



1
00:00:25,030 --> 00:00:16,080

[Music]

2
00:00:27,519 --> 00:00:25,040

so I'm talking here about my matter

3
00:00:28,420 --> 00:00:27,529

interaction experiments with light some

4
00:00:30,280 --> 00:00:28,430

of what I'm gonna say is a

5
00:00:32,589 --> 00:00:30,290

recapitulation of the two talks that you

6
00:00:38,040 --> 00:00:32,599

just heard there shall be pictures of

7
00:00:40,240 --> 00:00:38,050

cats but but only two pictures of cats

8
00:00:42,420 --> 00:00:40,250

so I'm going to talk about three things

9
00:00:44,350 --> 00:00:42,430

first of all a mystery in physics

10
00:00:46,900 --> 00:00:44,360

interpretations of the mysteries and

11
00:00:50,080 --> 00:00:46,910

then experiments involving them the

12
00:00:52,930 --> 00:00:50,090

mystery as Richard Fineman said is

13
00:00:55,360 --> 00:00:52,940

absolutely impossible to explain in any

14

00:00:57,460 --> 00:00:55,370

classical way and which has it at the

15

00:01:01,210 --> 00:00:57,470

heart of quantum mechanics in reality it

16

00:01:02,920 --> 00:01:01,220

contains the only mystery in terms of

17

00:01:05,380 --> 00:01:02,930

the interpretations of this mystery

18

00:01:08,289 --> 00:01:05,390

there are ideas like many worlds

19

00:01:10,149 --> 00:01:08,299

hypothesis decoherence Copenhagen

20

00:01:12,249 --> 00:01:10,159

interpretation and the one that I'll

21

00:01:15,340 --> 00:01:12,259

focus on most is the one that proposed

22

00:01:16,809 --> 00:01:15,350

by John von Neumann and presented in

23

00:01:18,340 --> 00:01:16,819

among other places in his book the

24

00:01:21,520 --> 00:01:18,350

mathematical foundations of quantum

25

00:01:23,739 --> 00:01:21,530

mechanics in terms of experiments I'm

26
00:01:26,440 --> 00:01:23,749
going to talk about work that we've been

27
00:01:28,289 --> 00:01:26,450
doing for the last almost seven years

28
00:01:30,699 --> 00:01:28,299
now

29
00:01:32,109 --> 00:01:30,709
so let's look in more detail about the

30
00:01:35,139 --> 00:01:32,119
mystery the mystery of course is the

31
00:01:37,269 --> 00:01:35,149
quantum measurement problem and to talk

32
00:01:40,899 --> 00:01:37,279
about this in terms that everyone can

33
00:01:42,669 --> 00:01:40,909
understand they'll use cows the cows

34
00:01:46,029 --> 00:01:42,679
behave in a certain way provided that

35
00:01:47,949 --> 00:01:46,039
there's no one watching when somebody

36
00:01:51,399 --> 00:01:47,959
comes by the cows act in a different way

37
00:01:52,569 --> 00:01:51,409
and then they go back in a different way

38
00:01:55,269 --> 00:01:52,579

when they're not being watched anymore

39

00:01:57,160 --> 00:01:55,279

so this is one of the problems that this

40

00:01:59,019 --> 00:01:57,170

doesn't just happen for cows it also

41

00:02:01,690 --> 00:01:59,029

happens for elementary particles

42

00:02:03,519 --> 00:02:01,700

electrons photons and so on the other

43

00:02:06,849 --> 00:02:03,529

part of the problem or the mystery is

44

00:02:10,029 --> 00:02:06,859

that photons and elementary particles

45

00:02:12,550 --> 00:02:10,039

can simultaneously be in two different

46

00:02:15,130 --> 00:02:12,560

states so this is like wave particle

47

00:02:19,470 --> 00:02:15,140

though your skier is a particle but can

48

00:02:25,660 --> 00:02:23,979

if you take golf balls and you shoot

49

00:02:27,490 --> 00:02:25,670

them through two slits then you would

50

00:02:28,959 --> 00:02:27,500

expect that when you look at the other

51
00:02:32,470 --> 00:02:28,969
side of the screen that you'll get two

52
00:02:34,690 --> 00:02:32,480
bands of golf ball hits and the same is

53
00:02:37,089 --> 00:02:34,700
true for light provided that you're

54
00:02:38,349 --> 00:02:37,099
looking where each photon goes but if

55
00:02:40,300 --> 00:02:38,359
you don't look then you get this

56
00:02:42,069 --> 00:02:40,310
interference pattern so this is the same

57
00:02:43,569 --> 00:02:42,079
thing about the cows whether you look or

58
00:02:46,479 --> 00:02:43,579
don't look you get different kinds of

59
00:02:49,449 --> 00:02:46,489
distributions so the path is knowable

60
00:02:51,550 --> 00:02:49,459
and photons behave like particles if

61
00:02:55,210 --> 00:02:51,560
it's unknowable photons behave like

62
00:02:56,830 --> 00:02:55,220
waves you actually do this in the

63
00:02:58,569 --> 00:02:56,840

laboratory and use something like a

64

00:03:01,659 --> 00:02:58,579

double slit system with a laser on the

65

00:03:03,460 --> 00:03:01,669

top you see the particle pattern like a

66

00:03:05,409 --> 00:03:03,470

single slit pattern and the bottom is a

67

00:03:10,059 --> 00:03:05,419

double slit pattern where both slits are

68

00:03:11,949 --> 00:03:10,069

open that's what it looks like so all of

69

00:03:14,259 --> 00:03:11,959

this has something to do with words like

70

00:03:17,770 --> 00:03:14,269

knowledge information observation

71

00:03:18,670 --> 00:03:17,780

measurement and they're related in there

72

00:03:20,860 --> 00:03:18,680

I mean they're semantically different

73

00:03:23,680 --> 00:03:20,870

but they're related in ways that we we

74

00:03:25,659 --> 00:03:23,690

kind of grok and we grok it in terms of

75

00:03:29,379 --> 00:03:25,669

this like where we're information

76

00:03:31,780 --> 00:03:29,389

processing machines kind of and we what

77

00:03:33,580 --> 00:03:31,790

we do involves knowledge information and

78

00:03:38,670 --> 00:03:33,590

observation and that then becomes a link

79

00:03:43,149 --> 00:03:41,589

so now let's look at interpretations in

80

00:03:45,129 --> 00:03:43,159

a little more detail in particular the

81

00:03:46,240 --> 00:03:45,139

one button john von neumann he had this

82

00:03:48,879 --> 00:03:46,250

principle of what he called

83

00:03:50,920 --> 00:03:48,889

psychophysical parallelism where

84

00:03:53,469 --> 00:03:50,930

consciousness collapses the quantum

85

00:03:58,629 --> 00:03:53,479

wave-like behavior into a classical

86

00:04:00,309 --> 00:03:58,639

particle like behavior what's your

87

00:04:02,020 --> 00:04:00,319

opinion of the importance of the quantum

88

00:04:06,009 --> 00:04:02,030

measurement problem this was asked at a

89

00:04:07,390 --> 00:04:06,019

conference in 2011 by Zeilinger 33

90

00:04:09,069 --> 00:04:07,400

people were present these are all

91

00:04:11,379 --> 00:04:09,079

specialists and the foundations of

92

00:04:13,179 --> 00:04:11,389

quantum mechanics and they gave a

93

00:04:14,559 --> 00:04:13,189

variety of answers and the reason I

94

00:04:16,629 --> 00:04:14,569

bring this up is because sometimes

95

00:04:18,039 --> 00:04:16,639

physicists might say well the quantum

96

00:04:20,499 --> 00:04:18,049

measurement problem has been solved by

97

00:04:22,330 --> 00:04:20,509

this or it's been solved by that and

98

00:04:24,370 --> 00:04:22,340

what are the specialists say actually

99

00:04:26,890 --> 00:04:24,380

you can see by their responses that

100

00:04:30,219 --> 00:04:26,900

there there is no clear consensus and

101

00:04:32,679 --> 00:04:30,229

the interesting response is this it's a

102

00:04:35,320 --> 00:04:32,689

severe difficulty threatening or under

103

00:04:37,719 --> 00:04:35,330

standing of quantum mechanics so even

104

00:04:40,389 --> 00:04:37,729

among specialists there is first of all

105

00:04:42,549 --> 00:04:40,399

no consensus no clear consensus and also

106

00:04:44,739 --> 00:04:42,559

some like a quarter of the people

107

00:04:48,999 --> 00:04:44,749

responding said this is a very important

108

00:04:50,499 --> 00:04:49,009

problem that is not yet resolved and

109

00:04:54,309 --> 00:04:50,509

then he asked the philosophers like

110

00:04:55,779 --> 00:04:54,319

David Chalmers he says that the hard

111

00:04:58,509 --> 00:04:55,789

problem of consciousness has already

112

00:05:00,459 --> 00:04:58,519

been raised it's about subjectivity so

113

00:05:04,479 --> 00:05:00,469

he proposes we might need one or two

114

00:05:06,459 --> 00:05:04,489

ideas that might seem crazy his crazy

115

00:05:08,199 --> 00:05:06,469

idea is the same as John von neumann's

116

00:05:10,089 --> 00:05:08,209

and Vig neurs and others that

117

00:05:13,059 --> 00:05:10,099

consciousness may be fundamental in some

118

00:05:19,359 --> 00:05:13,069

way that physics is not yet able to deal

119

00:05:20,529 --> 00:05:19,369

with so what about experiments the

120

00:05:22,449 --> 00:05:20,539

experiments that we've been doing have

121

00:05:25,239 --> 00:05:22,459

been looking at what we might call the

122

00:05:27,399 --> 00:05:25,249

observer effect those pure subjectivity

123

00:05:30,369 --> 00:05:27,409

collapse the quantum wave function or

124

00:05:31,509 --> 00:05:30,379

not you would think that within physics

125

00:05:33,039 --> 00:05:31,519

given that this is an outstanding

126
00:05:34,959 --> 00:05:33,049
problem that there would be many many

127
00:05:38,049 --> 00:05:34,969
experiments in the physics literature

128
00:05:40,929 --> 00:05:38,059
and there are a couple but with one

129
00:05:43,540 --> 00:05:40,939
exception all of them are involved

130
00:05:48,579 --> 00:05:43,550
people who are doing parapsychology and

131
00:05:49,839 --> 00:05:48,589
not physics and here's here's one cat

132
00:05:51,729 --> 00:05:49,849
but it's a cartoon cat

133
00:05:53,379 --> 00:05:51,739
so with Schrodinger's cat paradox what

134
00:05:55,529 --> 00:05:53,389
we're interested in is can we select a

135
00:05:58,059 --> 00:05:55,539
preferred outcome by mental means alone

136
00:06:00,850 --> 00:05:58,069
so we're going to try to select that

137
00:06:04,029 --> 00:06:00,860
outcome part of what I'm talking about

138
00:06:05,319 --> 00:06:04,039

here I had mentioned in a talk at SSC a

139

00:06:06,819 --> 00:06:05,329

few years ago and I'm going to go

140

00:06:10,119 --> 00:06:06,829

quickly through that and then bring you

141

00:06:15,300 --> 00:06:10,129

up up to speed on the latest work so no

142

00:06:20,590 --> 00:06:17,860

and instead we use a Michelson

143

00:06:23,740 --> 00:06:20,600

interferometer instead of a cat so this

144

00:06:24,790 --> 00:06:23,750

is a very nice interferometer you send a

145

00:06:27,040 --> 00:06:24,800

light beam through there through a

146

00:06:29,290 --> 00:06:27,050

half-silvered mirror and so part of the

147

00:06:30,970 --> 00:06:29,300

beam is reflected to a solid mirror and

148

00:06:34,090 --> 00:06:30,980

the other part goes through to a solid

149

00:06:35,860 --> 00:06:34,100

mirror and then the two beams combine

150

00:06:37,510 --> 00:06:35,870

and you get a nice interference pattern

151
00:06:39,520 --> 00:06:37,520
which in this particular design comes

152
00:06:43,030 --> 00:06:39,530
out as a concentric circle so there's

153
00:06:45,280 --> 00:06:43,040
the interference pattern so the idea in

154
00:06:47,890 --> 00:06:45,290
this sort of experiment is that you have

155
00:06:50,170 --> 00:06:47,900
the optical apparatus inside some sealed

156
00:06:51,910 --> 00:06:50,180
container in this case it's inside our

157
00:06:54,480 --> 00:06:51,920
shield electromagnetically shielded room

158
00:06:57,250 --> 00:06:54,490
which also in this case was white tight

159
00:07:00,370 --> 00:06:57,260
and then outside the room we have a

160
00:07:03,190 --> 00:07:00,380
person we tell them to put your mind in

161
00:07:05,380 --> 00:07:03,200
the arm of the interferometer and we're

162
00:07:07,000 --> 00:07:05,390
using interferometer this particular one

163
00:07:08,470 --> 00:07:07,010

in this experiment because it's big

164

00:07:11,620 --> 00:07:08,480

enough so you can tell somebody it's

165

00:07:13,330 --> 00:07:11,630

about the size of a grapefruit it's a

166

00:07:15,430 --> 00:07:13,340

big space where you need to put your

167

00:07:17,110 --> 00:07:15,440

mind so it's easy to describe what to do

168

00:07:19,060 --> 00:07:17,120

with it and when your mind is there

169

00:07:20,770 --> 00:07:19,070

imagine you can see the photons if you

170

00:07:22,600 --> 00:07:20,780

can and you're gaining which path

171

00:07:24,070 --> 00:07:22,610

information out of the system and you

172

00:07:27,370 --> 00:07:24,080

would so-called collapse the wave

173

00:07:30,370 --> 00:07:27,380

function their job is to gain knowledge

174

00:07:32,710 --> 00:07:30,380

some people can't do this task very well

175

00:07:34,210 --> 00:07:32,720

they get confused with the idea that in

176

00:07:35,620 --> 00:07:34,220

their minds eye they have to see a

177

00:07:37,750 --> 00:07:35,630

photon well they don't know how to do

178

00:07:39,660 --> 00:07:37,760

that so I said okay if you can't do that

179

00:07:42,070 --> 00:07:39,670

imagine you can block the photons

180

00:07:45,010 --> 00:07:42,080

imagine you can move on imagine you can

181

00:07:47,050 --> 00:07:45,020

do anything with the photons and so

182

00:07:50,350 --> 00:07:47,060

people figure out themselves what

183

00:07:52,540 --> 00:07:50,360

they're going to do so under calibration

184

00:07:56,020 --> 00:07:52,550

conditions you run the system under

185

00:07:58,210 --> 00:07:56,030

conditions where you ask in this case no

186

00:08:00,190 --> 00:07:58,220

one there but you ask them to observe

187

00:08:02,170 --> 00:08:00,200

with your mind's eye and then rest and

188

00:08:04,150 --> 00:08:02,180

withdraw your attention and now observe

189

00:08:06,040 --> 00:08:04,160

again withdraw your attention for

190

00:08:08,800 --> 00:08:06,050

roughly 30 seconds to a minute at a time

191

00:08:10,810 --> 00:08:08,810

and you see how the system behaves it

192

00:08:12,730 --> 00:08:10,820

should show no change at all and in fact

193

00:08:15,280 --> 00:08:12,740

this is calibration condition there's no

194

00:08:16,900 --> 00:08:15,290

change in the interference pattern but

195

00:08:18,730 --> 00:08:16,910

when you ask a person to do this under

196

00:08:20,380 --> 00:08:18,740

experimental conditions the line on the

197

00:08:22,930 --> 00:08:20,390

bottom here is what happens when a

198

00:08:23,560 --> 00:08:22,940

highly experienced meditator did this

199

00:08:25,490 --> 00:08:23,570

task

200

00:08:28,100 --> 00:08:25,500

now this meditator is

201
00:08:29,450 --> 00:08:28,110
at the time is probably about 75 years

202
00:08:32,810 --> 00:08:29,460
old and he said that he had been

203
00:08:38,899 --> 00:08:32,820
meditating about 70 years not

204
00:08:41,149 --> 00:08:38,909
continually but but enough so that he's

205
00:08:42,680 --> 00:08:41,159
able to go into a state which in the

206
00:08:45,050 --> 00:08:42,690
yogic tradition would be called a city

207
00:08:47,870 --> 00:08:45,060
he's able to do the the special yoga

208
00:08:50,030 --> 00:08:47,880
super powers which involves manipulation

209
00:08:52,550 --> 00:08:50,040
of mind and matter so he did that in

210
00:08:56,630 --> 00:08:52,560
this in this case and we've got a very

211
00:08:59,630 --> 00:08:56,640
good result we're an non-meditators and

212
00:09:01,100 --> 00:08:59,640
meditators partially because we expect

213
00:09:03,530 --> 00:09:01,110

that meditators have attention training

214

00:09:05,780 --> 00:09:03,540

and this kind of experiment requires you

215

00:09:07,280 --> 00:09:05,790

focus attention so we expected they

216

00:09:09,050 --> 00:09:07,290

would do better and in fact all of the

217

00:09:11,660 --> 00:09:09,060

action and this experiment was from the

218

00:09:14,060 --> 00:09:11,670

meditators they ended up with odds

219

00:09:15,980 --> 00:09:14,070

against chance of about a hundred

220

00:09:19,340 --> 00:09:15,990

thousand to one and we published this in

221

00:09:21,680 --> 00:09:19,350

2008 so as a result of that experiment

222

00:09:24,470 --> 00:09:21,690

we decided to take the plunge and go to

223

00:09:26,570 --> 00:09:24,480

a double stoo optical system as you see

224

00:09:29,270 --> 00:09:26,580

the design is extremely simple just a

225

00:09:32,030 --> 00:09:29,280

laser accepting a filter that reduces

226

00:09:34,940 --> 00:09:32,040

the illumination level a double set and

227

00:09:37,329 --> 00:09:34,950

then a camera that's what it looks like

228

00:09:41,480 --> 00:09:37,339

laser tube is on the left

229

00:09:43,430 --> 00:09:41,490

it's a helium-neon laser and the double

230

00:09:47,390 --> 00:09:43,440

slit and the camera are inside the box

231

00:09:49,940 --> 00:09:47,400

in the middle and inside the box there's

232

00:09:52,130 --> 00:09:49,950

the holder for the double slit and

233

00:09:56,900 --> 00:09:52,140

there's also a line camera and so that's

234

00:09:59,540 --> 00:09:56,910

very simple the idea of this is on the

235

00:10:01,850 --> 00:09:59,550

top you see the intensity level of the

236

00:10:03,290 --> 00:10:01,860

camera measures it's a line camera but

237

00:10:06,230 --> 00:10:03,300

what is showing here is the intensity

238

00:10:10,340 --> 00:10:06,240

and the the pattern is the interference

239

00:10:12,650 --> 00:10:10,350

pattern on the bottom is a Fourier

240

00:10:15,440 --> 00:10:12,660

transform of the picture on the top and

241

00:10:18,860 --> 00:10:15,450

it shows three peaks middle peak is a

242

00:10:20,660 --> 00:10:18,870

double slit peak this is the single slit

243

00:10:23,180 --> 00:10:20,670

peak and the peak on the right is a

244

00:10:24,590 --> 00:10:23,190

harmonic of the double slit so this is a

245

00:10:26,900 --> 00:10:24,600

very easy way of taking an entire

246

00:10:28,760 --> 00:10:26,910

pattern doing Fourier transform and

247

00:10:30,710 --> 00:10:28,770

getting two points of interest double

248

00:10:32,750 --> 00:10:30,720

set and the single slit peaks that

249

00:10:35,300 --> 00:10:32,760

allows you to get basically capture the

250

00:10:37,490 --> 00:10:35,310

whole pattern and see how much as I call

251
00:10:42,680 --> 00:10:37,500
it double slit enos there

252
00:10:45,080 --> 00:10:42,690
is going on so we used a measure of the

253
00:10:47,780 --> 00:10:45,090
ratio between the double slit and single

254
00:10:49,070 --> 00:10:47,790
slit spectral Peaks and had the

255
00:10:50,630 --> 00:10:49,080
prediction that when somebody was

256
00:10:52,910 --> 00:10:50,640
observing the system and trying to get

257
00:10:54,410 --> 00:10:52,920
which which path knowledge out of it

258
00:10:56,510 --> 00:10:54,420
that the double said power would go down

259
00:10:59,600 --> 00:10:56,520
the single sub-par would go up so the

260
00:11:02,540 --> 00:10:59,610
ratio should go down when the mind is in

261
00:11:04,070 --> 00:11:02,550
the box so to speak so there's the

262
00:11:05,990 --> 00:11:04,080
picture of what the signal actually

263
00:11:08,900 --> 00:11:06,000

looks like over the course of around 11

264

00:11:13,210 --> 00:11:08,910

minutes we're looking at the spectral

265

00:11:15,890 --> 00:11:13,220

ratio we have assignments down here

266

00:11:19,040 --> 00:11:15,900

attention towards the box attention away

267

00:11:20,840 --> 00:11:19,050

from the box and these are automatically

268

00:11:23,510 --> 00:11:20,850

given by a computer to the participant

269

00:11:26,090 --> 00:11:23,520

and the experiment and the bottom line

270

00:11:29,180 --> 00:11:26,100

is when you look at the means of the

271

00:11:31,490 --> 00:11:29,190

that signal and the attention away

272

00:11:33,860 --> 00:11:31,500

versus the attention towards there

273

00:11:35,480 --> 00:11:33,870

should be a difference between them in a

274

00:11:37,520 --> 00:11:35,490

predictable direction maybe there should

275

00:11:39,980 --> 00:11:37,530

be less double slit power when people

276
00:11:41,270 --> 00:11:39,990
are attending toward the system that's

277
00:11:43,910 --> 00:11:41,280
because they're gaining which path

278
00:11:45,260 --> 00:11:43,920
information out of the system the signal

279
00:11:46,730 --> 00:11:45,270
looks like it's going all over the place

280
00:11:50,090 --> 00:11:46,740
but the actual variance here is only

281
00:11:51,710 --> 00:11:50,100
0.4% I just this is just an expansion of

282
00:11:55,760 --> 00:11:51,720
it so you can see the way that the

283
00:11:57,500 --> 00:11:55,770
signal moves so we did a couple of

284
00:12:00,290 --> 00:11:57,510
experiments first of all the the first

285
00:12:01,820 --> 00:12:00,300
experiment is here we were asking does

286
00:12:04,250 --> 00:12:01,830
anything happen at all when you do this

287
00:12:07,490 --> 00:12:04,260
so we had 30 sessions people did the

288
00:12:09,860 --> 00:12:07,500

experiment repeatedly the green dot show

289

00:12:12,740 --> 00:12:09,870

up yeah the green dot is all data the

290

00:12:14,720 --> 00:12:12,750

red God is meditators and the blue da is

291

00:12:17,890 --> 00:12:14,730

non-meditators so the first experiment

292

00:12:21,800 --> 00:12:17,900

did pretty well it was a modest

293

00:12:24,800 --> 00:12:21,810

significant decline as we expected as we

294

00:12:25,910 --> 00:12:24,810

hoped then we did another experiment

295

00:12:27,560 --> 00:12:25,920

which is basically the same thing

296

00:12:30,470 --> 00:12:27,570

because we looked at the first result

297

00:12:32,540 --> 00:12:30,480

and we said really that was really what

298

00:12:34,340 --> 00:12:32,550

happened well so the experiment second

299

00:12:37,579 --> 00:12:34,350

experiment overall result was basically

300

00:12:38,900 --> 00:12:37,589

the same meditators did better a third

301
00:12:40,520 --> 00:12:38,910
experiment we were a concerned that

302
00:12:43,850 --> 00:12:40,530
maybe what we're seeing is an artifact

303
00:12:46,100 --> 00:12:43,860
as a result of the participants being

304
00:12:48,230 --> 00:12:46,110
within two meters of the optical system

305
00:12:50,030 --> 00:12:48,240
and so we thought that's because

306
00:12:51,020 --> 00:12:50,040
interferometers are so sensitive to

307
00:12:52,670 --> 00:12:51,030
everything that may

308
00:12:54,320 --> 00:12:52,680
what was happening is that the

309
00:12:55,730 --> 00:12:54,330
participants were leaning forward a

310
00:12:56,960 --> 00:12:55,740
little bit when their attempt when

311
00:12:58,880 --> 00:12:56,970
they're putting their mind in the box

312
00:13:00,440 --> 00:12:58,890
and that would raise the temperature of

313
00:13:02,690 --> 00:13:00,450

the box maybe a thousandth of a degree

314

00:13:04,610 --> 00:13:02,700

and that might be enough in order to see

315

00:13:06,710 --> 00:13:04,620

the effect we were saying so we put

316

00:13:09,560 --> 00:13:06,720

thermocouples on the interferometer to

317

00:13:11,300 --> 00:13:09,570

measure the temperature changes to see

318

00:13:13,520 --> 00:13:11,310

if that was in fact what was going on

319

00:13:15,140 --> 00:13:13,530

and the answer is it was not that that

320

00:13:19,040 --> 00:13:15,150

wasn't what's happening the temperature

321

00:13:21,110 --> 00:13:19,050

wasn't changing at all so overall we get

322

00:13:23,000 --> 00:13:21,120

slightly smaller effect but still in the

323

00:13:24,650 --> 00:13:23,010

predicted direction meditators did quite

324

00:13:27,890 --> 00:13:24,660

well and in this case the non-meditators

325

00:13:30,260 --> 00:13:27,900

didn't do well at all we did the

326

00:13:33,200 --> 00:13:30,270

experiment again using a delayed choice

327

00:13:35,660 --> 00:13:33,210

version and this is a little complicated

328

00:13:37,490 --> 00:13:35,670

to wrap your brain around but the notion

329

00:13:39,740 --> 00:13:37,500

of observation in this case it doesn't

330

00:13:42,110 --> 00:13:39,750

have to take place in real time could

331

00:13:43,880 --> 00:13:42,120

take place in the future so the

332

00:13:45,950 --> 00:13:43,890

observation that took place in this

333

00:13:50,780 --> 00:13:45,960

experiment took place two months after

334

00:13:52,970 --> 00:13:50,790

the data was recorded so the meditators

335

00:13:54,530 --> 00:13:52,980

did very well in this version overall

336

00:13:57,170 --> 00:13:54,540

people did pretty well and again the

337

00:13:59,240 --> 00:13:57,180

non-meditators did not do so good we ran

338

00:14:01,670 --> 00:13:59,250

five different control tests which are

339

00:14:03,290 --> 00:14:01,680

the same apparatus the same analysis the

340

00:14:04,730 --> 00:14:03,300

same everything under conditions where

341

00:14:07,460 --> 00:14:04,740

there's nobody around just to see what

342

00:14:09,920 --> 00:14:07,470

what the box is doing and none of those

343

00:14:11,300 --> 00:14:09,930

are statistically significant and then

344

00:14:14,570 --> 00:14:11,310

overall this is what we get with the

345

00:14:16,550 --> 00:14:14,580

first four pilot studies meditators did

346

00:14:18,800 --> 00:14:16,560

extremely well that's what the p-value

347

00:14:22,250 --> 00:14:18,810

there is but even overall people did

348

00:14:24,080 --> 00:14:22,260

quite well so that encouraged us to do a

349

00:14:26,390 --> 00:14:24,090

formal experiment this is a pre planned

350

00:14:27,980 --> 00:14:26,400

experiment with 50 sessions where we

351

00:14:29,540 --> 00:14:27,990

tried to optimize the results by

352

00:14:32,210 --> 00:14:29,550

selecting the people who would do the

353

00:14:34,100 --> 00:14:32,220

experiment based on how they did in the

354

00:14:36,590 --> 00:14:34,110

pilot test so we're selecting people

355

00:14:38,780 --> 00:14:36,600

based on what we think is a mild form of

356

00:14:41,000 --> 00:14:38,790

talent and they did extremely well so

357

00:14:45,650 --> 00:14:41,010

the red dot or humans and the white dot

358

00:14:47,600 --> 00:14:45,660

there is a control a match control when

359

00:14:49,250 --> 00:14:47,610

you look at the difference between the

360

00:14:50,960 --> 00:14:49,260

meditators and non-meditators you can

361

00:14:53,620 --> 00:14:50,970

see that cumulatively the meditators

362

00:14:55,490 --> 00:14:53,630

actually did very well

363

00:14:58,220 --> 00:14:55,500

accumulating down to about four and a

364

00:15:01,490 --> 00:14:58,230

half sigma results and non-meditators

365

00:15:04,240 --> 00:15:01,500

did okay but just the they didn't get a

366

00:15:12,560 --> 00:15:06,740

so we published this in physics essays

367

00:15:14,180 --> 00:15:12,570

in 2012 and then we decided to it's very

368

00:15:15,920 --> 00:15:14,190

difficult to do this experiment and get

369

00:15:17,180 --> 00:15:15,930

four or five Sigma results and actually

370

00:15:19,400 --> 00:15:17,190

believe that that's what's happening

371

00:15:20,990 --> 00:15:19,410

because I've done many many experiments

372

00:15:24,079 --> 00:15:21,000

involving random number generators and

373

00:15:26,720 --> 00:15:24,089

you don't often get results that good so

374

00:15:28,579 --> 00:15:26,730

I maintained a certain degree of

375

00:15:30,350 --> 00:15:28,589

suspicion about what's going on here and

376

00:15:32,870 --> 00:15:30,360

we decided to we have to replicate it

377

00:15:35,660 --> 00:15:32,880

again and so we did it again again with

378

00:15:37,550 --> 00:15:35,670

selected people this time we also

379

00:15:39,499 --> 00:15:37,560

concentrated on something we're looking

380

00:15:41,900 --> 00:15:39,509

for other ways of seeing whether this is

381

00:15:43,550 --> 00:15:41,910

really what it appears to be and so one

382

00:15:45,980 --> 00:15:43,560

of the effects here is that the task

383

00:15:48,769 --> 00:15:45,990

involves asking people to put your mind

384

00:15:50,389 --> 00:15:48,779

over there and now withdraw it and now

385

00:15:51,860 --> 00:15:50,399

put it back and I withdraw and the

386

00:15:54,470 --> 00:15:51,870

machine is telling you when to do that

387

00:15:56,689 --> 00:15:54,480

if you think about it and you were asked

388

00:15:58,579 --> 00:15:56,699

to do that task you'd realize you can't

389

00:16:01,249 --> 00:15:58,589

switch your attention that quickly and

390

00:16:03,650 --> 00:16:01,259

and the cognitive world is called task

391

00:16:06,139 --> 00:16:03,660

switching cost it takes a couple of

392

00:16:07,699 --> 00:16:06,149

seconds to switch gears mentally and so

393

00:16:09,439 --> 00:16:07,709

we figured that what should be happening

394

00:16:13,040 --> 00:16:09,449

in this experiment is that we should see

395

00:16:14,990 --> 00:16:13,050

a delay in the data suggesting that if

396

00:16:16,910 --> 00:16:15,000

the people are actually taking a few

397

00:16:18,800 --> 00:16:16,920

seconds to change their attention you

398

00:16:21,470 --> 00:16:18,810

should see that delay in the in the data

399

00:16:25,100 --> 00:16:21,480

itself so we predicted something between

400

00:16:27,439 --> 00:16:25,110

two and five seconds delay and so this

401
00:16:29,990 --> 00:16:27,449
is a delay analysis or lagging from zero

402
00:16:32,000 --> 00:16:30,000
seconds to minus fifteen seconds in

403
00:16:34,879 --> 00:16:32,010
effect you see you do see a delayed in

404
00:16:36,500 --> 00:16:34,889
this case it was around two seconds two

405
00:16:39,559 --> 00:16:36,510
seconds after the instruction was given

406
00:16:41,329 --> 00:16:39,569
you actually get a better result and

407
00:16:42,769 --> 00:16:41,339
under these so that's the experimental

408
00:16:44,990 --> 00:16:42,779
data on the top we're looking at the

409
00:16:47,210 --> 00:16:45,000
control data so the controls are not

410
00:16:50,030 --> 00:16:47,220
significant the experimental data is

411
00:16:53,900 --> 00:16:50,040
very significant so this we publish and

412
00:16:56,179 --> 00:16:53,910
also in physics si is last year in that

413
00:16:58,819 --> 00:16:56,189

paper we also did an analysis of these

414

00:17:01,579 --> 00:16:58,829

data using a theoretical model you can

415

00:17:03,350 --> 00:17:01,589

do you can very precisely model this

416

00:17:07,280 --> 00:17:03,360

using wave mechanics based on a

417

00:17:09,260 --> 00:17:07,290

Fraunhofer diffraction model so there's

418

00:17:10,850 --> 00:17:09,270

what there's how you characterize the

419

00:17:14,210 --> 00:17:10,860

model these are what the equations look

420

00:17:15,890 --> 00:17:14,220

like the equation on the bottom they're

421

00:17:16,900 --> 00:17:15,900

showing the intensity level that you

422

00:17:19,900 --> 00:17:16,910

would measure

423

00:17:21,700 --> 00:17:19,910

it has three components one is the

424

00:17:23,410 --> 00:17:21,710

amount of light coming through one slit

425

00:17:25,030 --> 00:17:23,420

and one through the other slit and then

426
00:17:26,860 --> 00:17:25,040
the light coming through both slits you

427
00:17:29,830 --> 00:17:26,870
know if this allows you to partition out

428
00:17:33,430 --> 00:17:29,840
the contribution of light from each of

429
00:17:36,160 --> 00:17:33,440
the slits the model then is on the top

430
00:17:39,130 --> 00:17:36,170
you get a very nicely well-behaved and

431
00:17:41,170 --> 00:17:39,140
symmetrical interference pattern and the

432
00:17:43,540 --> 00:17:41,180
bottom is the actual data so the actual

433
00:17:46,360 --> 00:17:43,550
data is a little bit skewed it's not a

434
00:17:47,890 --> 00:17:46,370
perfectly symmetrical the Fourier

435
00:17:49,600 --> 00:17:47,900
transform which is on the right you see

436
00:17:51,670 --> 00:17:49,610
is not exactly the way the model would

437
00:17:53,200 --> 00:17:51,680
would show and the reason for this is

438
00:17:55,210 --> 00:17:53,210

because when you're working on the real

439

00:17:57,130 --> 00:17:55,220

system there's small imperfections in it

440

00:17:58,930 --> 00:17:57,140

and of course it's very very difficult

441

00:18:01,450 --> 00:17:58,940

to arrange it so it actually looks

442

00:18:03,760 --> 00:18:01,460

exactly like the theoretical model but

443

00:18:07,060 --> 00:18:03,770

it's pretty good so we modeled the data

444

00:18:10,330 --> 00:18:07,070

based on the Fraunhofer equations and

445

00:18:12,160 --> 00:18:10,340

what we come up with is is this that on

446

00:18:14,050 --> 00:18:12,170

the top when somebody is asked to relax

447

00:18:16,030 --> 00:18:14,060

and withdraw their mind from the system

448

00:18:18,250 --> 00:18:16,040

the amount of light going through two

449

00:18:19,690 --> 00:18:18,260

slits is symmetrical total amount of

450

00:18:20,890 --> 00:18:19,700

light is the same going through two

451

00:18:23,800 --> 00:18:20,900

slits that's what the model would

452

00:18:26,050 --> 00:18:23,810

predict when they concentrate though the

453

00:18:28,330 --> 00:18:26,060

amount of light becomes skewed there's

454

00:18:29,740 --> 00:18:28,340

more light through one slit less light

455

00:18:31,060 --> 00:18:29,750

through the other and that would produce

456

00:18:33,220 --> 00:18:31,070

the results that we see in this

457

00:18:34,810 --> 00:18:33,230

experiment this doesn't mean that that

458

00:18:36,940 --> 00:18:34,820

this is what's happening in this

459

00:18:38,980 --> 00:18:36,950

experiment but it's consistent with what

460

00:18:41,170 --> 00:18:38,990

we see so it's as though the act of

461

00:18:45,550 --> 00:18:41,180

observing is making the light skewed in

462

00:18:48,880 --> 00:18:45,560

some way becomes asymmetrical for this

463

00:18:50,350 --> 00:18:48,890

same paper we also decided to replicate

464

00:18:52,690 --> 00:18:50,360

the experiment using a completely

465

00:18:57,100 --> 00:18:52,700

different system so this is a diode

466

00:19:00,700 --> 00:18:57,110

laser which is designed to be extremely

467

00:19:03,610 --> 00:19:00,710

stable in many respects in terms of the

468

00:19:06,310 --> 00:19:03,620

stability of power output it's very

469

00:19:08,950 --> 00:19:06,320

stable it's temperature resistant it's

470

00:19:11,560 --> 00:19:08,960

vibration resistant it's 200 meter

471

00:19:14,230 --> 00:19:11,570

coherence length it's specially designed

472

00:19:16,600 --> 00:19:14,240

for experiments requiring very stable

473

00:19:18,400 --> 00:19:16,610

outputs and this is by contrast to a

474

00:19:21,130 --> 00:19:18,410

helium neon laser if those of you who've

475

00:19:23,110 --> 00:19:21,140

used helium neon laser ZnO that it does

476

00:19:25,930 --> 00:19:23,120

what's called mode hopping and that's

477

00:19:27,640 --> 00:19:25,940

because it's a it's a gas tube it's it's

478

00:19:29,680 --> 00:19:27,650

like these fluorescent tubes up here

479

00:19:31,299 --> 00:19:29,690

with slight

480

00:19:33,789 --> 00:19:31,309

arrangement that's a little bit

481

00:19:35,590 --> 00:19:33,799

different but the idea is that and when

482

00:19:38,680 --> 00:19:35,600

you have a gas tube it gets heated up on

483

00:19:40,210 --> 00:19:38,690

one side the the gas inside is moving

484

00:19:43,299 --> 00:19:40,220

that causes a little bit difference in

485

00:19:45,430 --> 00:19:43,309

power output and also it you hope that

486

00:19:47,200 --> 00:19:45,440

it stays in a standing wave and it's

487

00:19:48,490 --> 00:19:47,210

lasing mode but there are other modes

488

00:19:49,990 --> 00:19:48,500

that it can be in it could also

489

00:19:52,299 --> 00:19:50,000

sometimes switch so that's like three

490

00:19:54,279 --> 00:19:52,309

lobes and every time it switches

491

00:19:57,249 --> 00:19:54,289

randomly it produces a different power

492

00:19:58,899 --> 00:19:57,259

output that introduces noise into our

493

00:20:01,240 --> 00:19:58,909

measurement because if you look very

494

00:20:03,310 --> 00:20:01,250

carefully at the interference pattern

495

00:20:04,840 --> 00:20:03,320

the total amount of power will make it

496

00:20:06,909 --> 00:20:04,850

actually hop up and down a little bit

497

00:20:08,379 --> 00:20:06,919

and so we have to do a lot of fancy

498

00:20:10,119 --> 00:20:08,389

statistics in order to get rid of that

499

00:20:12,700 --> 00:20:10,129

and we decided we needed a system that

500

00:20:14,919 --> 00:20:12,710

was stable enough so they didn't need to

501
00:20:16,509 --> 00:20:14,929
use any fancy statistics at all the

502
00:20:19,509 --> 00:20:16,519
system was just stable so that's what

503
00:20:22,509 --> 00:20:19,519
this is about the laser is sent in this

504
00:20:25,779 --> 00:20:22,519
case through a crystal quartz crystal

505
00:20:27,970 --> 00:20:25,789
from the the place where they have

506
00:20:30,399 --> 00:20:27,980
quartz crystals from John of God you can

507
00:20:32,379 --> 00:20:30,409
buy these crystals so I bought that

508
00:20:35,889 --> 00:20:32,389
because I figured we need God's help on

509
00:20:37,690 --> 00:20:35,899
this or maybe John of God's help and the

510
00:20:39,730 --> 00:20:37,700
reason for it really was that we need

511
00:20:41,590 --> 00:20:39,740
something to diverge Allah the beam

512
00:20:43,119 --> 00:20:41,600
itself the beam coming a little bit

513
00:20:44,889 --> 00:20:43,129

smaller than a millimeter in diameter

514

00:20:46,330 --> 00:20:44,899

and we need roughly two to three

515

00:20:48,129 --> 00:20:46,340

millimeters in order to get through the

516

00:20:50,139 --> 00:20:48,139

double slit and the uniform way so it's

517

00:20:53,980 --> 00:20:50,149

it was a nice beam divergence method and

518

00:20:55,810 --> 00:20:53,990

it also looked nice so here again we

519

00:20:58,330 --> 00:20:55,820

have a slightly different task the task

520

00:21:00,369 --> 00:20:58,340

in the previous experiments was we

521

00:21:01,240 --> 00:21:00,379

instruct you what to do whether you're

522

00:21:03,340 --> 00:21:01,250

ready for it or not

523

00:21:04,509 --> 00:21:03,350

now do this and now do that so we

524

00:21:07,480 --> 00:21:04,519

changed it this time

525

00:21:09,399 --> 00:21:07,490

so people were allowed to intervene with

526
00:21:10,450 --> 00:21:09,409
the system whenever they wanted to it's

527
00:21:12,909 --> 00:21:10,460
like oh you felt you're ready to

528
00:21:14,980 --> 00:21:12,919
concentrate you press a button 10

529
00:21:16,749 --> 00:21:14,990
seconds later would you actually would

530
00:21:18,700 --> 00:21:16,759
get the instruction ok now concentrate

531
00:21:20,980 --> 00:21:18,710
but it gave you a little bit of time

532
00:21:23,409 --> 00:21:20,990
whenever you feel like you're ready go

533
00:21:25,960 --> 00:21:23,419
get ready to get ready get ready and now

534
00:21:29,230 --> 00:21:25,970
concentrate so what you're seeing here

535
00:21:30,940 --> 00:21:29,240
then is at where the finger is pointing

536
00:21:32,950 --> 00:21:30,950
is somebody has pressed the button and

537
00:21:34,779 --> 00:21:32,960
they know ten seconds later they have to

538
00:21:38,019 --> 00:21:34,789

concentrate so they have this ten-second

539

00:21:40,779 --> 00:21:38,029

warmup period and we expected a delay

540

00:21:44,340 --> 00:21:40,789

even after they start to concentrate

541

00:21:46,770 --> 00:21:44,350

because it's a task is slightly differ

542

00:21:51,480 --> 00:21:46,780

and so we're down almost at 3 Sigma 3

543

00:21:55,400 --> 00:21:51,490

Sigma drop and this is how many people

544

00:21:59,820 --> 00:21:55,410

this is 20 sessions each person spending

545

00:22:02,220 --> 00:21:59,830

about 25 minutes doing the task and each

546

00:22:05,550 --> 00:22:02,230

one has to press the button 30 times so

547

00:22:08,010 --> 00:22:05,560

30 trials in one given session so

548

00:22:11,090 --> 00:22:08,020

there's the result again we got a drop

549

00:22:14,520 --> 00:22:11,100

in the double set power as we predicted

550

00:22:16,800 --> 00:22:14,530

and there's exactly the same system

551
00:22:24,159 --> 00:22:16,810
under control conditions and none of

552
00:22:29,049 --> 00:22:26,710
in the same paper we also presented a

553
00:22:32,080 --> 00:22:29,059
third result which is using the

554
00:22:34,930 --> 00:22:32,090
helium-neon system online and this was

555
00:22:38,919 --> 00:22:34,940
done to make a very rigorous test of the

556
00:22:40,629 --> 00:22:38,929
possibility that what we are we dealing

557
00:22:43,629 --> 00:22:40,639
with some sort of an artifact due to the

558
00:22:45,820 --> 00:22:43,639
proximity of the person or not so in

559
00:22:47,619 --> 00:22:45,830
this case the closest participant in

560
00:22:50,859 --> 00:22:47,629
this experiment was four kilometers away

561
00:22:53,619 --> 00:22:50,869
and the farthest participant was 18,000

562
00:22:55,450 --> 00:22:53,629
kilometers away so nobody is close to

563
00:23:00,009 --> 00:22:55,460

the system it's in the lab it's only

564

00:23:01,539 --> 00:23:00,019

accessible over the Internet these are

565

00:23:05,109 --> 00:23:01,549

locations around the world where people

566

00:23:07,629 --> 00:23:05,119

had done this experiment our lab is

567

00:23:09,519 --> 00:23:07,639

where the checkmark is and the 18,000

568

00:23:14,440 --> 00:23:09,529

kilometers is South Africa that's the

569

00:23:17,979 --> 00:23:14,450

farthest away the way it works is you

570

00:23:22,840 --> 00:23:17,989

have a server that somebody the human or

571

00:23:25,029 --> 00:23:22,850

a robot system we have a Linux robot act

572

00:23:28,690 --> 00:23:25,039

as a simulated human for our control

573

00:23:31,539 --> 00:23:28,700

task here so if a human comes in they go

574

00:23:33,879 --> 00:23:31,549

to the commercial server and we have

575

00:23:36,970 --> 00:23:33,889

about 5,000 sessions from humans 6000

576

00:23:40,210 --> 00:23:36,980

sessions from our robot they go to the

577

00:23:41,919 --> 00:23:40,220

server it connects to the server that it

578

00:23:44,349 --> 00:23:41,929

connected to the double-slit and it

579

00:23:47,470 --> 00:23:44,359

starts feeding data to their web browser

580

00:23:50,200 --> 00:23:47,480

and so the nice thing about this design

581

00:23:52,149 --> 00:23:50,210

is that the the double-set system and

582

00:23:53,950 --> 00:23:52,159

the server that is dealing with the data

583

00:23:56,529 --> 00:23:53,960

it doesn't know whether a human has

584

00:23:58,509 --> 00:23:56,539

asked for data or whether a robot has

585

00:24:00,669 --> 00:23:58,519

asked for data so we have a very very

586

00:24:02,609 --> 00:24:00,679

nice control here because the system

587

00:24:06,099 --> 00:24:02,619

adjusts all it does is push out bits

588

00:24:07,720 --> 00:24:06,109

pushes out data actually and it doesn't

589

00:24:09,430 --> 00:24:07,730

know where where it's coming from or

590

00:24:11,950 --> 00:24:09,440

what's who's requesting the data it's

591

00:24:13,749 --> 00:24:11,960

always exactly the same when the human

592

00:24:16,149 --> 00:24:13,759

does the experiment they see two screens

593

00:24:17,950 --> 00:24:16,159

these are in flash and they see it in

594

00:24:19,989 --> 00:24:17,960

their browser if they're given the

595

00:24:21,190 --> 00:24:19,999

instruction to relax they just see a

596

00:24:23,710 --> 00:24:21,200

blue screen and there's nothing

597

00:24:24,909 --> 00:24:23,720

happening if they see the instruction or

598

00:24:26,440 --> 00:24:24,919

they hear the instruction now please

599

00:24:28,690 --> 00:24:26,450

concentrate they see a squiggly line

600

00:24:31,899 --> 00:24:28,700

they're told to try to make the squiggly

601
00:24:34,149 --> 00:24:31,909
line go up and there's also a tone that

602
00:24:35,560 --> 00:24:34,159
sounds like a whistling wind so the

603
00:24:36,960 --> 00:24:35,570
whistle you try to get the whistling

604
00:24:39,120 --> 00:24:36,970
wind to go up in pitch

605
00:24:42,029 --> 00:24:39,130
which in it goes kind of goes along with

606
00:24:43,980 --> 00:24:42,039
this moving a line so you could do this

607
00:24:45,539 --> 00:24:43,990
experiment with your eyes closed because

608
00:24:47,820 --> 00:24:45,549
you don't have to look at the the line

609
00:24:49,919 --> 00:24:47,830
you can just listen to the pitch it

610
00:24:51,510 --> 00:24:49,929
lasts for 11 minutes and we have checks

611
00:24:53,279 --> 00:24:51,520
in there to make sure that the person

612
00:24:55,110 --> 00:24:53,289
still doing the experiment because if

613
00:24:56,909 --> 00:24:55,120

there's not we don't get a proper

614

00:24:58,049 --> 00:24:56,919

handshake back from the person's

615

00:25:01,470 --> 00:24:58,059

computer then we know that they've

616

00:25:04,470 --> 00:25:01,480

stopped the experiment and so we end it

617

00:25:06,899 --> 00:25:04,480

at that point so again we've given

618

00:25:08,580 --> 00:25:06,909

roulette can instructions to now

619

00:25:10,230 --> 00:25:08,590

concentrate your attention on the system

620

00:25:14,370 --> 00:25:10,240

make the squiggly squiggly line move up

621

00:25:16,590 --> 00:25:14,380

or relax and do nothing here - we expect

622

00:25:18,630 --> 00:25:16,600

a delay but it's longer than a task

623

00:25:20,399 --> 00:25:18,640

switching delay it's not simply 3 or 5

624

00:25:22,950 --> 00:25:20,409

seconds where we also have Internet

625

00:25:25,130 --> 00:25:22,960

delays we have a delay in terms of the

626
00:25:27,419 --> 00:25:25,140
feedback that we give people because

627
00:25:28,950 --> 00:25:27,429
feedback is based on the last couple of

628
00:25:30,630 --> 00:25:28,960
seconds of data in order to give a

629
00:25:32,700 --> 00:25:30,640
smooth response so we did some

630
00:25:35,730 --> 00:25:32,710
calculations and measurements we decided

631
00:25:37,230 --> 00:25:35,740
that the the feedback delay or the delay

632
00:25:39,770 --> 00:25:37,240
that we would expect in the data would

633
00:25:42,180 --> 00:25:39,780
be roughly 5 to 10 seconds delay

634
00:25:44,580 --> 00:25:42,190
empirically it turns out that 9 seconds

635
00:25:47,070 --> 00:25:44,590
is the optimal time so there's

636
00:25:49,169 --> 00:25:47,080
instruction to concentrate and when we

637
00:25:52,169 --> 00:25:49,179
delay the data a little bit because the

638
00:25:53,370 --> 00:25:52,179

reaction would be slowed so here's what

639

00:25:55,169 --> 00:25:53,380

this interference pattern looks like

640

00:25:57,840 --> 00:25:55,179

this one is a little bit rectangular and

641

00:26:00,779 --> 00:25:57,850

we did a very simple analysis based on

642

00:26:03,990 --> 00:26:00,789

Fringe visibility this is simply looking

643

00:26:07,080 --> 00:26:04,000

at for an adjacent peak and trough

644

00:26:09,720 --> 00:26:07,090

it's the proportional heights so in a

645

00:26:11,520 --> 00:26:09,730

perfect interference pattern you have a

646

00:26:14,060 --> 00:26:11,530

hundred percent fringe visibility you

647

00:26:18,510 --> 00:26:14,070

have a very very low trough a very high

648

00:26:20,159 --> 00:26:18,520

peak we looked at the middle twenty

649

00:26:21,690 --> 00:26:20,169

fringes and the interference pattern

650

00:26:25,919 --> 00:26:21,700

because so they're the ones that are the

651
00:26:27,450 --> 00:26:25,929
most stable measure each fringe and so

652
00:26:30,299 --> 00:26:27,460
here we're looking at the difference in

653
00:26:33,419 --> 00:26:30,309
fringe visibility during concentrating

654
00:26:36,299 --> 00:26:33,429
versus relaxing the the red line in the

655
00:26:38,880 --> 00:26:36,309
middle is a two Sigma level and as you

656
00:26:40,860 --> 00:26:38,890
see some fringe number nine which is

657
00:26:42,659 --> 00:26:40,870
more or less in the center of the

658
00:26:45,360 --> 00:26:42,669
interference pattern actually went down

659
00:26:46,919 --> 00:26:45,370
to about three and a half Sigma drop the

660
00:26:48,870 --> 00:26:46,929
interesting thing is that all twenty

661
00:26:50,220 --> 00:26:48,880
fringes are negative they're predicted

662
00:26:52,380 --> 00:26:50,230
to be negative because we're

663
00:26:54,930 --> 00:26:52,390

basically saying that fringe visibility

664

00:26:56,340 --> 00:26:54,940

should drop it should shrink when people

665

00:26:57,680 --> 00:26:56,350

are putting their mind in the box and

666

00:27:00,480 --> 00:26:57,690

that is what we see

667

00:27:03,630 --> 00:27:00,490

so fringe visibility declines and mind

668

00:27:05,580 --> 00:27:03,640

focuses on the double-slit and it does

669

00:27:08,400 --> 00:27:05,590

not decrease when you have a simulated

670

00:27:09,919 --> 00:27:08,410

human do the same task so again the

671

00:27:12,960 --> 00:27:09,929

reason why this is so nice is because

672

00:27:14,610 --> 00:27:12,970

the the double stood system has been

673

00:27:17,280 --> 00:27:14,620

sitting there now almost for three years

674

00:27:19,710 --> 00:27:17,290

it's on continually it has no idea who's

675

00:27:21,289 --> 00:27:19,720

asking for data sometimes it's humans on

676

00:27:23,610 --> 00:27:21,299

the other end sometimes not

677

00:27:25,650 --> 00:27:23,620

you get fringe visibility drops

678

00:27:27,000 --> 00:27:25,660

significantly when people are on the

679

00:27:29,580 --> 00:27:27,010

other end and you don't when you have a

680

00:27:31,590 --> 00:27:29,590

Linux box now for those of you who

681

00:27:34,740 --> 00:27:31,600

believe in the the possibility of

682

00:27:38,640 --> 00:27:34,750

machine consciousness we know at least

683

00:27:39,960 --> 00:27:38,650

that a boon to box is not sufficiently

684

00:27:43,830 --> 00:27:39,970

conscious in order to make this thing

685

00:27:49,650 --> 00:27:43,840

work so there the human observers

686

00:27:52,169 --> 00:27:49,660

there's the robot observers this is a

687

00:27:54,419 --> 00:27:52,179

compass as a reminder for me that when

688

00:27:56,310 --> 00:27:54,429

you're doing something like this where

689

00:27:59,250 --> 00:27:56,320

you have 20 fringes that are not

690

00:28:00,600 --> 00:27:59,260

completely independent of each other you

691

00:28:01,890 --> 00:28:00,610

can do something called a false

692

00:28:03,960 --> 00:28:01,900

discovery rate which is like a

693

00:28:05,419 --> 00:28:03,970

bonferroni correction to see how many of

694

00:28:08,220 --> 00:28:05,429

these drops are really statistically

695

00:28:11,580 --> 00:28:08,230

significant so false discovery rate is

696

00:28:13,260 --> 00:28:11,590

used very often an EEG research because

697

00:28:14,669 --> 00:28:13,270

if you're looking at electrodes and you

698

00:28:16,500 --> 00:28:14,679

want to know how many of the electrodes

699

00:28:18,960 --> 00:28:16,510

in a given area are significantly

700

00:28:20,430 --> 00:28:18,970

different you need to adjust for the

701
00:28:22,650 --> 00:28:20,440
correlations well you can do the same

702
00:28:26,490 --> 00:28:22,660
process here and it turns out that of

703
00:28:28,620 --> 00:28:26,500
all of the 20 fringes that in this case

704
00:28:32,360 --> 00:28:28,630
there's something like 10 of the 20

705
00:28:34,620 --> 00:28:32,370
fringes which are significantly dropped

706
00:28:38,970 --> 00:28:34,630
so even though there are correlations

707
00:28:41,100 --> 00:28:38,980
here there's still significant many of

708
00:28:42,900 --> 00:28:41,110
them so what causes this change in the

709
00:28:44,130 --> 00:28:42,910
fringe visibility well remember our

710
00:28:46,380 --> 00:28:44,140
models said that there's something like

711
00:28:48,419 --> 00:28:46,390
an asymmetry going on it's as though the

712
00:28:50,190 --> 00:28:48,429
mind is causing the amount of light to

713
00:28:53,570 --> 00:28:50,200

go through one slit a little bit less

714

00:28:56,430 --> 00:28:53,580

than the other so when somebody's has to

715

00:28:59,820 --> 00:28:56,440

mentally observe even from many many

716

00:29:02,580 --> 00:28:59,830

kilometers away maybe that's what's

717

00:29:03,869 --> 00:29:02,590

happening so if you do a fringe

718

00:29:05,999 --> 00:29:03,879

visibility and analysis

719

00:29:09,599 --> 00:29:06,009

you can model that if you have perfect

720

00:29:12,779 --> 00:29:09,609

symmetry between one slit and the other

721

00:29:14,399 --> 00:29:12,789

their fringes are very there's the peak

722

00:29:16,709 --> 00:29:14,409

and there's a trough so the truck is

723

00:29:18,719 --> 00:29:16,719

very close to the zero the peak is where

724

00:29:21,389 --> 00:29:18,729

it is and now we've introduced a little

725

00:29:22,469 --> 00:29:21,399

eight asymmetry the trough Rises but the

726

00:29:24,930 --> 00:29:22,479

peak stays the same

727

00:29:28,319 --> 00:29:24,940

more asymmetry trough Rises peak stays

728

00:29:31,019 --> 00:29:28,329

the same and more so on so as you make

729

00:29:33,419 --> 00:29:31,029

more and more asymmetry the trough is

730

00:29:35,069 --> 00:29:33,429

where the action is the trough is rising

731

00:29:36,539 --> 00:29:35,079

and the peak stays the same so let's

732

00:29:40,919 --> 00:29:36,549

look at our actual data to see what

733

00:29:43,649 --> 00:29:40,929

happened the troughs rise and the peak

734

00:29:45,779 --> 00:29:43,659

stays the same so this is again

735

00:29:48,389 --> 00:29:45,789

suggesting that one way to think about

736

00:29:50,639 --> 00:29:48,399

what's happening is it is as though the

737

00:29:52,529 --> 00:29:50,649

light becomes asymmetrical in the two

738

00:29:55,199 --> 00:29:52,539

slits because the troughs are rising a

739

00:29:58,949 --> 00:29:55,209

lot in this case over five Sigma and for

740

00:30:05,009 --> 00:29:58,959

the center fringe but the peaks don't

741

00:30:07,739 --> 00:30:05,019

change at all so that all of those

742

00:30:10,319 --> 00:30:07,749

involved studies with continual

743

00:30:12,180 --> 00:30:10,329

continuous beam laser if we think about

744

00:30:15,119 --> 00:30:12,190

the number of photons involved in this

745

00:30:17,129 --> 00:30:15,129

case photons per second are many many

746

00:30:19,319 --> 00:30:17,139

gazillion trillions of photons per

747

00:30:20,309 --> 00:30:19,329

second you can actually calculate how

748

00:30:22,199 --> 00:30:20,319

many of there are but I don't remember

749

00:30:24,329 --> 00:30:22,209

just say many trillions of photons per

750

00:30:26,539 --> 00:30:24,339

second so when the mind is doing this

751
00:30:30,899 --> 00:30:26,549
task you don't have any possibility of

752
00:30:32,759 --> 00:30:30,909
capturing individual photons even though

753
00:30:34,589 --> 00:30:32,769
that's the task the task is to imagine

754
00:30:36,239 --> 00:30:34,599
you can gain which path information but

755
00:30:38,699 --> 00:30:36,249
how can you gain which path information

756
00:30:40,949 --> 00:30:38,709
of a trillion things per second so we

757
00:30:43,379 --> 00:30:40,959
decided to do this as a single photon

758
00:30:45,239 --> 00:30:43,389
double slit system that give the

759
00:30:46,649 --> 00:30:45,249
possibility that mind actually might be

760
00:30:48,419 --> 00:30:46,659
able to capture what was going on

761
00:30:50,069 --> 00:30:48,429
remember all of this is happening in

762
00:30:51,449 --> 00:30:50,079
your mind it's imagination which is

763
00:30:53,029 --> 00:30:51,459

doing the capture but nevertheless at

764

00:30:55,589 --> 00:30:53,039

least you have the possibility of

765

00:30:58,109 --> 00:30:55,599

capturing something at a human scale

766

00:31:01,199 --> 00:30:58,119

rather than a trillion protons per

767

00:31:02,339 --> 00:31:01,209

second scale so this device you see on

768

00:31:05,430 --> 00:31:02,349

the right there with Little Buddha

769

00:31:08,519 --> 00:31:05,440

sitting on it this is about a 1 meter

770

00:31:10,589 --> 00:31:08,529

long chamber and the way that and it's

771

00:31:12,629 --> 00:31:10,599

sitting on a vibration isolation table

772

00:31:15,089 --> 00:31:12,639

it's a very heavy table that is does

773

00:31:17,760 --> 00:31:15,099

that's sitting on pneumatic legs that is

774

00:31:20,730 --> 00:31:17,770

designed to dampen vibration

775

00:31:23,070 --> 00:31:20,740

a very stable system this is a schematic

776

00:31:24,990 --> 00:31:23,080

of it and the left you have the source

777

00:31:27,390 --> 00:31:25,000

of the light it's a very tiny little

778

00:31:29,130 --> 00:31:27,400

bulb and you can tune it down so that

779

00:31:31,860 --> 00:31:29,140

the amount of light coming out of the

780

00:31:35,340 --> 00:31:31,870

bulb is very very low that goes through

781

00:31:37,169 --> 00:31:35,350

a very heavy green filter the photons

782

00:31:38,850 --> 00:31:37,179

coming out are actually yellow the

783

00:31:40,950 --> 00:31:38,860

yellow bulb goes through a green filter

784

00:31:42,780 --> 00:31:40,960

and there are not very many yellow

785

00:31:44,660 --> 00:31:42,790

things that can get through green so you

786

00:31:46,830 --> 00:31:44,670

end up with even fewer number of photons

787

00:31:49,200 --> 00:31:46,840

those go through a single slit to

788

00:31:50,850 --> 00:31:49,210

collimate them and by the way this is

789

00:31:53,100 --> 00:31:50,860

not a laser this is just an incandescent

790

00:31:54,930 --> 00:31:53,110

bulb so that goes through a single slit

791

00:31:56,910 --> 00:31:54,940

go then goes through a double slit and

792

00:31:58,890 --> 00:31:56,920

then it goes on to another double

793

00:32:02,160 --> 00:31:58,900

another single slit that you can move on

794

00:32:03,780 --> 00:32:02,170

a stage and select which photons go into

795

00:32:05,190 --> 00:32:03,790

the photomultiplier tube because we need

796

00:32:08,100 --> 00:32:05,200

to count each photon as it goes through

797

00:32:09,660 --> 00:32:08,110

now the reason that you can move the

798

00:32:11,850 --> 00:32:09,670

stage because you want to be able to

799

00:32:13,680 --> 00:32:11,860

check is it actually producing an

800

00:32:16,770 --> 00:32:13,690

interference pattern one photon at a

801
00:32:18,120 --> 00:32:16,780
time and then you have a digital counter

802
00:32:21,960 --> 00:32:18,130
that's simply counting the number of

803
00:32:23,700 --> 00:32:21,970
photons per second so here you have a

804
00:32:25,560 --> 00:32:23,710
new vertical scale the number of photons

805
00:32:28,140 --> 00:32:25,570
per second in this particular case is

806
00:32:30,780 --> 00:32:28,150
roughly 25 to 30 photons per second

807
00:32:32,310 --> 00:32:30,790
that's being counted it's a very

808
00:32:33,870 --> 00:32:32,320
well-behaved system it gives a nice

809
00:32:35,940 --> 00:32:33,880
pause own distribution as you would

810
00:32:38,190 --> 00:32:35,950
expect and when you move the little

811
00:32:39,450 --> 00:32:38,200
stage around you can see what is what

812
00:32:41,520 --> 00:32:39,460
are the number of photons that we're

813
00:32:45,720 --> 00:32:41,530

actually getting well it ranges from

814

00:32:47,390 --> 00:32:45,730

around 25 up to around 700 and though

815

00:32:49,440 --> 00:32:47,400

you can see the error bars there and it

816

00:32:51,600 --> 00:32:49,450

actually showing a very nice

817

00:32:54,540 --> 00:32:51,610

interference pattern one photon at a

818

00:32:57,510 --> 00:32:54,550

time so this is how you know that what's

819

00:33:01,650 --> 00:32:57,520

happening here is the wave property of

820

00:33:03,150 --> 00:33:01,660

light actually it really does work it's

821

00:33:05,970 --> 00:33:03,160

somehow the lights going through two

822

00:33:09,210 --> 00:33:05,980

slits at the same time so the task now

823

00:33:12,360 --> 00:33:09,220

is you ask somebody to put their

824

00:33:13,799 --> 00:33:12,370

attention onto the onto the system we're

825

00:33:17,190 --> 00:33:13,809

going to look at a trough we're going to

826

00:33:19,590 --> 00:33:17,200

look at that particular spot and if the

827

00:33:20,850 --> 00:33:19,600

idea is that what's going on is collapse

828

00:33:23,460 --> 00:33:20,860

of the wave function then we're going to

829

00:33:26,580 --> 00:33:23,470

get by virtue of looking at the system

830

00:33:27,570 --> 00:33:26,590

we will interfere with interference in

831

00:33:29,100 --> 00:33:27,580

other words we'll get rid of the

832

00:33:30,549 --> 00:33:29,110

interference and we should increase the

833

00:33:32,619 --> 00:33:30,559

photon count rate

834

00:33:33,999 --> 00:33:32,629

so now rather than trying to drop a

835

00:33:37,350 --> 00:33:34,009

level we're trying to raise the number

836

00:33:39,669 --> 00:33:37,360

of photons that's that's the prediction

837

00:33:41,560 --> 00:33:39,679

again we use a volitional task we allow

838

00:33:43,210 --> 00:33:41,570

people to intervene in this system when

839

00:33:45,730 --> 00:33:43,220

they wish so that they're at an optimal

840

00:33:46,930 --> 00:33:45,740

attentional period so they can relax as

841

00:33:49,539 --> 00:33:46,940

long as they want and they press a

842

00:33:51,100 --> 00:33:49,549

button to to do the task they wait a

843

00:33:53,560 --> 00:33:51,110

couple of seconds and then the computer

844

00:33:55,419 --> 00:33:53,570

says now concentrate now concentrate for

845

00:33:59,169 --> 00:33:55,429

30 seconds and then they go back to

846

00:34:02,470 --> 00:33:59,179

relaxing so the first experiment we did

847

00:34:04,269 --> 00:34:02,480

there's the the mean for resting for

848

00:34:07,899 --> 00:34:04,279

waiting and concentrating this is a 5

849

00:34:10,599 --> 00:34:07,909

Sigma drop so this is opposite to our

850

00:34:12,250 --> 00:34:10,609

prediction this is not show a collapse

851
00:34:14,800 --> 00:34:12,260
of the wave function of anything this is

852
00:34:16,389 --> 00:34:14,810
showing a sharpening of the fringes or

853
00:34:18,879 --> 00:34:16,399
another way of thinking of it is that

854
00:34:24,909 --> 00:34:18,889
the entire system becomes much more

855
00:34:27,040 --> 00:34:24,919
orderly much much better behaved so we

856
00:34:29,470 --> 00:34:27,050
like this because when you get a 5 Sigma

857
00:34:32,290 --> 00:34:29,480
anomaly you can get the Nobel Prize if

858
00:34:34,960 --> 00:34:32,300
it happens to be the Higgs boson in this

859
00:34:36,909 --> 00:34:34,970
case we were pleased with that because

860
00:34:39,550 --> 00:34:36,919
it told us a clue that maybe our

861
00:34:41,139 --> 00:34:39,560
original concept was either incorrect or

862
00:34:42,669 --> 00:34:41,149
maybe something different is going on

863
00:34:44,260 --> 00:34:42,679

when you're reducing a trillion photons

864

00:34:48,309 --> 00:34:44,270

per second as compared to when you're

865

00:34:50,230 --> 00:34:48,319

using 25 or 30 per second so we didn't

866

00:34:51,790 --> 00:34:50,240

we did it now a sequence of experiments

867

00:34:53,409 --> 00:34:51,800

I'm just going to mention the couples so

868

00:34:56,559 --> 00:34:53,419

the second experiment we did we got it

869

00:34:58,660 --> 00:34:56,569

two and a half signal rise now this was

870

00:35:00,640 --> 00:34:58,670

a different design different people do a

871

00:35:02,319 --> 00:35:00,650

lot of things that were different in the

872

00:35:04,930 --> 00:35:02,329

experiment but we're now thinking well

873

00:35:06,970 --> 00:35:04,940

we might be on to something but we don't

874

00:35:09,220 --> 00:35:06,980

know what it is yet because we're

875

00:35:12,640 --> 00:35:09,230

flip-flopping from one to the other in

876

00:35:14,140 --> 00:35:12,650

statistically meaningful ways and that

877

00:35:16,900 --> 00:35:14,150

experiment with the two and a half Sigma

878

00:35:18,579 --> 00:35:16,910

rise we're also keeping track of the

879

00:35:20,700 --> 00:35:18,589

personality of the people involved in

880

00:35:25,300 --> 00:35:20,710

the experiment using the Cloninger

881

00:35:27,059 --> 00:35:25,310

inventory and what we found is that the

882

00:35:29,910 --> 00:35:27,069

people in our experiment were very

883

00:35:32,620 --> 00:35:29,920

significantly deviant from the norm and

884

00:35:36,910 --> 00:35:32,630

particularly characteristic called self

885

00:35:38,650 --> 00:35:36,920

transcendence so these were the people

886

00:35:40,690 --> 00:35:38,660

who tend to end up in our experiments

887

00:35:42,550 --> 00:35:40,700

are interested in things like meditation

888

00:35:43,670 --> 00:35:42,560

and self-development so it's not too

889

00:35:45,109 --> 00:35:43,680

surprising but

890

00:35:47,660 --> 00:35:45,119

compared to the population norm these

891

00:35:49,640 --> 00:35:47,670

are not normal people compared to the

892

00:35:51,049 --> 00:35:49,650

average person off the street in

893

00:35:52,549 --> 00:35:51,059

California especially in Northern

894

00:35:57,440 --> 00:35:52,559

California they probably kind of look

895

00:35:58,400 --> 00:35:57,450

like this we also were took taking

896

00:36:00,680 --> 00:35:58,410

32-channel

897

00:36:02,089 --> 00:36:00,690

EEG so we could look at brain response

898

00:36:06,020 --> 00:36:02,099

while they're doing the double stat

899

00:36:07,760 --> 00:36:06,030

tasks and so here's pictures of many

900

00:36:10,970 --> 00:36:07,770

people that were involved in the

901
00:36:16,370 --> 00:36:10,980
experiment and the the upshot of this is

902
00:36:18,140 --> 00:36:16,380
that when they're concentrating a double

903
00:36:19,700 --> 00:36:18,150
sit count went up it didn't stay up for

904
00:36:21,079 --> 00:36:19,710
very long it actually over the course of

905
00:36:23,180 --> 00:36:21,089
the twenty five seconds that they're

906
00:36:25,940 --> 00:36:23,190
concentrating it went back down to

907
00:36:27,950 --> 00:36:25,950
chance pretty quickly so even at

908
00:36:30,140 --> 00:36:27,960
meditators doing this experiment could

909
00:36:32,329 --> 00:36:30,150
not maintain the kind of concentration

910
00:36:34,910 --> 00:36:32,339
that was necessary for more than around

911
00:36:36,380 --> 00:36:34,920
five seconds but nicely because we're

912
00:36:38,059 --> 00:36:36,390
looking at their EEG we're able to

913
00:36:40,400 --> 00:36:38,069

measure alpha D synchronization in the

914

00:36:42,440 --> 00:36:40,410

brain which is correlated with attention

915

00:36:45,819 --> 00:36:42,450

with concentration in particular and

916

00:36:48,289 --> 00:36:45,829

that drops so we're getting a nice

917

00:36:50,150 --> 00:36:48,299

anti-correlation between alpha D

918

00:36:52,069 --> 00:36:50,160

synchronization and the result in the

919

00:36:53,930 --> 00:36:52,079

double-slit so the more cut the more you

920

00:36:56,410 --> 00:36:53,940

concentrate the better the result in the

921

00:36:58,819 --> 00:36:56,420

experiment which is nice

922

00:37:00,079 --> 00:36:58,829

we also found since we ran 20

923

00:37:01,849 --> 00:37:00,089

participants were able to look on

924

00:37:03,980 --> 00:37:01,859

average what is happening in terms of

925

00:37:05,420 --> 00:37:03,990

different frequencies in the brain and

926

00:37:07,430 --> 00:37:05,430

we found that one of the frequencies

927

00:37:09,920 --> 00:37:07,440

showed a significant result across all

928

00:37:13,390 --> 00:37:09,930

20 people this is a directional

929

00:37:17,210 --> 00:37:13,400

correlation with gamma gamma frequency

930

00:37:18,980 --> 00:37:17,220

so this is not an increase in gamma and

931

00:37:21,890 --> 00:37:18,990

the temporal and the occipital but

932

00:37:25,789 --> 00:37:21,900

actually a decrease in gamma gamma

933

00:37:27,920 --> 00:37:25,799

becomes D synchronized as well so it

934

00:37:29,510 --> 00:37:27,930

actually everything alpha beta gal all

935

00:37:31,039 --> 00:37:29,520

of the brain frequencies become D

936

00:37:33,200 --> 00:37:31,049

synchronized and the process of doing in

937

00:37:35,359 --> 00:37:33,210

this experiment the bottom is showing

938

00:37:37,460 --> 00:37:35,369

however an absolute change that's it

939

00:37:39,849 --> 00:37:37,470

doesn't matter whether the gamma went up

940

00:37:43,069 --> 00:37:39,859

or down but some change from a baseline

941

00:37:45,230 --> 00:37:43,079

very significant results in the temporal

942

00:37:48,260 --> 00:37:45,240

area this says that what we're seeing is

943

00:37:50,420 --> 00:37:48,270

not consistent across people some people

944

00:37:52,309 --> 00:37:50,430

gamma went up some people gamma went

945

00:37:53,960 --> 00:37:52,319

down we're thinking okay well there's

946

00:37:55,640 --> 00:37:53,970

something going on with that particular

947

00:37:57,120 --> 00:37:55,650

frequency which is much greater than any

948

00:38:01,349 --> 00:37:57,130

other frequency we saw

949

00:38:04,230 --> 00:38:01,359

which is related to these results so

950

00:38:05,490 --> 00:38:04,240

here we have our other cat and this this

951
00:38:07,109 --> 00:38:05,500
came about because you're trying to

952
00:38:09,269 --> 00:38:07,119
think now what is it about doing this

953
00:38:10,650 --> 00:38:09,279
experiment with single photons where

954
00:38:12,059 --> 00:38:10,660
sometimes you get a very strong result

955
00:38:13,460 --> 00:38:12,069
in one direction and sometimes a very

956
00:38:16,740 --> 00:38:13,470
strong result in the other direction

957
00:38:18,690 --> 00:38:16,750
doesn't seem to make sense until I

958
00:38:22,259 --> 00:38:18,700
started to realize that the quantum Zeno

959
00:38:23,730 --> 00:38:22,269
effect is one of the properties of what

960
00:38:25,470 --> 00:38:23,740
happens when you observe a quantum

961
00:38:27,420 --> 00:38:25,480
system doesn't work for all quantum

962
00:38:30,210 --> 00:38:27,430
systems because it needs to be in a

963
00:38:31,950 --> 00:38:30,220

certain certain configuration but

964

00:38:34,680 --> 00:38:31,960

suitable quantum systems when you look

965

00:38:36,170 --> 00:38:34,690

at it they basically freeze it freezes

966

00:38:39,839 --> 00:38:36,180

the evolution of the quantum system

967

00:38:41,910 --> 00:38:39,849

that's the quantum Zeno effect what I

968

00:38:43,559 --> 00:38:41,920

did not realize until I started looking

969

00:38:46,230 --> 00:38:43,569

into this is there is also a quantum

970

00:38:47,910 --> 00:38:46,240

anti Zeno effect and this is that there

971

00:38:50,670 --> 00:38:47,920

you can look at certain systems and

972

00:38:52,319 --> 00:38:50,680

accelerate its evolution so you can do

973

00:38:53,880 --> 00:38:52,329

both and it depends a lot in the way

974

00:38:56,039 --> 00:38:53,890

that the system is devised you can

975

00:38:58,380 --> 00:38:56,049

depending on the frequency with which

976
00:39:00,870 --> 00:38:58,390
you observe the system you can freeze it

977
00:39:03,210 --> 00:39:00,880
or you can accelerate it so we've been

978
00:39:06,539 --> 00:39:03,220
doing experiments evolving single

979
00:39:07,890 --> 00:39:06,549
quantum events with different designs so

980
00:39:10,559 --> 00:39:07,900
maybe I thought well let's do an

981
00:39:13,200 --> 00:39:10,569
experiment where we do what amounts to a

982
00:39:16,980 --> 00:39:13,210
quantum Zeno experiment so we used our

983
00:39:19,130 --> 00:39:16,990
diode laser we set it up to get this

984
00:39:21,150 --> 00:39:19,140
time looking at Fringe visibility and

985
00:39:22,890 --> 00:39:21,160
there's who are tracking fringe

986
00:39:25,859 --> 00:39:22,900
visibility in one particular fringe and

987
00:39:28,740 --> 00:39:25,869
it's a very nice well-behaved system and

988
00:39:30,599 --> 00:39:28,750

the observers task is that we're

989

00:39:32,039 --> 00:39:30,609

measuring 50 samples per second we're

990

00:39:34,140 --> 00:39:32,049

getting fringe visibility out of the

991

00:39:36,599 --> 00:39:34,150

system 50 times a second but sometimes

992

00:39:40,349 --> 00:39:36,609

we presented to people very very slowly

993

00:39:42,120 --> 00:39:40,359

like one out of every 200 samples and

994

00:39:43,829 --> 00:39:42,130

then sometimes a little bit faster like

995

00:39:45,839 --> 00:39:43,839

one out of every 50 samples and then

996

00:39:48,450 --> 00:39:45,849

even faster so there's four different

997

00:39:50,999 --> 00:39:48,460

levels of speed in this experiment

998

00:39:53,279 --> 00:39:51,009

systems just keeps pumping out data but

999

00:39:57,059 --> 00:39:53,289

there's an observer of what's happening

1000

00:39:57,539 --> 00:39:57,069

at different time scales so this is the

1001
00:40:00,180 --> 00:39:57,549
result

1002
00:40:03,559 --> 00:40:00,190
so you see 14 controls heston sessions

1003
00:40:06,749 --> 00:40:03,569
14 also with humans observing a system

1004
00:40:08,999 --> 00:40:06,759
the variance for the results with the

1005
00:40:10,530 --> 00:40:09,009
humans is very statistically significant

1006
00:40:13,350 --> 00:40:10,540
and for the control it's not

1007
00:40:14,880 --> 00:40:13,360
so this is a suggestion that may be

1008
00:40:17,400 --> 00:40:14,890
what's going on here is that there are

1009
00:40:18,660 --> 00:40:17,410
different modes of observation going on

1010
00:40:20,120 --> 00:40:18,670
and the different experiments that we

1011
00:40:22,380 --> 00:40:20,130
did which we didn't even think of

1012
00:40:23,880 --> 00:40:22,390
originally which may be accounting for

1013
00:40:26,250 --> 00:40:23,890

the fact that we're sometimes freezing

1014

00:40:27,780 --> 00:40:26,260

the system and sometimes accelerating it

1015

00:40:30,000 --> 00:40:27,790

and that's why we're getting flip-flops

1016

00:40:32,430 --> 00:40:30,010

it is also the case that individuals

1017

00:40:35,070 --> 00:40:32,440

observe in very different ways and so

1018

00:40:36,510 --> 00:40:35,080

even the same exact experiment you can

1019

00:40:38,670 --> 00:40:36,520

have people doing something different in

1020

00:40:40,110 --> 00:40:38,680

their head and ending up with different

1021

00:40:44,070 --> 00:40:40,120

results because the nature of the

1022

00:40:45,630 --> 00:40:44,080

observation is different so whatever we

1023

00:40:47,610 --> 00:40:45,640

learned so far we've learned that

1024

00:40:50,400 --> 00:40:47,620

attention affects behavior of light and

1025

00:40:52,170 --> 00:40:50,410

quantum optics systems it's somewhat

1026
00:40:54,150 --> 00:40:52,180
consistent with von neumann's proposal

1027
00:40:56,940 --> 00:40:54,160
especially the ones involving continuous

1028
00:40:59,070 --> 00:40:56,950
lasers and also that some crazy ideas

1029
00:41:00,990 --> 00:40:59,080
might be correct so how does this

1030
00:41:03,900 --> 00:41:01,000
particular crazy idea fit into the rest

1031
00:41:05,190 --> 00:41:03,910
of science well in the big jigsaw puzzle

1032
00:41:08,400 --> 00:41:05,200
we're trying to understand the universe

1033
00:41:10,680 --> 00:41:08,410
maybe three places one is that it it is

1034
00:41:13,260 --> 00:41:10,690
sigh like I mean it's involving some

1035
00:41:15,690 --> 00:41:13,270
kind of mind matter interaction it

1036
00:41:18,690 --> 00:41:15,700
probably fits into this rising interest

1037
00:41:20,520 --> 00:41:18,700
in information physics and also probably

1038
00:41:22,920 --> 00:41:20,530

with quantum biology like there's

1039

00:41:24,510 --> 00:41:22,930

something about those three areas will

1040

00:41:28,440 --> 00:41:24,520

probably fill in the jigsaw at some

1041

00:41:32,420 --> 00:41:28,450

point maybe consciousness is fundamental

1042

00:41:35,550 --> 00:41:32,430

after all and I'll end with

1043

00:41:38,160 --> 00:41:35,560

acknowledging many fine collaborators

1044

00:41:40,230 --> 00:41:38,170

who helped in this design and execution

1045

00:41:41,970 --> 00:41:40,240

and also this work which could not have

1046

00:41:44,490 --> 00:41:41,980

been done without our funders the BI

1047

00:41:47,040 --> 00:41:44,500

foundation in Portugal Fetzer Memorial

1048

00:41:48,420 --> 00:41:47,050

Trust and Michigan mental insight

1049

00:41:50,460 --> 00:41:48,430

foundation in California and the

1050

00:41:54,680 --> 00:41:50,470

Federico and Elvia fijian foundation

1051
00:42:06,420 --> 00:41:54,690
here in Silicon Valley and with that I

1052
00:42:16,710 --> 00:42:10,390
thank you very much Dean fascinating we

1053
00:42:23,470 --> 00:42:19,930
Dean regarding the observers themselves

1054
00:42:25,900 --> 00:42:23,480
is that the act of simply concentrating

1055
00:42:29,890 --> 00:42:25,910
or is it the act of concentrating

1056
00:42:32,650 --> 00:42:29,900
specifically on the the area where the

1057
00:42:34,480 --> 00:42:32,660
slit is because I've noticed I don't

1058
00:42:37,480 --> 00:42:34,490
know if you're familiar with a new toy

1059
00:42:41,020 --> 00:42:37,490
called a mind flex where you actually

1060
00:42:43,120 --> 00:42:41,030
can change this little device based on

1061
00:42:44,340 --> 00:42:43,130
whether you're concentrating or not if

1062
00:42:47,710 --> 00:42:44,350
your mind is just kind of you know

1063
00:42:49,390 --> 00:42:47,720

drifting so did you try that two

1064

00:42:51,970 --> 00:42:49,400

separate whether they're concentrating

1065

00:42:54,970 --> 00:42:51,980

specifically on tasks or just

1066

00:42:56,890 --> 00:42:54,980

concentrating that's a very good

1067

00:42:58,420 --> 00:42:56,900

question and actually it was addressed

1068

00:43:00,670 --> 00:42:58,430

somewhat in the the quantum Zeno

1069

00:43:03,730 --> 00:43:00,680

experiment because in that experiment

1070

00:43:06,400 --> 00:43:03,740

the only instruction is look at the dots

1071

00:43:07,600 --> 00:43:06,410

on the screen and they and I mean they

1072

00:43:09,520 --> 00:43:07,610

knew that it had to do with a double

1073

00:43:12,430 --> 00:43:09,530

slit but I didn't say very much about it

1074

00:43:14,290 --> 00:43:12,440

so simply just pay attention to the fact

1075

00:43:17,080 --> 00:43:14,300

that things are happening so that's

1076
00:43:18,940 --> 00:43:17,090
attention without any any knowledge of

1077
00:43:21,520 --> 00:43:18,950
the system and all of the other systems

1078
00:43:22,960 --> 00:43:21,530
we did tell people what it's about you

1079
00:43:24,880 --> 00:43:22,970
know this is a double slit and there's

1080
00:43:26,680 --> 00:43:24,890
this theory and so on when you ask

1081
00:43:29,860 --> 00:43:26,690
people after the experiment what did you

1082
00:43:31,960 --> 00:43:29,870
do for about 20 seconds they followed

1083
00:43:34,270 --> 00:43:31,970
instructions and then they found it was

1084
00:43:36,250 --> 00:43:34,280
too difficult to do that so they did a

1085
00:43:39,370 --> 00:43:36,260
huge range of different kinds of

1086
00:43:42,550 --> 00:43:39,380
strategies so in that respect it's kind

1087
00:43:44,230 --> 00:43:42,560
of a miracle that the the continuous

1088
00:43:47,170 --> 00:43:44,240

laser experiments worked as well as it

1089

00:43:48,940 --> 00:43:47,180

did so maybe it doesn't matter the exact

1090

00:43:51,070 --> 00:43:48,950

form of concentration doesn't matter too

1091

00:43:52,690 --> 00:43:51,080

much and I think that is also now what

1092

00:43:55,770 --> 00:43:52,700

we see in this quantum Zeno type of

1093

00:43:57,970 --> 00:43:55,780

experiment that it's it's more about

1094

00:44:00,010 --> 00:43:57,980

observing that something is happening

1095

00:44:02,530 --> 00:44:00,020

and not the details and in particular

1096

00:44:04,090 --> 00:44:02,540

for people doing this over the web they

1097

00:44:05,770 --> 00:44:04,100

don't they don't see anything about a

1098

00:44:09,300 --> 00:44:05,780

double slit they just see a squiggly

1099

00:44:12,670 --> 00:44:09,310

line and it works for them too so

1100

00:44:15,640 --> 00:44:12,680

extending that point we know that inside

1101

00:44:16,590 --> 00:44:15,650

experiments our intention affects the

1102

00:44:22,890 --> 00:44:16,600

outcome

1103

00:44:24,870 --> 00:44:22,900

being affected via the mechanisms that

1104

00:44:27,240 --> 00:44:24,880

you're suggesting in terms of collapse

1105

00:44:28,680 --> 00:44:27,250

of wavefunction as you know we've done

1106

00:44:31,770 --> 00:44:28,690

experiments at the University of

1107

00:44:33,930 --> 00:44:31,780

Colorado with intention on reflection of

1108

00:44:35,810 --> 00:44:33,940

light and we find that there is an

1109

00:44:39,150 --> 00:44:35,820

effect on reflection of light and

1110

00:44:41,160 --> 00:44:39,160

moreover the more lability we give to

1111

00:44:45,380 --> 00:44:41,170

the system the more noise there is in

1112

00:44:48,330 --> 00:44:45,390

the system the greater the effect and so

1113

00:44:52,170 --> 00:44:48,340

how do we know what part of it we're

1114

00:44:54,030 --> 00:44:52,180

affecting I don't think there's a clear

1115

00:44:56,460 --> 00:44:54,040

answer to that yet I mean in particular

1116

00:44:58,950 --> 00:44:56,470

because the delayed choice version of

1117

00:45:00,980 --> 00:44:58,960

this worked there's always the

1118

00:45:03,350 --> 00:45:00,990

possibility that the analyst is

1119

00:45:06,480 --> 00:45:03,360

collapsing the system backwards in time

1120

00:45:07,800 --> 00:45:06,490

so there are ways to get around that of

1121

00:45:09,510 --> 00:45:07,810

course you have different analysts

1122

00:45:11,250 --> 00:45:09,520

involved and one of them one of my hopes

1123

00:45:12,930 --> 00:45:11,260

in this kind of experiment since we've

1124

00:45:15,210 --> 00:45:12,940

gotten such good and relatively

1125

00:45:17,610 --> 00:45:15,220

consistently good results is to inspire

1126

00:45:19,020 --> 00:45:17,620

others to do something like it because

1127

00:45:20,460 --> 00:45:19,030

that's really the only way of knowing

1128

00:45:22,350 --> 00:45:20,470

whether it's an analyst effect and

1129

00:45:24,090 --> 00:45:22,360

eventually we'll get clever enough and

1130

00:45:26,670 --> 00:45:24,100

figure out ways of answering that very

1131

00:45:30,540 --> 00:45:26,680

important question at this point I don't

1132

00:45:32,790 --> 00:45:30,550

know that's all the time we have for

1133

00:45:34,890 --> 00:45:32,800

questions right now but you may proceed

1134

00:45:37,500 --> 00:45:34,900

to rush Dean with your myriad questions

1135

00:45:42,490 --> 00:45:37,510

at the lunch break thank you very much