherÂ a single oxygen atom is a gas, or whatâ\200\231s theÂ Â
5:20
marital status of your small intestine. Itâ\200\231sÂ what philosophers call a â\200\234category errorâ\200\235. Itâ\200\231dÂ Â
5:27
be trying to assign a property to a class toÂ which it doesnâ\200\231t belong. Emergent propertiesÂ Â
5:32
donâ\200\231t make sense on the underlying levels. ButÂ that doesnâ\200\231t mean they donâ\200\231t exist. Chairs exist,Â Â
5:40
alright, but they exist on the macroscopic level,Â and not on the level of elementary particles.
5:45
Curiously enough, our universe is organizedÂ so that the details of what happens at shortÂ Â
5:51
distances become less important at largeÂ distances. This is why, if you want toÂ Â
5:57
understand planetary motion you donâ\200\231t need toÂ know the population of New York City. This is why,Â Â
6:03
if you want to understand chemical reactions youÂ donâ\200\231t need to know the standard model of particleÂ Â
6:08
physics. And this is why, if you want to becomeÂ a YouTuber, you donâ\200\231t need to know anything.
6:14
Physicists call it the â\200\234decoupling ofÂ scalesâ\200\235, the mysterious but empiricallyÂ Â
6:19
well-confirmed fact that the detailsÂ of what goes on small scales can beÂ Â
6:25
disregarded if youâ\200\231re only interestedÂ in what happens on large scales. AndÂ Â
6:29
this is why we have so many disciplinesÂ of science. Because each discipline ofÂ Â
6:34
science has its own language about emergentÂ properties that are adequate to its subject.
6:39
But that we get new, emergent, propertiesÂ from the interactions of the constituents,Â Â
6:45
doesnâ\200\231t mean the equations that determineÂ the behaviour of the constituents no longerÂ Â
6:50
apply. Emergent behaviour is a consequenceÂ of combining large numbers of particles with Â Â
6:56

complicated interactions. It *follows from theÂ underlying laws, it doesnâ\200\231t make them go away.Â
7:02
Some philosophers have speculated that largeÂ systems could have emergent behaviours whi chÂ Â
7:08
*donâ\200\231t follow from the laws of theÂ constituents. This is sometimesÂ Â
7:12
called â\200\234strong emergenceâ\200\235. But there is noÂ evidence this happens in the real world.
7:18
Though there are some mathematicalÂ examples. If you have an infiniteÂ Â
7:22
number of constituents or an infiniteÂ number of properties of the constituents,Â Â
7:27
or anything else being actually infinite,Â there are cases where it becomes impossibleÂ Â
7:32
to calculate one or the other quantity of theÂ entire system. A few examples for this ha veÂ Â
7:39
been constructed in the literature. Usually, theÂ proof works by a map to the halting pr oblems orÂ Â
7:45
similar examples of computational complexity.Â However, those are mathematical construct ionsÂ Â
7:52
that have no real-world counterpart because inÂ the real world nothing is ever truly inf inite.
7:57
Ok, so emergent properties are an interestingÂ consequence of the underlying laws, but w eâ\200\231reÂ Â
8:04
still governed by a mix of determinism andÂ indeterminism. What does this mean for free will?
Free Will?
8:10
Free will is often described as theÂ possibility that one could have doneÂ Â
8:14
otherwise. But this description stoppedÂ being useful with quantum mechanics,Â Â
8:19
because itâ\200\231d mean that singleÂ particles also have free will.
8:23
If you take for example a photon, a single quantumÂ of light, and you send it through a beam splitter,Â Â
8:29
then thereâ\200\231s a 50 percent chance theÂ photon goes left and 50 percent chanceÂ Â
8:34
the photon goes right. If you measureÂ the photon on the left you can say, well,Â Â
8:39
it could have done otherwise. It could have goneÂ right, right? Does that mean it has fr ee will?Â Â
8:46
Well, Iâ\200\231d say thatâ\200\231s not whatÂ normal people would call free will,Â Â
8:51
though some physicists actually believe thatÂ photons are observers. One of the conseque ncesÂ Â
8:57
of that is that theyâ\200\231ve concluded reality doesnâ\200\231tÂ exist. I talked about this in an earlier video.
9:02
This is also what happens in the â\200\234Free WillÂ Theoremâ\200\235. This theorem was mathematicallyÂ Â
9:08
proved by John Conway and Simon Kochen inÂ 2006. It says that if humans have free will,Â Â
9:14
then elementary particles also have free will.Â But the statement of the theorem is logi callyÂ Â
9:20

equivalent to the statement, â\200\234If particles doÂ not have free will, then neither have humans.â\200\235Â Â
9:26
I donâ\200\231t know about you, but toÂ me it seems reasonable to assumeÂ Â
9:29
that particles do not have freeÂ will. And either way you put it,Â Â
9:33
the free will theorem says nothing about theÂ existence of free will in the first place.
9:38
So letâ\200\231s return to the question of what we meanÂ by free will. We have seen that the idea that youÂ Â
9:44
could have done otherwise or that your actionsÂ were not determined is not descriptive because Â Â
9:49
of this random element from quantum mechanics.Â Contemporary philosophers have therefore tried toÂ Â
9:55
capture the essence of free will in the ideaÂ that human decisions are to a large extent Â Â
10:01
independent from external factors, and insteadÂ dominantly driven by internal deliberation.
10:07
Different philosophers have putÂ somewhat different spins on thisÂ Â
10:11
story. But it always comes down to theÂ idea that human decisions are difficult,Â Â
10:16
if not impossible, to predict fromÂ external input and observations alone.
10:21
The philosopher Daniel Dennett for exampleÂ captures the essence of free will in ourÂ Â
10:26
â\200\234ability to see probable futures â\200\223 futuresÂ that seem like theyâ\200\231re going to happenâ\200\235 andÂ Â
10:33
then the possibility to take steps thatÂ something else happens instead, like,Â Â
10:38
for example an autonomous vehicle does.Â The philosopher Jennan Ismael has evenÂ Â
10:43
written a book called â\200\234How Physics Makes UsÂ Freeâ\200\235. She basically says that free will liesÂ Â
10:49
in the large degree of autonomy that our brainÂ has from environmental factors as it operates.
10:55
Those are typical examples ofÂ what is called â\200\234compatibilismâ\200\235,Â Â
10:59
thatâ\200\231s the philosophy that free will isÂ compatible with the laws of nature as they are,Â Â
11:05
a mixture of determinism and indeterminism. MostÂ contemporary philosophers are compatibilists.Â Â
11:12
According to a 2020 survey, almost 60Â percent. But itâ\200\231s not like this is a new idea,Â Â
11:17
well known philosophers like David HumeÂ and John Stuart Mill were compatibilists.
11:23
The other big camp is that of libertarianism,Â whose supporters also believe in free will.Â Â
11:28
Their philosophy comes in several variants.Â First, there are those who insist thatÂ Â
11:34
the randomness of quantum mechanicsÂ makes place for free will. As I said,Â Â
11:38
I donâ\200\231t see how this makes sense. Then thereÂ are those who acknowledge that an element ofÂ Â
11:44
indeterminism doesnâ\200\231t entail free will, butÂ who then throw out some established science toÂ Â

11:50
make place for miracles. Like for example theÂ ability to change the past by your though
ts.
11:56
And then there are those who just insist that freeÂ will exists but itâ\200\231s nonphys
ical. The latter isÂ Â
12:03
a well-trodden road. For example, Rene DescartesÂ and Immanuel Kant were both in that ca
mp. Iâ\200\231d sayÂ Â
12:10
the idea is not wrong, but I never understoodÂ what the point is. Because if free will i
s notÂ Â
12:15
physical it doesnâ\200\231t explain anything in theÂ physical world, so why bother inven
ting it?
12:20
I am in neither of those camps. The scienceÂ writer John Horgan once called me a â\200
\234freeÂ Â
12:25
will denierâ\200\235. I think thatâ\200\231s a misunderstanding.Â Itâ\200\231s not that
Iâ\200\231m denying people feel like theyÂ Â
12:31
have free will. But Iâ\200\231m with libertariansÂ in that I think free will is incompat
ibleÂ Â
12:37
with determinism. I also think itâ\200\231sÂ incompatible with indeterminism. AndÂ Â
12:41
since the real world is governed by a mixtureÂ of determinism and indeterminism, I arriv
e atÂ Â
12:47
the conclusion that free will doesnâ\200\231t exist.Â Itâ\200\231s sometimes called â
\200\234hard incompatibilismâ\200\235.
12:52
The good thing about hard incompatibilism is thatÂ Â
12:56
you donâ\200\231t need to explain what free willÂ is in any detail. You just need to say
:Â Â
13:01
whatever it is, it isnâ\200\231t compatible withÂ what we know about the laws of nature.
13:06
That said, I donâ\200\231t have a problemÂ with compatibilism. If you wantÂ Â
13:10
to define whatever as free will, please go ahead,Â Â
13:14
itâ\200\231s just a definition after all. If yourÂ definition leads you to the conclusio
n thatÂ Â
13:19
photons also have free will Iâ\200\231d find that aÂ tad bit ridiculous but maybe thatâ
\200\231s just me.Â
13:24
I should add that when neurologist discussÂ the question of free will they talk aboutÂ Â

13:29
something else entirely. They are concernedÂ with the question whether we make decisions
Â Â
13:35
consciously or unconsciously. InterestingÂ question, but not what Iâ\200\231m talking ab
out today
13:40
I recently gave an interview and the guyÂ said to me if free will doesnâ\200\231t exist,
Â Â
Decisions, Decisions
13:46
why donâ\200\231t I kill myself tomorrow because whatâ\200\231sÂ the point of anything.
This isnâ\200\231t a joke,Â Â
13:52
it actually happened. It wasnâ\200\231t even the firstÂ time people said something like
this to me.Â Â
13:57
And Iâ\200\231m afraid it wonâ\200\231t be the last time. WhichÂ is why Iâ\200\231m here

talking about free will again.
14:03
Iâ\200\231m not a psychologist. Iâ\200\231m a physicist.Â I donâ\200\231t know what to say to people whoÂ Â
14:08
have existential angst other than,Â please see a psychologist. Iâ\200\231m notÂ Â
14:13
a philosopher either. For what I amÂ concerned, if free will doesnâ\200\231t exist,Â Â
14:17
itâ\200\231s never existed, so what differenceÂ could it possibly make for your life.
14:22
I believe the problem is that many ofÂ us have grown up thinking our brainÂ Â
14:27
works in a particular way. Then we learnÂ that this isnâ\200\231t compatible with science,Â Â
14:32
and we have a hard time readjustingÂ how we think about ourselves.
14:37
The free will story suggests that the brainÂ works like this. You use your neural circuitsÂ Â
14:43
to consider different options, for example, whatÂ you could eat for lunch. You draw on your memory,Â Â
14:49
and the associations you have for eachÂ possible option, and try to imagine howÂ Â
14:54
much you would enjoy it. Then you take thisÂ thing called â\200\234free willâ\200\235 and use it to pick one.Â Â
15:01
The challenge is now to integrateÂ the knowledge that the thing youÂ Â
15:05
call free will is just another part of thisÂ algorithm that runs in your neural circuits.
15:10
A good way Iâ\200\231ve found to make sense of this goesÂ back to Wittgenstein. We canâ\200\231t know the resultÂ Â
15:17
of a calculation that our brain performs beforeÂ we have completed the calculation. If we did,Â Â
15:23
we wouldnâ\200\231t have to do the calculation.Â This is why we have the impression that theÂ Â
15:28
decision is â\200\234freeâ\200\235 until weâ\200\231ve arrived at theÂ conclusion. But the result ultimately followsÂ Â
15:34
from deterministic brain functions,Â with the occasional random element.
15:38
If that sounds weird, all it means isÂ that our decisions follow from what weÂ Â
15:44
want. And I think thatâ\200\231s a good thing. Iâ\200\231dÂ find it creepy if there was something else,Â Â
15:49
call it free will or whatever, thatÂ would affect the decisions in my brain.Â
15:53
So that you donâ\200\231t have free will doesnâ\200\231tÂ mean you donâ\200\231t make decisions. Of course,Â Â
15:59
you make decisions. You decided to watch thisÂ video, didnâ\200\231t you? Good choice by the way.
16:04
Did the Big Bang made me do this video?Â Â
16:07
No. Thatâ\200\231s because all those structures in theÂ universe, including this planet and life on it,Â Â
16:14
were created by quantum fluctuations in theÂ plasma in the early universe. Their detailsÂ Â
16:19
were not determined at the Big Bang, if thereÂ was a Big Bang. Itâ\200\231s also extreme

ly likely thatÂ Â
16:25
one or the other quantum event played a role forÂ the world becoming just exactly as it is today.
16:30
Why does it matter? It matters becauseÂ to come to good decisions we need toÂ Â
Why Does it Matter?
16:36
understand how our own brain works, and howÂ society works overall. And the idea of free Â Â
16:43
will suggests an inaccurate descriptionÂ of reality. It makes people believe theyÂ Â
16:48
have more control over what goes onÂ in their head than is really the case.
16:52
Fact is that our brains will process inputÂ whether we want that or not. Once itâ\200\231s in,Â Â
16:58
we canâ\200\231t get it out. This is why trauma is so hardÂ to cope with. This is why misinformation is soÂ Â
17:04
hard to combat. This is why what the FIFA calledÂ â\200\234three victorious hands around a soccer ballâ\200\235Â Â
17:10
will forever look like a facepalm once someoneÂ told you it does. You canâ\200\231t â\200\234unseeâ\200\235 something.
17:16
And this is also why I take issue with upbeatÂ climate change activists, who attack realistsÂ Â
17:23
as â\200\234doomersâ\200\235 because they believe we justÂ need the â\200\234willâ\200\235 to take action. The ideaÂ Â
17:29
that â\200\234willâ\200\235 is all we need has led to utopianÂ plans for staggering amounts of carbon capture,Â Â
17:35
home insulation and renovation, upgradesÂ of the electric grid, energy storage,Â Â
17:40
and a hydrogen economy, all of which isÂ somehow magically supposed to pop outÂ Â
17:45
of nowhere if we just have the â\200\234willâ\200\235.Â This belief in free will puts the blameÂ Â
17:52
on individuals when really the problem isÂ the way that weâ\200\231ve organized our societies.
17:57
Iâ\200\231d say it isnâ\200\231t me who is a problem forÂ action on climate change, itâ\200\231s people whoÂ Â
18:03
disregard the limits of human cognitiveÂ ability. I have a chapter about free willÂ Â
18:08
in my book â\200\234Existential Physicsâ\200\235 where I alsoÂ discuss the question of moral responsibility,Â Â
18:13
so if you want to know more, go check this out.
Learn More With Brilliant
18:16
The reason why the laws of physics areÂ deterministic, plus that random element,Â Â
18:20
is that they are based on differentialÂ equations. If you want to know moreÂ Â
18:25
about how they work, thereâ\200\231s a great courseÂ about differential equations on Brilliant.Â
18:30
Brilliant.org offers courses on a large varietyÂ of topics in science and mathematics. Itâ\200\231s aÂ Â
18:36
fresh and new approach to learning withÂ interactive visualizations and follow-upÂ Â
18:40
questions. Iâ\200\231ve found it to be a highly effectiveÂ way to understand and also to

remember material.Â Â
18:47
If you want to know more about the physicsÂ behind this video, check out for exampleÂ Â
18:52
their course on differential equations.Â Itâ\200\231s full of examples from many differentÂ Â
18:57
areas of science and it gives you a step-by-stepÂ guide to understanding how these equations work.
19:03
If you want to know more about quantumÂ mechanics, you might want to try my course,Â Â
19:08
thatâ\200\231s an introduction to quantum mechanics.Â It starts from the very basics and doesnâ\200\231tÂ Â
19:14
require you to bring background knowledge.Â My course covers topics such as interference,Â Â
19:19
superpositions and entanglement, the uncertaintyÂ principle, and Bellâ\200\231s theorem. And afterwards,Â Â
19:25
maybe you want to continue learning moreÂ about quantum computing or special relativity.Â
19:31
If you’re interested in trying Brilliant out, useÂ our link Brilliant.org slash Sabine and sign upÂ Â
19:37
for free. You’ll get to try out everythingÂ Brilliant has to offer for 30 days, and theÂ Â
19:42
first 200 subscribers using this link will getÂ 20 percent off the annual premium subscription.
19:47
Thanks for watching, see you next week.