

1
00:00:00,490 --> 00:00:08,529
[Music]

2
00:00:16,089 --> 00:00:25,039
[Music]

3
00:00:22,239 --> 00:00:27,528
so I'm talking here about my matter

4
00:00:25,039 --> 00:00:28,429
interaction experiments with light some

5
00:00:27,528 --> 00:00:30,289
of what I'm gonna say is a

6
00:00:28,429 --> 00:00:32,598
recapitulation of the two talks that you

7
00:00:30,289 --> 00:00:38,049
just heard there shall be pictures of

8
00:00:32,598 --> 00:00:40,250
cats but but only two pictures of cats

9
00:00:38,049 --> 00:00:42,429
so I'm going to talk about three things

10
00:00:40,250 --> 00:00:44,359
first of all a mystery in physics

11
00:00:42,429 --> 00:00:46,909
interpretations of the mysteries and

12
00:00:44,359 --> 00:00:50,090
then experiments involving them the

13
00:00:46,909 --> 00:00:52,939
mystery as Richard Fineman said is

14
00:00:50,090 --> 00:00:55,370
absolutely impossible to explain in any

15
00:00:52,939 --> 00:00:57,469
classical way and which has it at the

16
00:00:55,369 --> 00:01:01,219
heart of quantum mechanics in reality it

17
00:00:57,469 --> 00:01:02,929
contains the only mystery in terms of

18
00:01:01,219 --> 00:01:05,390
the interpretations of this mystery

19
00:01:02,929 --> 00:01:08,299
there are ideas like many worlds

20
00:01:05,390 --> 00:01:10,159
hypothesis decoherence Copenhagen

21
00:01:08,299 --> 00:01:12,259
interpretation and the one that I'll

22
00:01:10,159 --> 00:01:15,350
focus on most is the one that proposed

23
00:01:12,259 --> 00:01:16,819
by John von Neumann and presented in

24
00:01:15,349 --> 00:01:18,349
among other places in his book the

25
00:01:16,819 --> 00:01:21,530
mathematical foundations of quantum

26
00:01:18,349 --> 00:01:23,748
mechanics in terms of experiments I'm

27
00:01:21,530 --> 00:01:26,450
going to talk about work that we've been

28
00:01:23,748 --> 00:01:28,298
doing for the last almost seven years

29

00:01:26,450 --> 00:01:30,709
now

30
00:01:28,299 --> 00:01:32,118
so let's look in more detail about the

31
00:01:30,709 --> 00:01:35,149
mystery the mystery of course is the

32
00:01:32,118 --> 00:01:37,278
quantum measurement problem and to talk

33
00:01:35,149 --> 00:01:40,909
about this in terms that everyone can

34
00:01:37,278 --> 00:01:42,679
understand they'll use cows the cows

35
00:01:40,909 --> 00:01:46,039
behave in a certain way provided that

36
00:01:42,679 --> 00:01:47,959
there's no one watching when somebody

37
00:01:46,039 --> 00:01:51,409
comes by the cows act in a different way

38
00:01:47,959 --> 00:01:52,579
and then they go back in a different way

39
00:01:51,409 --> 00:01:55,279
when they're not being watched anymore

40
00:01:52,578 --> 00:01:57,169
so this is one of the problems that this

41
00:01:55,278 --> 00:01:59,028
doesn't just happen for cows it also

42
00:01:57,170 --> 00:02:01,700
happens for elementary particles

43
00:01:59,028 --> 00:02:03,528

electrons photons and so on the other

44

00:02:01,700 --> 00:02:06,859

part of the problem or the mystery is

45

00:02:03,528 --> 00:02:10,038

that photons and elementary particles

46

00:02:06,858 --> 00:02:12,560

can simultaneously be in two different

47

00:02:10,038 --> 00:02:15,139

states so this is like wave particle

48

00:02:12,560 --> 00:02:18,908

though your skier is a particle but can

49

00:02:15,139 --> 00:02:18,908

act like a wave occasionally as well

50

00:02:19,479 --> 00:02:25,669

if you take golf balls and you shoot

51

00:02:23,989 --> 00:02:27,500

them through two slits then you would

52

00:02:25,669 --> 00:02:28,968

expect that when you look at the other

53

00:02:27,500 --> 00:02:32,479

side of the screen that you'll get two

54

00:02:28,968 --> 00:02:34,699

bands of golf ball hits and the same is

55

00:02:32,479 --> 00:02:37,098

true for light provided that you're

56

00:02:34,699 --> 00:02:38,358

looking where each photon goes but if

57

00:02:37,098 --> 00:02:40,310

you don't look then you get this

58
00:02:38,359 --> 00:02:42,079
interference pattern so this is the same

59
00:02:40,310 --> 00:02:43,579
thing about the cows whether you look or

60
00:02:42,079 --> 00:02:46,489
don't look you get different kinds of

61
00:02:43,579 --> 00:02:49,459
distributions so the path is knowable

62
00:02:46,489 --> 00:02:51,560
and photons behave like particles if

63
00:02:49,459 --> 00:02:55,219
it's unknowable photons behave like

64
00:02:51,560 --> 00:02:56,840
waves you actually do this in the

65
00:02:55,219 --> 00:02:58,579
laboratory and use something like a

66
00:02:56,840 --> 00:03:01,669
double slit system with a laser on the

67
00:02:58,579 --> 00:03:03,469
top you see the particle pattern like a

68
00:03:01,669 --> 00:03:05,419
single slit pattern and the bottom is a

69
00:03:03,469 --> 00:03:10,068
double slit pattern where both slits are

70
00:03:05,419 --> 00:03:11,959
open that's what it looks like so all of

71
00:03:10,068 --> 00:03:14,268
this has something to do with words like

72
00:03:11,959 --> 00:03:17,780
knowledge information observation

73
00:03:14,269 --> 00:03:18,680
measurement and they're related in there

74
00:03:17,780 --> 00:03:20,870
I mean they're semantically different

75
00:03:18,680 --> 00:03:23,689
but they're related in ways that we we

76
00:03:20,870 --> 00:03:25,669
kind of grok and we grok it in terms of

77
00:03:23,689 --> 00:03:29,389
this like where we're information

78
00:03:25,669 --> 00:03:31,790
processing machines kind of and we what

79
00:03:29,389 --> 00:03:33,590
we do involves knowledge information and

80
00:03:31,789 --> 00:03:38,108
observation and that then becomes a link

81
00:03:33,590 --> 00:03:38,109
between possible mind matter interaction

82
00:03:38,680 --> 00:03:43,159
so now let's look at interpretations in

83
00:03:41,598 --> 00:03:45,138
a little more detail in particular the

84
00:03:43,158 --> 00:03:46,250
one button john von neumann he had this

85
00:03:45,139 --> 00:03:48,889
principle of what he called

86

00:03:46,250 --> 00:03:50,930
psychophysical parallelism where

87
00:03:48,889 --> 00:03:53,479
consciousness collapses the quantum

88
00:03:50,930 --> 00:03:58,639
wave-like behavior into a classical

89
00:03:53,479 --> 00:04:00,319
particle like behavior what's your

90
00:03:58,639 --> 00:04:02,030
opinion of the importance of the quantum

91
00:04:00,318 --> 00:04:06,018
measurement problem this was asked at a

92
00:04:02,030 --> 00:04:07,400
conference in 2011 by Zeilinger 33

93
00:04:06,019 --> 00:04:09,079
people were present these are all

94
00:04:07,400 --> 00:04:11,389
specialists and the foundations of

95
00:04:09,079 --> 00:04:13,189
quantum mechanics and they gave a

96
00:04:11,389 --> 00:04:14,569
variety of answers and the reason I

97
00:04:13,188 --> 00:04:16,639
bring this up is because sometimes

98
00:04:14,568 --> 00:04:18,048
physicists might say well the quantum

99
00:04:16,639 --> 00:04:20,509
measurement problem has been solved by

100
00:04:18,048 --> 00:04:22,339

this or it's been solved by that and

101

00:04:20,509 --> 00:04:24,379

what are the specialists say actually

102

00:04:22,339 --> 00:04:26,899

you can see by their responses that

103

00:04:24,379 --> 00:04:30,228

there there is no clear consensus and

104

00:04:26,899 --> 00:04:32,688

the interesting response is this it's a

105

00:04:30,228 --> 00:04:35,329

severe difficulty threatening or under

106

00:04:32,689 --> 00:04:37,729

standing of quantum mechanics so even

107

00:04:35,329 --> 00:04:40,399

among specialists there is first of all

108

00:04:37,728 --> 00:04:42,558

no consensus no clear consensus and also

109

00:04:40,399 --> 00:04:44,749

some like a quarter of the people

110

00:04:42,559 --> 00:04:49,009

responding said this is a very important

111

00:04:44,749 --> 00:04:50,509

problem that is not yet resolved and

112

00:04:49,009 --> 00:04:54,319

then he asked the philosophers like

113

00:04:50,509 --> 00:04:55,788

David Chalmers he says that the hard

114

00:04:54,319 --> 00:04:58,519

problem of consciousness has already

115
00:04:55,788 --> 00:05:00,468
been raised it's about subjectivity so

116
00:04:58,519 --> 00:05:04,489
he proposes we might need one or two

117
00:05:00,468 --> 00:05:06,468
ideas that might seem crazy his crazy

118
00:05:04,488 --> 00:05:08,209
idea is the same as John von neumann's

119
00:05:06,468 --> 00:05:10,098
and Vig neurs and others that

120
00:05:08,209 --> 00:05:13,069
consciousness may be fundamental in some

121
00:05:10,098 --> 00:05:19,368
way that physics is not yet able to deal

122
00:05:13,069 --> 00:05:20,539
with so what about experiments the

123
00:05:19,369 --> 00:05:22,459
experiments that we've been doing have

124
00:05:20,538 --> 00:05:25,248
been looking at what we might call the

125
00:05:22,459 --> 00:05:27,408
observer effect those pure subjectivity

126
00:05:25,249 --> 00:05:30,379
collapse the quantum wave function or

127
00:05:27,408 --> 00:05:31,519
not you would think that within physics

128
00:05:30,379 --> 00:05:33,049
given that this is an outstanding

129
00:05:31,519 --> 00:05:34,968
problem that there would be many many

130
00:05:33,048 --> 00:05:38,058
experiments in the physics literature

131
00:05:34,968 --> 00:05:40,939
and there are a couple but with one

132
00:05:38,059 --> 00:05:43,550
exception all of them are involved

133
00:05:40,939 --> 00:05:48,588
people who are doing parapsychology and

134
00:05:43,550 --> 00:05:49,848
not physics and here's here's one cat

135
00:05:48,588 --> 00:05:51,738
but it's a cartoon cat

136
00:05:49,848 --> 00:05:53,389
so with Schrodinger's cat paradox what

137
00:05:51,738 --> 00:05:55,538
we're interested in is can we select a

138
00:05:53,389 --> 00:05:58,069
preferred outcome by mental means alone

139
00:05:55,538 --> 00:06:00,860
so we're going to try to select that

140
00:05:58,069 --> 00:06:04,039
outcome part of what I'm talking about

141
00:06:00,860 --> 00:06:05,329
here I had mentioned in a talk at SSC a

142
00:06:04,038 --> 00:06:06,829
few years ago and I'm going to go

143

00:06:05,329 --> 00:06:10,129
quickly through that and then bring you

144
00:06:06,829 --> 00:06:12,879
up up to speed on the latest work so no

145
00:06:10,129 --> 00:06:12,879
cats were harmed

146
00:06:15,310 --> 00:06:20,600
and instead we use a Michelson

147
00:06:17,870 --> 00:06:23,750
interferometer instead of a cat so this

148
00:06:20,600 --> 00:06:24,800
is a very nice interferometer you send a

149
00:06:23,750 --> 00:06:27,050
light beam through there through a

150
00:06:24,800 --> 00:06:29,300
half-silvered mirror and so part of the

151
00:06:27,050 --> 00:06:30,980
beam is reflected to a solid mirror and

152
00:06:29,300 --> 00:06:34,100
the other part goes through to a solid

153
00:06:30,980 --> 00:06:35,870
mirror and then the two beams combine

154
00:06:34,100 --> 00:06:37,520
and you get a nice interference pattern

155
00:06:35,870 --> 00:06:39,530
which in this particular design comes

156
00:06:37,519 --> 00:06:43,039
out as a concentric circle so there's

157
00:06:39,529 --> 00:06:45,289

the interference pattern so the idea in

158

00:06:43,040 --> 00:06:47,900

this sort of experiment is that you have

159

00:06:45,290 --> 00:06:50,180

the optical apparatus inside some sealed

160

00:06:47,899 --> 00:06:51,919

container in this case it's inside our

161

00:06:50,180 --> 00:06:54,490

shield electromagnetically shielded room

162

00:06:51,920 --> 00:06:57,259

which also in this case was white tight

163

00:06:54,490 --> 00:07:00,379

and then outside the room we have a

164

00:06:57,259 --> 00:07:03,199

person we tell them to put your mind in

165

00:07:00,379 --> 00:07:05,389

the arm of the interferometer and we're

166

00:07:03,199 --> 00:07:07,009

using interferometer this particular one

167

00:07:05,389 --> 00:07:08,479

in this experiment because it's big

168

00:07:07,009 --> 00:07:11,629

enough so you can tell somebody it's

169

00:07:08,480 --> 00:07:13,340

about the size of a grapefruit it's a

170

00:07:11,629 --> 00:07:15,439

big space where you need to put your

171

00:07:13,339 --> 00:07:17,119

mind so it's easy to describe what to do

172
00:07:15,439 --> 00:07:19,069
with it and when your mind is there

173
00:07:17,120 --> 00:07:20,780
imagine you can see the photons if you

174
00:07:19,069 --> 00:07:22,610
can and you're gaining which path

175
00:07:20,779 --> 00:07:24,079
information out of the system and you

176
00:07:22,610 --> 00:07:27,379
would so-called collapse the wave

177
00:07:24,079 --> 00:07:30,379
function their job is to gain knowledge

178
00:07:27,379 --> 00:07:32,719
some people can't do this task very well

179
00:07:30,379 --> 00:07:34,219
they get confused with the idea that in

180
00:07:32,720 --> 00:07:35,630
their minds eye they have to see a

181
00:07:34,220 --> 00:07:37,760
photon well they don't know how to do

182
00:07:35,629 --> 00:07:39,670
that so I said okay if you can't do that

183
00:07:37,759 --> 00:07:42,079
imagine you can block the photons

184
00:07:39,670 --> 00:07:45,020
imagine you can move on imagine you can

185
00:07:42,079 --> 00:07:47,060
do anything with the photons and so

186
00:07:45,019 --> 00:07:50,359
people figure out themselves what

187
00:07:47,060 --> 00:07:52,550
they're going to do so under calibration

188
00:07:50,360 --> 00:07:56,030
conditions you run the system under

189
00:07:52,550 --> 00:07:58,220
conditions where you ask in this case no

190
00:07:56,029 --> 00:08:00,199
one there but you ask them to observe

191
00:07:58,220 --> 00:08:02,180
with your mind's eye and then rest and

192
00:08:00,199 --> 00:08:04,159
withdraw your attention and now observe

193
00:08:02,180 --> 00:08:06,050
again withdraw your attention for

194
00:08:04,160 --> 00:08:08,810
roughly 30 seconds to a minute at a time

195
00:08:06,050 --> 00:08:10,819
and you see how the system behaves it

196
00:08:08,810 --> 00:08:12,740
should show no change at all and in fact

197
00:08:10,819 --> 00:08:15,290
this is calibration condition there's no

198
00:08:12,740 --> 00:08:16,910
change in the interference pattern but

199
00:08:15,290 --> 00:08:18,740
when you ask a person to do this under

200

00:08:16,910 --> 00:08:20,390
experimental conditions the line on the

201
00:08:18,740 --> 00:08:22,939
bottom here is what happens when a

202
00:08:20,389 --> 00:08:23,569
highly experienced meditator did this

203
00:08:22,939 --> 00:08:25,500
task

204
00:08:23,569 --> 00:08:28,110
now this meditator is

205
00:08:25,500 --> 00:08:29,459
at the time is probably about 75 years

206
00:08:28,110 --> 00:08:32,820
old and he said that he had been

207
00:08:29,459 --> 00:08:38,908
meditating about 70 years not

208
00:08:32,820 --> 00:08:41,159
continually but but enough so that he's

209
00:08:38,908 --> 00:08:42,689
able to go into a state which in the

210
00:08:41,158 --> 00:08:45,059
yogic tradition would be called a city

211
00:08:42,690 --> 00:08:47,880
he's able to do the the special yoga

212
00:08:45,059 --> 00:08:50,039
super powers which involves manipulation

213
00:08:47,879 --> 00:08:52,559
of mind and matter so he did that in

214
00:08:50,039 --> 00:08:56,639

this in this case and we've got a very

215

00:08:52,559 --> 00:08:59,639

good result we're an non-meditators and

216

00:08:56,639 --> 00:09:01,110

meditators partially because we expect

217

00:08:59,639 --> 00:09:03,539

that meditators have attention training

218

00:09:01,110 --> 00:09:05,789

and this kind of experiment requires you

219

00:09:03,539 --> 00:09:07,289

focus attention so we expected they

220

00:09:05,789 --> 00:09:09,059

would do better and in fact all of the

221

00:09:07,289 --> 00:09:11,669

action and this experiment was from the

222

00:09:09,059 --> 00:09:14,069

meditators they ended up with odds

223

00:09:11,669 --> 00:09:15,990

against chance of about a hundred

224

00:09:14,070 --> 00:09:19,350

thousand to one and we published this in

225

00:09:15,990 --> 00:09:21,690

2008 so as a result of that experiment

226

00:09:19,350 --> 00:09:24,480

we decided to take the plunge and go to

227

00:09:21,690 --> 00:09:26,580

a double stood optical system as you see

228

00:09:24,480 --> 00:09:29,279

the design is extremely simple just a

229
00:09:26,580 --> 00:09:32,040
laser accepting a filter that reduces

230
00:09:29,279 --> 00:09:34,949
the illumination level a double set and

231
00:09:32,039 --> 00:09:37,338
then a camera that's what it looks like

232
00:09:34,950 --> 00:09:41,490
laser tube is on the left

233
00:09:37,339 --> 00:09:43,440
it's a helium-neon laser and the double

234
00:09:41,490 --> 00:09:47,399
slit and the camera are inside the box

235
00:09:43,440 --> 00:09:49,950
in the middle and inside the box there's

236
00:09:47,399 --> 00:09:52,139
the holder for the double slit and

237
00:09:49,950 --> 00:09:56,910
there's also a line camera and so that's

238
00:09:52,139 --> 00:09:59,549
very simple the idea of this is on the

239
00:09:56,909 --> 00:10:01,860
top you see the intensity level of the

240
00:09:59,549 --> 00:10:03,299
camera measures it's a line camera but

241
00:10:01,860 --> 00:10:06,240
what is showing here is the intensity

242
00:10:03,299 --> 00:10:10,349
and the the pattern is the interference

243
00:10:06,240 --> 00:10:12,659
pattern on the bottom is a Fourier

244
00:10:10,350 --> 00:10:15,450
transform of the picture on the top and

245
00:10:12,659 --> 00:10:18,870
it shows three peaks middle peak is a

246
00:10:15,450 --> 00:10:20,670
double slit peak this is the single slit

247
00:10:18,870 --> 00:10:23,190
peak and the peak on the right is a

248
00:10:20,669 --> 00:10:24,599
harmonic of the double slit so this is a

249
00:10:23,190 --> 00:10:26,910
very easy way of taking an entire

250
00:10:24,600 --> 00:10:28,769
pattern doing Fourier transform and

251
00:10:26,909 --> 00:10:30,719
getting two points of interest double

252
00:10:28,769 --> 00:10:32,759
set and the single slit peaks that

253
00:10:30,720 --> 00:10:35,310
allows you to get basically capture the

254
00:10:32,759 --> 00:10:37,500
whole pattern and see how much as I call

255
00:10:35,309 --> 00:10:42,689
it double slit ends there

256
00:10:37,500 --> 00:10:45,090
is going on so we used a measure of the

257

00:10:42,690 --> 00:10:47,790
ratio between the double slit and single

258
00:10:45,090 --> 00:10:49,080
slit spectral Peaks and had the

259
00:10:47,789 --> 00:10:50,639
prediction that when somebody was

260
00:10:49,080 --> 00:10:52,920
observing the system and trying to get

261
00:10:50,639 --> 00:10:54,419
which which path knowledge out of it

262
00:10:52,919 --> 00:10:56,519
that the double said power would go down

263
00:10:54,419 --> 00:10:59,610
the single sub-par would go up so the

264
00:10:56,519 --> 00:11:02,549
ratio should go down when the mind is in

265
00:10:59,610 --> 00:11:04,080
the box so to speak so there's the

266
00:11:02,549 --> 00:11:06,000
picture of what the signal actually

267
00:11:04,080 --> 00:11:08,910
looks like over the course of around 11

268
00:11:06,000 --> 00:11:13,220
minutes we're looking at the spectral

269
00:11:08,909 --> 00:11:15,899
ratio we have assignments down here

270
00:11:13,220 --> 00:11:19,050
attention towards the box attention away

271
00:11:15,899 --> 00:11:20,850

from the box and these are automatically

272

00:11:19,049 --> 00:11:23,519

given by a computer to the participant

273

00:11:20,850 --> 00:11:26,100

and the experiment and the bottom line

274

00:11:23,519 --> 00:11:29,189

is when you look at the means of the

275

00:11:26,100 --> 00:11:31,500

that signal and the attention away

276

00:11:29,190 --> 00:11:33,870

versus the attention towards there

277

00:11:31,500 --> 00:11:35,490

should be a difference between them in a

278

00:11:33,870 --> 00:11:37,529

predictable direction maybe there should

279

00:11:35,490 --> 00:11:39,990

be less double slit power when people

280

00:11:37,529 --> 00:11:41,279

are attending toward the system that's

281

00:11:39,990 --> 00:11:43,919

because they're gaining which path

282

00:11:41,279 --> 00:11:45,269

information out of the system the signal

283

00:11:43,919 --> 00:11:46,740

looks like it's going all over the place

284

00:11:45,269 --> 00:11:50,100

but the actual variance here is only

285

00:11:46,740 --> 00:11:51,720

0.4% I just this is just an expansion of

286
00:11:50,100 --> 00:11:55,769
it so you can see the way that the

287
00:11:51,720 --> 00:11:57,509
signal moves so we did a couple of

288
00:11:55,769 --> 00:12:00,299
experiments first of all the the first

289
00:11:57,509 --> 00:12:01,830
experiment is here we were asking does

290
00:12:00,299 --> 00:12:04,259
anything happen at all when you do this

291
00:12:01,830 --> 00:12:07,500
so we had 30 sessions people did the

292
00:12:04,259 --> 00:12:09,870
experiment repeatedly the green dot show

293
00:12:07,500 --> 00:12:12,750
up yeah the green dot is all data the

294
00:12:09,870 --> 00:12:14,730
red God is meditators and the blue da is

295
00:12:12,750 --> 00:12:17,899
non-meditators so the first experiment

296
00:12:14,730 --> 00:12:21,810
did pretty well it was a modest

297
00:12:17,899 --> 00:12:24,809
significant decline as we expected as we

298
00:12:21,809 --> 00:12:25,919
hoped then we did another experiment

299
00:12:24,809 --> 00:12:27,569
which is basically the same thing

300
00:12:25,919 --> 00:12:30,479
because we looked at the first result

301
00:12:27,570 --> 00:12:32,550
and we said really that was really what

302
00:12:30,480 --> 00:12:34,350
happened well so the experiment second

303
00:12:32,549 --> 00:12:37,588
experiment overall result was basically

304
00:12:34,350 --> 00:12:38,909
the same meditators did better a third

305
00:12:37,589 --> 00:12:40,530
experiment we were a concerned that

306
00:12:38,909 --> 00:12:43,860
maybe what we're seeing is an artifact

307
00:12:40,529 --> 00:12:46,110
as a result of the participants being

308
00:12:43,860 --> 00:12:48,240
within two meters of the optical system

309
00:12:46,110 --> 00:12:50,039
and so we thought that's because

310
00:12:48,240 --> 00:12:51,029
interferometers are so sensitive to

311
00:12:50,039 --> 00:12:52,679
everything that may

312
00:12:51,029 --> 00:12:54,329
what was happening is that the

313
00:12:52,679 --> 00:12:55,739
participants were leaning forward a

314

00:12:54,330 --> 00:12:56,970
little bit when their attempt when

315
00:12:55,740 --> 00:12:58,889
they're putting their mind in the box

316
00:12:56,970 --> 00:13:00,450
and that would raise the temperature of

317
00:12:58,889 --> 00:13:02,699
the box maybe a thousandth of a degree

318
00:13:00,450 --> 00:13:04,620
and that might be enough in order to see

319
00:13:02,700 --> 00:13:06,720
the effect we were saying so we put

320
00:13:04,620 --> 00:13:09,570
thermocouples on the interferometer to

321
00:13:06,720 --> 00:13:11,310
measure the temperature changes to see

322
00:13:09,570 --> 00:13:13,530
if that was in fact what was going on

323
00:13:11,309 --> 00:13:15,149
and the answer is it was not that that

324
00:13:13,529 --> 00:13:19,049
wasn't what's happening the temperature

325
00:13:15,149 --> 00:13:21,120
wasn't changing at all so overall we get

326
00:13:19,049 --> 00:13:23,009
slightly smaller effect but still in the

327
00:13:21,120 --> 00:13:24,659
predicted direction meditators did quite

328
00:13:23,009 --> 00:13:27,899

well and in this case the non-meditators

329

00:13:24,659 --> 00:13:30,269
didn't do well at all we did the

330

00:13:27,899 --> 00:13:33,209
experiment again using a delayed choice

331

00:13:30,269 --> 00:13:35,669
version and this is a little complicated

332

00:13:33,210 --> 00:13:37,500
to wrap your brain around but the notion

333

00:13:35,669 --> 00:13:39,750
of observation in this case it doesn't

334

00:13:37,500 --> 00:13:42,120
have to take place in real time could

335

00:13:39,750 --> 00:13:43,889
take place in the future so the

336

00:13:42,120 --> 00:13:45,960
observation that took place in this

337

00:13:43,889 --> 00:13:50,789
experiment took place two months after

338

00:13:45,960 --> 00:13:52,980
the data was recorded so the meditators

339

00:13:50,789 --> 00:13:54,539
did very well in this version overall

340

00:13:52,980 --> 00:13:57,180
people did pretty well and again the

341

00:13:54,539 --> 00:13:59,250
non-meditators did not do so good we ran

342

00:13:57,179 --> 00:14:01,679
five different control tests which are

343
00:13:59,250 --> 00:14:03,299
the same apparatus the same analysis the

344
00:14:01,679 --> 00:14:04,739
same everything under conditions where

345
00:14:03,299 --> 00:14:07,469
there's nobody around just to see what

346
00:14:04,740 --> 00:14:09,930
what the box is doing and none of those

347
00:14:07,470 --> 00:14:11,310
are statistically significant and then

348
00:14:09,929 --> 00:14:14,579
overall this is what we get with the

349
00:14:11,309 --> 00:14:16,559
first four pilot studies meditators did

350
00:14:14,580 --> 00:14:18,810
extremely well that's what the p-value

351
00:14:16,559 --> 00:14:22,259
there is but even overall people did

352
00:14:18,809 --> 00:14:24,089
quite well so that encouraged us to do a

353
00:14:22,259 --> 00:14:26,399
formal experiment this is a pre planned

354
00:14:24,090 --> 00:14:27,990
experiment with 50 sessions where we

355
00:14:26,399 --> 00:14:29,549
tried to optimize the results by

356
00:14:27,990 --> 00:14:32,220
selecting the people who would do the

357
00:14:29,549 --> 00:14:34,109
experiment based on how they did in the

358
00:14:32,220 --> 00:14:36,600
pilot test so we're selecting people

359
00:14:34,110 --> 00:14:38,789
based on what we think is a mild form of

360
00:14:36,600 --> 00:14:41,009
talent and they did extremely well so

361
00:14:38,789 --> 00:14:45,659
the red dot or humans and the white dot

362
00:14:41,009 --> 00:14:47,610
there is a control a match control when

363
00:14:45,659 --> 00:14:49,259
you look at the difference between the

364
00:14:47,610 --> 00:14:50,970
meditators and non-meditators you can

365
00:14:49,259 --> 00:14:53,629
see that cumulatively the meditators

366
00:14:50,970 --> 00:14:55,500
actually did very well

367
00:14:53,629 --> 00:14:58,230
accumulating down to about four and a

368
00:14:55,500 --> 00:15:01,500
half sigma results and non-meditators

369
00:14:58,230 --> 00:15:04,190
did okay but just the they didn't get a

370
00:15:01,500 --> 00:15:04,190
significant result

371

00:15:04,250 --> 00:15:12,570
so we published this in physics essays

372
00:15:06,750 --> 00:15:14,190
in 2012 and then we decided to it's very

373
00:15:12,570 --> 00:15:15,930
difficult to do this experiment and get

374
00:15:14,190 --> 00:15:17,190
four or five Sigma results and actually

375
00:15:15,929 --> 00:15:19,409
believe that that's what's happening

376
00:15:17,190 --> 00:15:21,000
because I've done many many experiments

377
00:15:19,409 --> 00:15:24,088
involving random number generators and

378
00:15:21,000 --> 00:15:26,730
you don't often get results that good so

379
00:15:24,089 --> 00:15:28,589
I maintained a certain degree of

380
00:15:26,730 --> 00:15:30,360
suspicion about what's going on here and

381
00:15:28,589 --> 00:15:32,880
we decided to we have to replicate it

382
00:15:30,360 --> 00:15:35,669
again and so we did it again again with

383
00:15:32,879 --> 00:15:37,559
selected people this time we also

384
00:15:35,669 --> 00:15:39,509
concentrated on something we're looking

385
00:15:37,559 --> 00:15:41,909

for other ways of seeing whether this is

386

00:15:39,509 --> 00:15:43,560

really what it appears to be and so one

387

00:15:41,909 --> 00:15:45,990

of the effects here is that the task

388

00:15:43,559 --> 00:15:48,778

involves asking people to put your mind

389

00:15:45,990 --> 00:15:50,399

over there and now withdraw it and now

390

00:15:48,778 --> 00:15:51,870

put it back and I withdraw and the

391

00:15:50,399 --> 00:15:54,480

machine is telling you when to do that

392

00:15:51,870 --> 00:15:56,698

if you think about it and you were asked

393

00:15:54,480 --> 00:15:58,589

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

394

00:15:56,698 --> 00:16:01,258

switch your attention that quickly and

395

00:15:58,589 --> 00:16:03,660

and the cognitive world is called task

396

00:16:01,259 --> 00:16:06,149

switching cost it takes a couple of

397

00:16:03,659 --> 00:16:07,708

seconds to switch gears mentally and so

398

00:16:06,149 --> 00:16:09,448

we figured that what should be happening

399

00:16:07,708 --> 00:16:13,049

in this experiment is that we should see

400
00:16:09,448 --> 00:16:15,000
a delay in the data suggesting that if

401
00:16:13,049 --> 00:16:16,919
the people are actually taking a few

402
00:16:15,000 --> 00:16:18,809
seconds to change their attention you

403
00:16:16,919 --> 00:16:21,479
should see that delay in the in the data

404
00:16:18,809 --> 00:16:25,109
itself so we predicted something between

405
00:16:21,480 --> 00:16:27,449
two and five seconds delay and so this

406
00:16:25,110 --> 00:16:30,000
is a delay analysis or lagging from zero

407
00:16:27,448 --> 00:16:32,009
seconds to minus fifteen seconds in

408
00:16:30,000 --> 00:16:34,889
effect you see you do see a delayed in

409
00:16:32,009 --> 00:16:36,509
this case it was around two seconds two

410
00:16:34,889 --> 00:16:39,568
seconds after the instruction was given

411
00:16:36,509 --> 00:16:41,338
you actually get a better result and

412
00:16:39,568 --> 00:16:42,778
under these so that's the experimental

413
00:16:41,339 --> 00:16:45,000
data on the top we're looking at the

414
00:16:42,778 --> 00:16:47,220
control data so the controls are not

415
00:16:45,000 --> 00:16:50,039
significant the experimental data is

416
00:16:47,220 --> 00:16:53,910
very significant so this we publish and

417
00:16:50,039 --> 00:16:56,188
also in physics si is last year in that

418
00:16:53,909 --> 00:16:58,828
paper we also did an analysis of these

419
00:16:56,188 --> 00:17:01,588
data using a theoretical model you can

420
00:16:58,828 --> 00:17:03,359
do you can very precisely model this

421
00:17:01,589 --> 00:17:07,289
using wave mechanics based on a

422
00:17:03,360 --> 00:17:09,269
Fraunhofer diffraction model so there's

423
00:17:07,289 --> 00:17:10,859
what there's how you characterize the

424
00:17:09,269 --> 00:17:14,220
model these are what the equations look

425
00:17:10,859 --> 00:17:15,899
like the equation on the bottom they're

426
00:17:14,220 --> 00:17:16,910
showing the intensity level that you

427
00:17:15,900 --> 00:17:19,910
would measure

428

00:17:16,910 --> 00:17:21,710
it has three components one is the

429
00:17:19,910 --> 00:17:23,420
amount of light coming through one slit

430
00:17:21,710 --> 00:17:25,039
and one through the other slit and then

431
00:17:23,420 --> 00:17:26,870
the light coming through both slits you

432
00:17:25,039 --> 00:17:29,839
know if this allows you to partition out

433
00:17:26,869 --> 00:17:33,439
the contribution of light from each of

434
00:17:29,839 --> 00:17:36,169
the slits the model then is on the top

435
00:17:33,440 --> 00:17:39,140
you get a very nicely well-behaved and

436
00:17:36,170 --> 00:17:41,180
symmetrical interference pattern and the

437
00:17:39,140 --> 00:17:43,550
bottom is the actual data so the actual

438
00:17:41,180 --> 00:17:46,370
data is a little bit skewed it's not a

439
00:17:43,549 --> 00:17:47,899
perfectly symmetrical the Fourier

440
00:17:46,369 --> 00:17:49,609
transform which is on the right you see

441
00:17:47,900 --> 00:17:51,680
is not exactly the way the model would

442
00:17:49,609 --> 00:17:53,209

would show and the reason for this is

443

00:17:51,680 --> 00:17:55,220

because when you're working on the real

444

00:17:53,210 --> 00:17:57,140

system there's small imperfections in it

445

00:17:55,220 --> 00:17:58,940

and of course it's very very difficult

446

00:17:57,140 --> 00:18:01,460

to arrange it so it actually looks

447

00:17:58,940 --> 00:18:03,769

exactly like the theoretical model but

448

00:18:01,460 --> 00:18:07,069

it's pretty good so we modeled the data

449

00:18:03,769 --> 00:18:10,339

based on the Fraunhofer equations and

450

00:18:07,069 --> 00:18:12,169

what we come up with is is this that on

451

00:18:10,339 --> 00:18:14,059

the top when somebody is asked to relax

452

00:18:12,170 --> 00:18:16,039

and withdraw their mind from the system

453

00:18:14,059 --> 00:18:18,259

the amount of light going through two

454

00:18:16,039 --> 00:18:19,700

slits is symmetrical total amount of

455

00:18:18,259 --> 00:18:20,900

light is the same going through two

456

00:18:19,700 --> 00:18:23,809

slits that's what the model would

457
00:18:20,900 --> 00:18:26,060
predict when they concentrate though the

458
00:18:23,809 --> 00:18:28,339
amount of light becomes skewed there's

459
00:18:26,059 --> 00:18:29,750
more light through one slit less light

460
00:18:28,339 --> 00:18:31,069
through the other and that would produce

461
00:18:29,750 --> 00:18:33,230
the results that we see in this

462
00:18:31,069 --> 00:18:34,819
experiment this doesn't mean that that

463
00:18:33,230 --> 00:18:36,950
this is what's happening in this

464
00:18:34,819 --> 00:18:38,990
experiment but it's consistent with what

465
00:18:36,950 --> 00:18:41,180
we see so it's as though the act of

466
00:18:38,990 --> 00:18:45,559
observing is making the light skewed in

467
00:18:41,180 --> 00:18:48,890
some way becomes asymmetrical for this

468
00:18:45,559 --> 00:18:50,359
same paper we also decided to replicate

469
00:18:48,890 --> 00:18:52,700
the experiment using a completely

470
00:18:50,359 --> 00:18:57,109
different system so this is a diode

471
00:18:52,700 --> 00:19:00,710
laser which is designed to be extremely

472
00:18:57,109 --> 00:19:03,619
stable in many respects in terms of the

473
00:19:00,710 --> 00:19:06,319
stability of power output it's very

474
00:19:03,619 --> 00:19:08,959
stable it's temperature resistant it's

475
00:19:06,319 --> 00:19:11,569
vibration resistant it's 200 meter

476
00:19:08,960 --> 00:19:14,240
coherence length it's specially designed

477
00:19:11,569 --> 00:19:16,609
for experiments requiring very stable

478
00:19:14,240 --> 00:19:18,410
outputs and this is by contrast to a

479
00:19:16,609 --> 00:19:21,139
helium neon laser if those of you who've

480
00:19:18,410 --> 00:19:23,120
used helium neon laser ZnO that it does

481
00:19:21,140 --> 00:19:25,940
what's called mode hopping and that's

482
00:19:23,119 --> 00:19:27,649
because it's a it's a gas tube it's it's

483
00:19:25,940 --> 00:19:29,690
like these fluorescent tubes up here

484
00:19:27,650 --> 00:19:31,309
with slight

485

00:19:29,690 --> 00:19:33,798
arrangement that's a little bit

486
00:19:31,308 --> 00:19:35,599
different but the idea is that and when

487
00:19:33,798 --> 00:19:38,690
you have a gas tube it gets heated up on

488
00:19:35,599 --> 00:19:40,219
one side the the gas inside is moving

489
00:19:38,690 --> 00:19:43,308
that causes a little bit difference in

490
00:19:40,220 --> 00:19:45,440
power output and also it you hope that

491
00:19:43,308 --> 00:19:47,210
it stays in a standing wave and it's

492
00:19:45,440 --> 00:19:48,500
lazing mode but there are other modes

493
00:19:47,210 --> 00:19:50,000
that it can be in it could also

494
00:19:48,500 --> 00:19:52,308
sometimes switch so that's like three

495
00:19:50,000 --> 00:19:54,288
lobes and every time it switches

496
00:19:52,308 --> 00:19:57,259
randomly it produces a different power

497
00:19:54,288 --> 00:19:58,908
output that introduces noise into our

498
00:19:57,259 --> 00:20:01,250
measurement because if you look very

499
00:19:58,909 --> 00:20:03,320

carefully at the interference pattern

500

00:20:01,250 --> 00:20:04,849

the total amount of power will make it

501

00:20:03,319 --> 00:20:06,918

actually hop up and down a little bit

502

00:20:04,849 --> 00:20:08,388

and so we have to do a lot of fancy

503

00:20:06,919 --> 00:20:10,129

statistics in order to get rid of that

504

00:20:08,388 --> 00:20:12,709

and we decided we needed a system that

505

00:20:10,128 --> 00:20:14,928

was stable enough so they didn't need to

506

00:20:12,710 --> 00:20:16,519

use any fancy statistics at all the

507

00:20:14,929 --> 00:20:19,519

system was just stable so that's what

508

00:20:16,519 --> 00:20:22,519

this is about the laser is sent in this

509

00:20:19,519 --> 00:20:25,788

case through a crystal quartz crystal

510

00:20:22,519 --> 00:20:27,980

from the the place where they have

511

00:20:25,788 --> 00:20:30,408

quartz crystals from John of God you can

512

00:20:27,980 --> 00:20:32,389

buy these crystals so I bought that

513

00:20:30,409 --> 00:20:35,899

because I figured we need God's help on

514
00:20:32,388 --> 00:20:37,699
this or maybe John of God's help and the

515
00:20:35,898 --> 00:20:39,739
reason for it really was that we need

516
00:20:37,700 --> 00:20:41,600
something to diverge Allah the beam

517
00:20:39,740 --> 00:20:43,128
itself the beam coming a little bit

518
00:20:41,599 --> 00:20:44,898
smaller than a millimeter in diameter

519
00:20:43,128 --> 00:20:46,339
and we need roughly two to three

520
00:20:44,898 --> 00:20:48,138
millimeters in order to get through the

521
00:20:46,339 --> 00:20:50,148
double slit and the uniform way so it's

522
00:20:48,138 --> 00:20:53,990
it was a nice beam divergence method and

523
00:20:50,148 --> 00:20:55,819
it also looked nice so here again we

524
00:20:53,990 --> 00:20:58,339
have a slightly different task the task

525
00:20:55,819 --> 00:21:00,378
in the previous experiments was we

526
00:20:58,339 --> 00:21:01,250
instruct you what to do whether you're

527
00:21:00,378 --> 00:21:03,349
ready for it or not

528
00:21:01,250 --> 00:21:04,519
now do this and now do that so we

529
00:21:03,349 --> 00:21:07,490
changed it this time

530
00:21:04,519 --> 00:21:09,409
so people were allowed to intervene with

531
00:21:07,490 --> 00:21:10,460
the system whenever they wanted to it's

532
00:21:09,409 --> 00:21:12,919
like oh you felt you're ready to

533
00:21:10,460 --> 00:21:14,990
concentrate you press a button 10

534
00:21:12,919 --> 00:21:16,759
seconds later would you actually would

535
00:21:14,990 --> 00:21:18,710
get the instruction ok now concentrate

536
00:21:16,759 --> 00:21:20,990
but it gave you a little bit of time

537
00:21:18,710 --> 00:21:23,419
whenever you feel like you're ready go

538
00:21:20,990 --> 00:21:25,970
get ready to get ready get ready and now

539
00:21:23,419 --> 00:21:29,240
concentrate so what you're seeing here

540
00:21:25,970 --> 00:21:30,950
then is at where the finger is pointing

541
00:21:29,240 --> 00:21:32,960
is somebody has pressed the button and

542

00:21:30,950 --> 00:21:34,788
they know ten seconds later they have to

543
00:21:32,960 --> 00:21:38,028
concentrate so they have this ten-second

544
00:21:34,788 --> 00:21:40,788
warmup period and we expected a delay

545
00:21:38,028 --> 00:21:44,349
even after they start to concentrate

546
00:21:40,788 --> 00:21:46,779
because it's a task is slightly differ

547
00:21:44,349 --> 00:21:51,490
and so we're down almost at 3 Sigma 3

548
00:21:46,779 --> 00:21:55,410
Sigma drop and this is how many people

549
00:21:51,490 --> 00:21:59,829
this is 20 sessions each person spending

550
00:21:55,410 --> 00:22:02,230
about 25 minutes doing the task and each

551
00:21:59,829 --> 00:22:05,559
one has to press the button 30 times so

552
00:22:02,230 --> 00:22:08,019
30 trials in one given session so

553
00:22:05,559 --> 00:22:11,099
there's the result again we got a drop

554
00:22:08,019 --> 00:22:14,529
in the double set power as we predicted

555
00:22:11,099 --> 00:22:16,809
and there's exactly the same system

556
00:22:14,529 --> 00:22:20,670

under control conditions and none of

557

00:22:16,809 --> 00:22:20,669

that is statistically significant

558

00:22:24,169 --> 00:22:29,059

in the same paper we also presented a

559

00:22:26,720 --> 00:22:32,089

third result which is using the

560

00:22:29,058 --> 00:22:34,940

helium-neon system online and this was

561

00:22:32,089 --> 00:22:38,928

done to make a very rigorous test of the

562

00:22:34,940 --> 00:22:40,639

possibility that what we are we dealing

563

00:22:38,929 --> 00:22:43,639

with some sort of an artifact due to the

564

00:22:40,638 --> 00:22:45,829

proximity of the person or not so in

565

00:22:43,638 --> 00:22:47,628

this case the closest participant in

566

00:22:45,829 --> 00:22:50,868

this experiment was four kilometers away

567

00:22:47,628 --> 00:22:53,628

and the farthest participant was 18,000

568

00:22:50,868 --> 00:22:55,459

kilometers away so nobody is close to

569

00:22:53,628 --> 00:23:00,019

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

570

00:22:55,460 --> 00:23:01,548

accessible over the Internet these are

571
00:23:00,019 --> 00:23:05,118
locations around the world where people

572
00:23:01,548 --> 00:23:07,638
had done this experiment our lab is

573
00:23:05,118 --> 00:23:09,528
where the checkmark is and the 18,000

574
00:23:07,638 --> 00:23:14,449
kilometers is South Africa that's the

575
00:23:09,528 --> 00:23:17,989
farthest away the way it works is you

576
00:23:14,450 --> 00:23:22,850
have a server that somebody the human or

577
00:23:17,989 --> 00:23:25,038
a robot system we have a Linux robot act

578
00:23:22,849 --> 00:23:28,699
as a simulated human for our control

579
00:23:25,038 --> 00:23:31,548
task here so if a human comes in they go

580
00:23:28,700 --> 00:23:33,889
to the commercial server and we have

581
00:23:31,548 --> 00:23:36,980
about 5,000 sessions from humans 6000

582
00:23:33,888 --> 00:23:40,219
sessions from our robot they go to the

583
00:23:36,980 --> 00:23:41,929
server it connects to the server that it

584
00:23:40,220 --> 00:23:44,358
connected to the double-slit and it

585
00:23:41,929 --> 00:23:47,480
starts feeding data to their web browser

586
00:23:44,358 --> 00:23:50,210
and so the nice thing about this design

587
00:23:47,480 --> 00:23:52,159
is that the the double-set system and

588
00:23:50,210 --> 00:23:53,960
the server that is dealing with the data

589
00:23:52,159 --> 00:23:56,539
it doesn't know whether a human has

590
00:23:53,960 --> 00:23:58,519
asked for data or whether a robot has

591
00:23:56,538 --> 00:24:00,679
asked for data so we have a very very

592
00:23:58,519 --> 00:24:02,618
nice control here because the system

593
00:24:00,679 --> 00:24:06,109
adjusts all it does is push out bits

594
00:24:02,618 --> 00:24:07,730
pushes out data actually and it doesn't

595
00:24:06,108 --> 00:24:09,439
know where where it's coming from or

596
00:24:07,730 --> 00:24:11,960
what's who's requesting the data it's

597
00:24:09,440 --> 00:24:13,759
always exactly the same when the human

598
00:24:11,960 --> 00:24:16,159
does the experiment they see two screens

599

00:24:13,759 --> 00:24:17,960
these are in flash and they see it in

600
00:24:16,159 --> 00:24:19,999
their browser if they're given the

601
00:24:17,960 --> 00:24:21,200
instruction to relax they just see a

602
00:24:19,999 --> 00:24:23,720
blue screen and there's nothing

603
00:24:21,200 --> 00:24:24,919
happening if they see the instruction or

604
00:24:23,720 --> 00:24:26,450
they hear the instruction now please

605
00:24:24,919 --> 00:24:28,700
concentrate they see a squiggly line

606
00:24:26,450 --> 00:24:31,909
they're told to try to make the squiggly

607
00:24:28,700 --> 00:24:34,159
line go up and there's also a tone that

608
00:24:31,909 --> 00:24:35,570
sounds like a whistling wind so the

609
00:24:34,159 --> 00:24:36,970
whistle you try to get the whistling

610
00:24:35,569 --> 00:24:39,129
wind to go up in pitch

611
00:24:36,970 --> 00:24:42,038
which in it goes kind of goes along with

612
00:24:39,130 --> 00:24:43,990
this moving a line so you could do this

613
00:24:42,038 --> 00:24:45,548

experiment with your eyes closed because

614

00:24:43,990 --> 00:24:47,829

you don't have to look at the the line

615

00:24:45,548 --> 00:24:49,929

you can just listen to the pitch it

616

00:24:47,829 --> 00:24:51,519

lasts for 11 minutes and we have checks

617

00:24:49,929 --> 00:24:53,288

in there to make sure that the person

618

00:24:51,519 --> 00:24:55,119

still doing the experiment because if

619

00:24:53,288 --> 00:24:56,919

there's not we don't get a proper

620

00:24:55,119 --> 00:24:58,058

handshake back from the person's

621

00:24:56,919 --> 00:25:01,480

computer then we know that they've

622

00:24:58,058 --> 00:25:04,480

stopped the experiment and so we end it

623

00:25:01,480 --> 00:25:06,909

at that point so again we've given

624

00:25:04,480 --> 00:25:08,589

roulette can instructions to now

625

00:25:06,909 --> 00:25:10,240

concentrate your attention on the system

626

00:25:08,589 --> 00:25:14,379

make the squiggly squiggly line move up

627

00:25:10,240 --> 00:25:16,599

or relax and do nothing here - we expect

628
00:25:14,380 --> 00:25:18,640
a delay but it's longer than a task

629
00:25:16,599 --> 00:25:20,408
switching delay it's not simply 3 or 5

630
00:25:18,640 --> 00:25:22,960
seconds where we also have Internet

631
00:25:20,409 --> 00:25:25,140
delays we have a delay in terms of the

632
00:25:22,960 --> 00:25:27,429
feedback that we give people because

633
00:25:25,140 --> 00:25:28,960
feedback is based on the last couple of

634
00:25:27,429 --> 00:25:30,640
seconds of data in order to give a

635
00:25:28,960 --> 00:25:32,710
smooth response so we did some

636
00:25:30,640 --> 00:25:35,740
calculations and measurements we decided

637
00:25:32,710 --> 00:25:37,240
that the the feedback delay or the delay

638
00:25:35,740 --> 00:25:39,779
that we would expect in the data would

639
00:25:37,240 --> 00:25:42,190
be roughly 5 to 10 seconds delay

640
00:25:39,779 --> 00:25:44,589
empirically it turns out that 9 seconds

641
00:25:42,190 --> 00:25:47,080
is the optimal time so there's

642
00:25:44,589 --> 00:25:49,178
instruction to concentrate and when we

643
00:25:47,079 --> 00:25:52,178
delay the data a little bit because the

644
00:25:49,179 --> 00:25:53,380
reaction would be slowed so here's what

645
00:25:52,179 --> 00:25:55,179
this interference pattern looks like

646
00:25:53,380 --> 00:25:57,850
this one is a little bit rectangular and

647
00:25:55,179 --> 00:26:00,788
we did a very simple analysis based on

648
00:25:57,849 --> 00:26:04,000
Fringe visibility this is simply looking

649
00:26:00,788 --> 00:26:07,089
at for an adjacent peak and trough

650
00:26:04,000 --> 00:26:09,730
it's the proportional heights so in a

651
00:26:07,089 --> 00:26:11,529
perfect interference pattern you have a

652
00:26:09,730 --> 00:26:14,069
hundred percent fringe visibility you

653
00:26:11,529 --> 00:26:18,519
have a very very low trough a very high

654
00:26:14,069 --> 00:26:20,168
peak we looked at the middle twenty

655
00:26:18,519 --> 00:26:21,700
fringes and the interference pattern

656

00:26:20,169 --> 00:26:25,929
because so they're the ones that are the

657
00:26:21,700 --> 00:26:27,460
most stable measure each fringe and so

658
00:26:25,929 --> 00:26:30,309
here we're looking at the difference in

659
00:26:27,460 --> 00:26:33,429
fringe visibility during concentrating

660
00:26:30,308 --> 00:26:36,308
versus relaxing the the red line in the

661
00:26:33,429 --> 00:26:38,890
middle is a two Sigma level and as you

662
00:26:36,308 --> 00:26:40,869
see some fringe number nine which is

663
00:26:38,890 --> 00:26:42,669
more or less in the center of the

664
00:26:40,869 --> 00:26:45,369
interference pattern actually went down

665
00:26:42,669 --> 00:26:46,929
to about three and a half Sigma drop the

666
00:26:45,369 --> 00:26:48,879
interesting thing is that all twenty

667
00:26:46,929 --> 00:26:50,230
fringes are negative they're predicted

668
00:26:48,880 --> 00:26:52,390
to be negative because we're

669
00:26:50,230 --> 00:26:54,940
basically saying that fringe visibility

670
00:26:52,390 --> 00:26:56,350

should drop it should shrink when people

671

00:26:54,940 --> 00:26:57,690

are putting their mind in the box and

672

00:26:56,349 --> 00:27:00,490

that is what we see

673

00:26:57,690 --> 00:27:03,640

so fringe visibility declines and mind

674

00:27:00,490 --> 00:27:05,589

focuses on the double-slit and it does

675

00:27:03,640 --> 00:27:08,410

not decrease when you have a simulated

676

00:27:05,589 --> 00:27:09,928

human do the same task so again the

677

00:27:08,410 --> 00:27:12,970

reason why this is so nice is because

678

00:27:09,929 --> 00:27:14,620

the the double stoo system has been

679

00:27:12,970 --> 00:27:17,289

sitting there now almost for three years

680

00:27:14,619 --> 00:27:19,719

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

681

00:27:17,289 --> 00:27:21,298

asking for data sometimes it's humans on

682

00:27:19,720 --> 00:27:23,620

the other end sometimes not

683

00:27:21,298 --> 00:27:25,660

you get fringe visibility drops

684

00:27:23,619 --> 00:27:27,009

significantly when people are on the

685
00:27:25,660 --> 00:27:29,590
other end and you don't when you have a

686
00:27:27,009 --> 00:27:31,599
Linux box now for those of you who

687
00:27:29,589 --> 00:27:34,750
believe in the the possibility of

688
00:27:31,599 --> 00:27:38,649
machine consciousness we know at least

689
00:27:34,750 --> 00:27:39,970
that a boon to box is not sufficiently

690
00:27:38,650 --> 00:27:43,840
conscious in order to make this thing

691
00:27:39,970 --> 00:27:49,660
work so there the human observers

692
00:27:43,839 --> 00:27:52,178
there's the robot observers this is a

693
00:27:49,660 --> 00:27:54,429
compass as a reminder for me that when

694
00:27:52,179 --> 00:27:56,320
you're doing something like this where

695
00:27:54,429 --> 00:27:59,259
you have 20 fringes that are not

696
00:27:56,319 --> 00:28:00,609
completely independent of each other you

697
00:27:59,259 --> 00:28:01,900
can do something called a false

698
00:28:00,609 --> 00:28:03,969
discovery rate which is like a

699
00:28:01,900 --> 00:28:05,429
bonferroni correction to see how many of

700
00:28:03,970 --> 00:28:08,230
these drops are really statistically

701
00:28:05,429 --> 00:28:11,590
significant so false discovery rate is

702
00:28:08,230 --> 00:28:13,269
used very often an EEG research because

703
00:28:11,589 --> 00:28:14,678
if you're looking at electrodes and you

704
00:28:13,269 --> 00:28:16,509
want to know how many of the electrodes

705
00:28:14,679 --> 00:28:18,970
in a given area are significantly

706
00:28:16,509 --> 00:28:20,440
different you need to adjust for the

707
00:28:18,970 --> 00:28:22,660
correlations well you can do the same

708
00:28:20,440 --> 00:28:26,500
process here and it turns out that of

709
00:28:22,660 --> 00:28:28,630
all of the 20 fringes that in this case

710
00:28:26,500 --> 00:28:32,369
there's something like 10 of the 20

711
00:28:28,630 --> 00:28:34,630
fringes which are significantly dropped

712
00:28:32,369 --> 00:28:38,979
so even though there are correlations

713

00:28:34,630 --> 00:28:41,110
here there's still significant many of

714
00:28:38,980 --> 00:28:42,910
them so what causes this change in the

715
00:28:41,109 --> 00:28:44,139
fringe visibility well remember our

716
00:28:42,910 --> 00:28:46,390
models said that there's something like

717
00:28:44,140 --> 00:28:48,429
an asymmetry going on it's as though the

718
00:28:46,390 --> 00:28:50,200
mind is causing the amount of light to

719
00:28:48,429 --> 00:28:53,580
go through one slit a little bit less

720
00:28:50,200 --> 00:28:56,440
than the other so when somebody's has to

721
00:28:53,579 --> 00:28:59,829
mentally observe even from many many

722
00:28:56,440 --> 00:29:02,590
kilometers away maybe that's what's

723
00:28:59,829 --> 00:29:03,878
happening so if you do a fringe

724
00:29:02,589 --> 00:29:06,009
visibility and analysis

725
00:29:03,878 --> 00:29:09,608
you can model that if you have perfect

726
00:29:06,009 --> 00:29:12,788
symmetry between one slit and the other

727
00:29:09,608 --> 00:29:14,408

their fringes are very there's the peak

728

00:29:12,788 --> 00:29:16,719

and there's a trough so the truck is

729

00:29:14,409 --> 00:29:18,729

very close to the zero the peak is where

730

00:29:16,719 --> 00:29:21,399

it is and now we've introduced a little

731

00:29:18,729 --> 00:29:22,479

eight asymmetry the trough Rises but the

732

00:29:21,398 --> 00:29:24,939

peak stays the same

733

00:29:22,479 --> 00:29:28,328

more asymmetry trough Rises peak stays

734

00:29:24,940 --> 00:29:31,028

the same and more so on so as you make

735

00:29:28,328 --> 00:29:33,428

more and more asymmetry the trough is

736

00:29:31,028 --> 00:29:35,078

where the action is the trough is rising

737

00:29:33,429 --> 00:29:36,548

and the peak stays the same so let's

738

00:29:35,078 --> 00:29:40,928

look at our actual data to see what

739

00:29:36,548 --> 00:29:43,658

happened the troughs rise and the peak

740

00:29:40,929 --> 00:29:45,788

stays the same so this is again

741

00:29:43,659 --> 00:29:48,399

suggesting that one way to think about

742
00:29:45,788 --> 00:29:50,648
what's happening is it is as though the

743
00:29:48,398 --> 00:29:52,538
light becomes asymmetrical in the two

744
00:29:50,648 --> 00:29:55,208
slits because the troughs are rising a

745
00:29:52,538 --> 00:29:58,959
lot in this case over five Sigma and for

746
00:29:55,209 --> 00:30:05,019
the center fringe but the peaks don't

747
00:29:58,959 --> 00:30:07,749
change at all so that all of those

748
00:30:05,019 --> 00:30:10,328
involved studies with continual

749
00:30:07,749 --> 00:30:12,190
continuous beam laser if we think about

750
00:30:10,328 --> 00:30:15,128
the number of photons involved in this

751
00:30:12,190 --> 00:30:17,139
case photons per second are many many

752
00:30:15,128 --> 00:30:19,328
gazillion trillions of photons per

753
00:30:17,138 --> 00:30:20,318
second you can actually calculate how

754
00:30:19,328 --> 00:30:22,209
many of there are but I don't remember

755
00:30:20,318 --> 00:30:24,338
just say many trillions of photons per

756
00:30:22,209 --> 00:30:26,548
second so when the mind is doing this

757
00:30:24,338 --> 00:30:30,908
task you don't have any possibility of

758
00:30:26,548 --> 00:30:32,769
capturing individual photons even though

759
00:30:30,909 --> 00:30:34,599
that's the task the task is to imagine

760
00:30:32,769 --> 00:30:36,249
you can gain which path information but

761
00:30:34,598 --> 00:30:38,708
how can you gain which path information

762
00:30:36,249 --> 00:30:40,959
of a trillion things per second so we

763
00:30:38,709 --> 00:30:43,389
decided to do this as a single photon

764
00:30:40,959 --> 00:30:45,249
double slit system that give the

765
00:30:43,388 --> 00:30:46,658
possibility that mind actually might be

766
00:30:45,249 --> 00:30:48,429
able to capture what was going on

767
00:30:46,659 --> 00:30:50,079
remember all of this is happening in

768
00:30:48,429 --> 00:30:51,459
your mind it's imagination which is

769
00:30:50,078 --> 00:30:53,038
doing the capture but nevertheless at

770

00:30:51,459 --> 00:30:55,599
least you have the possibility of

771
00:30:53,038 --> 00:30:58,118
capturing something at a human scale

772
00:30:55,598 --> 00:31:01,208
rather than a trillion protons per

773
00:30:58,118 --> 00:31:02,348
second scale so this device you see on

774
00:31:01,209 --> 00:31:05,440
the right there with Little Buddha

775
00:31:02,348 --> 00:31:08,528
sitting on it this is about a 1 meter

776
00:31:05,440 --> 00:31:10,599
long chamber and the way that and it's

777
00:31:08,528 --> 00:31:12,638
sitting on a vibration isolation table

778
00:31:10,598 --> 00:31:15,098
it's a very heavy table that is does

779
00:31:12,638 --> 00:31:17,769
that's sitting on pneumatic legs that is

780
00:31:15,098 --> 00:31:20,740
designed to dampen vibration

781
00:31:17,769 --> 00:31:23,079
a very stable system this is a schematic

782
00:31:20,740 --> 00:31:25,000
of it and the left you have the source

783
00:31:23,079 --> 00:31:27,399
of the light it's a very tiny little

784
00:31:25,000 --> 00:31:29,140

bulb and you can tune it down so that

785

00:31:27,400 --> 00:31:31,870

the amount of light coming out of the

786

00:31:29,140 --> 00:31:35,350

bulb is very very low that goes through

787

00:31:31,869 --> 00:31:37,178

a very heavy green filter the photons

788

00:31:35,349 --> 00:31:38,859

coming out are actually yellow the

789

00:31:37,179 --> 00:31:40,960

yellow bulb goes through a green filter

790

00:31:38,859 --> 00:31:42,789

and there are not very many yellow

791

00:31:40,960 --> 00:31:44,670

things that can get through green so you

792

00:31:42,789 --> 00:31:46,839

end up with even fewer number of photons

793

00:31:44,670 --> 00:31:49,210

those go through a single slit to

794

00:31:46,839 --> 00:31:50,859

collimate them and by the way this is

795

00:31:49,210 --> 00:31:53,110

not a laser this is just an incandescent

796

00:31:50,859 --> 00:31:54,939

bulb so that goes through a single slit

797

00:31:53,109 --> 00:31:56,919

go then goes through a double slit and

798

00:31:54,940 --> 00:31:58,900

then it goes on to another double

799
00:31:56,920 --> 00:32:02,170
another single slit that you can move on

800
00:31:58,900 --> 00:32:03,790
a stage and select which photons go into

801
00:32:02,170 --> 00:32:05,200
the photomultiplier tube because we need

802
00:32:03,789 --> 00:32:08,109
to count each photon as it goes through

803
00:32:05,200 --> 00:32:09,670
now the reason that you can move the

804
00:32:08,109 --> 00:32:11,859
stage because you want to be able to

805
00:32:09,670 --> 00:32:13,690
check is it actually producing an

806
00:32:11,859 --> 00:32:16,779
interference pattern one photon at a

807
00:32:13,690 --> 00:32:18,130
time and then you have a digital counter

808
00:32:16,779 --> 00:32:21,970
that's simply counting the number of

809
00:32:18,130 --> 00:32:23,710
photons per second so here you have a

810
00:32:21,970 --> 00:32:25,569
new vertical scale the number of photons

811
00:32:23,710 --> 00:32:28,150
per second in this particular case is

812
00:32:25,569 --> 00:32:30,789
roughly 25 to 30 photons per second

813
00:32:28,150 --> 00:32:32,320
that's being counted it's a very

814
00:32:30,789 --> 00:32:33,879
well-behaved system it gives a nice

815
00:32:32,319 --> 00:32:35,950
pause own distribution as you would

816
00:32:33,880 --> 00:32:38,200
expect and when you move the little

817
00:32:35,950 --> 00:32:39,460
stage around you can see what is what

818
00:32:38,200 --> 00:32:41,529
are the number of photons that we're

819
00:32:39,460 --> 00:32:45,730
actually getting well it ranges from

820
00:32:41,529 --> 00:32:47,399
around 25 up to around 700 and though

821
00:32:45,730 --> 00:32:49,450
you can see the error bars there and it

822
00:32:47,400 --> 00:32:51,610
actually showing a very nice

823
00:32:49,450 --> 00:32:54,549
interference pattern one photon at a

824
00:32:51,609 --> 00:32:57,519
time so this is how you know that what's

825
00:32:54,549 --> 00:33:01,659
happening here is the wave property of

826
00:32:57,519 --> 00:33:03,160
light actually it really does work it's

827

00:33:01,660 --> 00:33:05,980
somehow the lights going through two

828
00:33:03,160 --> 00:33:09,220
slits at the same time so the task now

829
00:33:05,980 --> 00:33:12,370
is you ask somebody to put their

830
00:33:09,220 --> 00:33:13,808
attention onto the onto the system we're

831
00:33:12,369 --> 00:33:17,199
going to look at a trough we're going to

832
00:33:13,808 --> 00:33:19,599
look at that particular spot and if the

833
00:33:17,200 --> 00:33:20,860
idea is that what's going on is collapse

834
00:33:19,599 --> 00:33:23,469
of the wave function then we're going to

835
00:33:20,859 --> 00:33:26,589
get by virtue of looking at the system

836
00:33:23,470 --> 00:33:27,579
we will interfere with interference in

837
00:33:26,589 --> 00:33:29,109
other words we'll get rid of the

838
00:33:27,579 --> 00:33:30,558
interference and we should increase the

839
00:33:29,109 --> 00:33:32,628
photon count rate

840
00:33:30,558 --> 00:33:34,009
so now rather than trying to drop a

841
00:33:32,628 --> 00:33:37,359

level we're trying to raise the number

842

00:33:34,009 --> 00:33:39,679

of photons that's that's the prediction

843

00:33:37,359 --> 00:33:41,569

again we use a volitional task we allow

844

00:33:39,679 --> 00:33:43,220

people to intervene in this system when

845

00:33:41,569 --> 00:33:45,740

they wish so that they're at an optimal

846

00:33:43,220 --> 00:33:46,940

attentional period so they can relax as

847

00:33:45,740 --> 00:33:49,548

long as they want and they press a

848

00:33:46,940 --> 00:33:51,110

button to to do the task they wait a

849

00:33:49,548 --> 00:33:53,569

couple of seconds and then the computer

850

00:33:51,109 --> 00:33:55,428

says now concentrate now concentrate for

851

00:33:53,569 --> 00:33:59,178

30 seconds and then they go back to

852

00:33:55,429 --> 00:34:02,480

relaxing so the first experiment we did

853

00:33:59,179 --> 00:34:04,278

there's the the mean for resting for

854

00:34:02,480 --> 00:34:07,909

waiting and concentrating this is a 5

855

00:34:04,278 --> 00:34:10,608

Sigma drop so this is opposite to our

856
00:34:07,909 --> 00:34:12,260
prediction this is not show a collapse

857
00:34:10,608 --> 00:34:14,809
of the wave function of anything this is

858
00:34:12,260 --> 00:34:16,399
showing a sharpening of the fringes or

859
00:34:14,809 --> 00:34:18,889
another way of thinking of it is that

860
00:34:16,398 --> 00:34:24,918
the entire system becomes much more

861
00:34:18,889 --> 00:34:27,050
orderly much much better behaved so we

862
00:34:24,918 --> 00:34:29,480
like this because when you get a 5 Sigma

863
00:34:27,050 --> 00:34:32,300
anomaly you can get the Nobel Prize if

864
00:34:29,480 --> 00:34:34,969
it happens to be the Higgs boson in this

865
00:34:32,300 --> 00:34:36,919
case we were pleased with that because

866
00:34:34,969 --> 00:34:39,559
it told us a clue that maybe our

867
00:34:36,918 --> 00:34:41,148
original concept was either incorrect or

868
00:34:39,559 --> 00:34:42,679
maybe something different is going on

869
00:34:41,148 --> 00:34:44,269
when you're reducing a trillion photons

870
00:34:42,679 --> 00:34:48,318
per second as compared to when you're

871
00:34:44,269 --> 00:34:50,239
using 25 or 30 per second so we didn't

872
00:34:48,318 --> 00:34:51,800
we did it now a sequence of experiments

873
00:34:50,239 --> 00:34:53,418
I'm just going to mention the couples so

874
00:34:51,800 --> 00:34:56,568
the second experiment we did we got it

875
00:34:53,418 --> 00:34:58,670
two and a half signal rise now this was

876
00:34:56,568 --> 00:35:00,650
a different design different people do a

877
00:34:58,670 --> 00:35:02,329
lot of things that were different in the

878
00:35:00,650 --> 00:35:04,940
experiment but we're now thinking well

879
00:35:02,329 --> 00:35:06,980
we might be on to something but we don't

880
00:35:04,940 --> 00:35:09,230
know what it is yet because we're

881
00:35:06,980 --> 00:35:12,650
flip-flopping from one to the other in

882
00:35:09,230 --> 00:35:14,150
statistically meaningful ways and that

883
00:35:12,650 --> 00:35:16,910
experiment with the two and a half Sigma

884

00:35:14,150 --> 00:35:18,588
rise we're also keeping track of the

885
00:35:16,909 --> 00:35:20,710
personality of the people involved in

886
00:35:18,588 --> 00:35:25,309
the experiment using the Cloninger

887
00:35:20,710 --> 00:35:27,068
inventory and what we found is that the

888
00:35:25,309 --> 00:35:29,920
people in our experiment were very

889
00:35:27,068 --> 00:35:32,630
significantly deviant from the norm and

890
00:35:29,920 --> 00:35:36,920
particularly characteristic called self

891
00:35:32,630 --> 00:35:38,660
transcendence so these were the people

892
00:35:36,920 --> 00:35:40,700
who tend to end up in our experiments

893
00:35:38,659 --> 00:35:42,559
are interested in things like meditation

894
00:35:40,699 --> 00:35:43,679
and self-development so it's not too

895
00:35:42,559 --> 00:35:45,119
surprising but

896
00:35:43,679 --> 00:35:47,669
compared to the population norm these

897
00:35:45,119 --> 00:35:49,650
are not normal people compared to the

898
00:35:47,670 --> 00:35:51,059

average person off the street in

899

00:35:49,650 --> 00:35:52,559

California especially in Northern

900

00:35:51,059 --> 00:35:57,450

California they probably kind of look

901

00:35:52,559 --> 00:35:58,410

like this we also were took taking

902

00:35:57,449 --> 00:36:00,689

32-channel

903

00:35:58,409 --> 00:36:02,098

EEG so we could look at brain response

904

00:36:00,690 --> 00:36:06,030

while they're doing the double stat

905

00:36:02,099 --> 00:36:07,769

tasks and so here's pictures of many

906

00:36:06,030 --> 00:36:10,980

people that were involved in the

907

00:36:07,769 --> 00:36:16,380

experiment and the the upshot of this is

908

00:36:10,980 --> 00:36:18,150

that when they're concentrating a double

909

00:36:16,380 --> 00:36:19,710

sit count went up it didn't stay up for

910

00:36:18,150 --> 00:36:21,088

very long it actually over the course of

911

00:36:19,710 --> 00:36:23,190

the twenty five seconds that they're

912

00:36:21,088 --> 00:36:25,949

concentrating it went back down to

913
00:36:23,190 --> 00:36:27,960
chance pretty quickly so even at

914
00:36:25,949 --> 00:36:30,149
meditators doing this experiment could

915
00:36:27,960 --> 00:36:32,338
not maintain the kind of concentration

916
00:36:30,150 --> 00:36:34,920
that was necessary for more than around

917
00:36:32,338 --> 00:36:36,389
five seconds but nicely because we're

918
00:36:34,920 --> 00:36:38,068
looking at their EEG we're able to

919
00:36:36,389 --> 00:36:40,409
measure alpha D synchronization in the

920
00:36:38,068 --> 00:36:42,449
brain which is correlated with attention

921
00:36:40,409 --> 00:36:45,828
with concentration in particular and

922
00:36:42,449 --> 00:36:48,298
that drops so we're getting a nice

923
00:36:45,829 --> 00:36:50,160
anti-correlation between alpha D

924
00:36:48,298 --> 00:36:52,079
synchronization and the result in the

925
00:36:50,159 --> 00:36:53,940
double-slit so the more cut the more you

926
00:36:52,079 --> 00:36:56,420
concentrate the better the result in the

927
00:36:53,940 --> 00:36:58,829
experiment which is nice

928
00:36:56,420 --> 00:37:00,088
we also found since we ran 20

929
00:36:58,829 --> 00:37:01,859
participants were able to look on

930
00:37:00,088 --> 00:37:03,989
average what is happening in terms of

931
00:37:01,858 --> 00:37:05,429
different frequencies in the brain and

932
00:37:03,989 --> 00:37:07,439
we found that one of the frequencies

933
00:37:05,429 --> 00:37:09,929
showed a significant result across all

934
00:37:07,440 --> 00:37:13,400
20 people this is a directional

935
00:37:09,929 --> 00:37:17,219
correlation with gamma gamma frequency

936
00:37:13,400 --> 00:37:18,990
so this is not an increase in gamma and

937
00:37:17,219 --> 00:37:21,899
the temporal and the occipital but

938
00:37:18,989 --> 00:37:25,798
actually a decrease in gamma gamma

939
00:37:21,900 --> 00:37:27,930
becomes D synchronized as well so it

940
00:37:25,798 --> 00:37:29,519
actually everything alpha beta gal all

941

00:37:27,929 --> 00:37:31,048
of the brain frequencies become D

942
00:37:29,519 --> 00:37:33,210
synchronized and the process of doing in

943
00:37:31,048 --> 00:37:35,369
this experiment the bottom is showing

944
00:37:33,210 --> 00:37:37,470
however an absolute change that's it

945
00:37:35,369 --> 00:37:39,858
doesn't matter whether the gamma went up

946
00:37:37,469 --> 00:37:43,078
or down but some change from a baseline

947
00:37:39,858 --> 00:37:45,239
very significant results in the temporal

948
00:37:43,079 --> 00:37:48,269
area this says that what we're seeing is

949
00:37:45,239 --> 00:37:50,429
not consistent across people some people

950
00:37:48,269 --> 00:37:52,318
gamma went up some people gamma went

951
00:37:50,429 --> 00:37:53,969
down we're thinking okay well there's

952
00:37:52,318 --> 00:37:55,650
something going on with that particular

953
00:37:53,969 --> 00:37:57,129
frequency which is much greater than any

954
00:37:55,650 --> 00:38:01,358
other frequency we saw

955
00:37:57,130 --> 00:38:04,240

which is related to these results so

956

00:38:01,358 --> 00:38:05,500

here we have our other cat and this this

957

00:38:04,239 --> 00:38:07,118

came about because you're trying to

958

00:38:05,500 --> 00:38:09,278

think now what is it about doing this

959

00:38:07,119 --> 00:38:10,660

experiment with single photons where

960

00:38:09,278 --> 00:38:12,068

sometimes you get a very strong result

961

00:38:10,659 --> 00:38:13,469

in one direction and sometimes a very

962

00:38:12,068 --> 00:38:16,750

strong result in the other direction

963

00:38:13,469 --> 00:38:18,699

doesn't seem to make sense until I

964

00:38:16,750 --> 00:38:22,268

started to realize that the quantum Zeno

965

00:38:18,699 --> 00:38:23,739

effect is one of the properties of what

966

00:38:22,268 --> 00:38:25,479

happens when you observe a quantum

967

00:38:23,739 --> 00:38:27,429

system doesn't work for all quantum

968

00:38:25,480 --> 00:38:30,219

systems because it needs to be in a

969

00:38:27,429 --> 00:38:31,960

certain certain configuration but

970
00:38:30,219 --> 00:38:34,689
suitable quantum systems when you look

971
00:38:31,960 --> 00:38:36,179
at it they basically freeze it freezes

972
00:38:34,690 --> 00:38:39,849
the evolution of the quantum system

973
00:38:36,179 --> 00:38:41,919
that's the quantum Zeno effect what I

974
00:38:39,849 --> 00:38:43,568
did not realize until I started looking

975
00:38:41,920 --> 00:38:46,240
into this is there is also a quantum

976
00:38:43,568 --> 00:38:47,920
anti Zeno effect and this is that there

977
00:38:46,239 --> 00:38:50,679
you can look at certain systems and

978
00:38:47,920 --> 00:38:52,329
accelerate its evolution so you can do

979
00:38:50,679 --> 00:38:53,889
both and it depends a lot in the way

980
00:38:52,329 --> 00:38:56,048
that the system is devised you can

981
00:38:53,889 --> 00:38:58,389
depending on the frequency with which

982
00:38:56,048 --> 00:39:00,880
you observe the system you can freeze it

983
00:38:58,389 --> 00:39:03,219
or you can accelerate it so we've been

984
00:39:00,880 --> 00:39:06,548
doing experiments evolving single

985
00:39:03,219 --> 00:39:07,899
quantum events with different designs so

986
00:39:06,548 --> 00:39:10,568
maybe I thought well let's do an

987
00:39:07,900 --> 00:39:13,210
experiment where we do what amounts to a

988
00:39:10,568 --> 00:39:16,989
quantum Zeno experiment so we used our

989
00:39:13,210 --> 00:39:19,139
diode laser we set it up to get this

990
00:39:16,989 --> 00:39:21,159
time looking at Fringe visibility and

991
00:39:19,139 --> 00:39:22,900
there's who are tracking fringe

992
00:39:21,159 --> 00:39:25,868
visibility in one particular fringe and

993
00:39:22,900 --> 00:39:28,750
it's a very nice well-behaved system and

994
00:39:25,869 --> 00:39:30,608
the observers task is that we're

995
00:39:28,750 --> 00:39:32,048
measuring 50 samples per second we're

996
00:39:30,608 --> 00:39:34,150
getting fringe visibility out of the

997
00:39:32,048 --> 00:39:36,608
system 50 times a second but sometimes

998

00:39:34,150 --> 00:39:40,358
we presented to people very very slowly

999
00:39:36,608 --> 00:39:42,130
like one out of every 200 samples and

1000
00:39:40,358 --> 00:39:43,838
then sometimes a little bit faster like

1001
00:39:42,130 --> 00:39:45,849
one out of every 50 samples and then

1002
00:39:43,838 --> 00:39:48,460
even faster so there's four different

1003
00:39:45,849 --> 00:39:51,009
levels of speed in this experiment

1004
00:39:48,460 --> 00:39:53,289
systems just keeps pumping out data but

1005
00:39:51,009 --> 00:39:57,068
there's an observer of what's happening

1006
00:39:53,289 --> 00:39:57,549
at different time scales so this is the

1007
00:39:57,068 --> 00:40:00,190
result

1008
00:39:57,548 --> 00:40:03,568
so you see 14 controls heston sessions

1009
00:40:00,190 --> 00:40:06,759
14 also with humans observing a system

1010
00:40:03,568 --> 00:40:09,009
the variance for the results with the

1011
00:40:06,759 --> 00:40:10,539
humans is very statistically significant

1012
00:40:09,009 --> 00:40:13,360

and for the control it's not

1013

00:40:10,539 --> 00:40:14,889

so this is a suggestion that may be

1014

00:40:13,360 --> 00:40:17,410

what's going on here is that there are

1015

00:40:14,889 --> 00:40:18,670

different modes of observation going on

1016

00:40:17,409 --> 00:40:20,129

and the different experiments that we

1017

00:40:18,670 --> 00:40:22,389

did which we didn't even think of

1018

00:40:20,130 --> 00:40:23,890

originally which may be accounting for

1019

00:40:22,389 --> 00:40:26,259

the fact that we're sometimes freezing

1020

00:40:23,889 --> 00:40:27,789

the system and sometimes accelerating it

1021

00:40:26,260 --> 00:40:30,010

and that's why we're getting flip-flops

1022

00:40:27,789 --> 00:40:32,440

it is also the case that individuals

1023

00:40:30,010 --> 00:40:35,080

observe in very different ways and so

1024

00:40:32,440 --> 00:40:36,519

even the same exact experiment you can

1025

00:40:35,079 --> 00:40:38,679

have people doing something different in

1026

00:40:36,519 --> 00:40:40,119

their head and ending up with different

1027
00:40:38,679 --> 00:40:44,079
results because the nature of the

1028
00:40:40,119 --> 00:40:45,639
observation is different so whatever we

1029
00:40:44,079 --> 00:40:47,619
learned so far we've learned that

1030
00:40:45,639 --> 00:40:50,409
attention affects behavior of light and

1031
00:40:47,619 --> 00:40:52,179
quantum optics systems it's somewhat

1032
00:40:50,409 --> 00:40:54,159
consistent with von neumann's proposal

1033
00:40:52,179 --> 00:40:56,949
especially the ones involving continuous

1034
00:40:54,159 --> 00:40:59,079
lasers and also that some crazy ideas

1035
00:40:56,949 --> 00:41:01,000
might be correct so how does this

1036
00:40:59,079 --> 00:41:03,909
particular crazy idea fit into the rest

1037
00:41:01,000 --> 00:41:05,199
of science well in the big jigsaw puzzle

1038
00:41:03,909 --> 00:41:08,409
we're trying to understand the universe

1039
00:41:05,199 --> 00:41:10,689
maybe three places one is that it is

1040
00:41:08,409 --> 00:41:13,269
sigh like I mean it's involving some

1041
00:41:10,690 --> 00:41:15,700
kind of mind matter interaction it

1042
00:41:13,269 --> 00:41:18,699
probably fits into this rising interest

1043
00:41:15,699 --> 00:41:20,529
in information physics and also probably

1044
00:41:18,699 --> 00:41:22,929
with quantum biology like there's

1045
00:41:20,530 --> 00:41:24,519
something about those three areas will

1046
00:41:22,929 --> 00:41:28,449
probably fill in the jigsaw at some

1047
00:41:24,519 --> 00:41:32,429
point maybe consciousness is fundamental

1048
00:41:28,449 --> 00:41:35,559
after all and I'll end with

1049
00:41:32,429 --> 00:41:38,169
acknowledging many fine collaborators

1050
00:41:35,559 --> 00:41:40,239
who helped in this design and execution

1051
00:41:38,170 --> 00:41:41,980
and also this work which could not have

1052
00:41:40,239 --> 00:41:44,500
been done without our funders the BI

1053
00:41:41,980 --> 00:41:47,050
foundation in Portugal Fetzner Memorial

1054
00:41:44,500 --> 00:41:48,429
Trust and Michigan mental insight

1055

00:41:47,050 --> 00:41:50,470
foundation in California and the

1056
00:41:48,429 --> 00:41:54,690
Federico and Elvia fijian foundation

1057
00:41:50,469 --> 00:41:58,469
here in Silicon Valley and with that I

1058
00:41:54,690 --> 00:41:58,470
thank you for your kind attention

1059
00:42:06,429 --> 00:42:13,119
thank you very much Dean fascinating we

1060
00:42:10,400 --> 00:42:13,119
will take a few questions

1061
00:42:16,719 --> 00:42:23,480
Dean regarding the observers themselves

1062
00:42:19,940 --> 00:42:25,909
is that the act of simply concentrating

1063
00:42:23,480 --> 00:42:29,900
or is it the act of concentrating

1064
00:42:25,909 --> 00:42:32,659
specifically on the the area where the

1065
00:42:29,900 --> 00:42:34,490
slit is because I've noticed I don't

1066
00:42:32,659 --> 00:42:37,489
know if you're familiar with a new toy

1067
00:42:34,489 --> 00:42:41,029
called a mind flex where you actually

1068
00:42:37,489 --> 00:42:43,129
can change this little device based on

1069
00:42:41,030 --> 00:42:44,350

whether you're concentrating or not if

1070

00:42:43,130 --> 00:42:47,720

your mind is just kind of you know

1071

00:42:44,349 --> 00:42:49,400

drifting so did you try that two

1072

00:42:47,719 --> 00:42:51,980

separate whether they're concentrating

1073

00:42:49,400 --> 00:42:54,980

specifically on tasks or just

1074

00:42:51,980 --> 00:42:56,900

concentrating that's a very good

1075

00:42:54,980 --> 00:42:58,429

question and actually it was addressed

1076

00:42:56,900 --> 00:43:00,680

somewhat in the the quantum Zeno

1077

00:42:58,429 --> 00:43:03,739

experiment because in that experiment

1078

00:43:00,679 --> 00:43:06,409

the only instruction is look at the dots

1079

00:43:03,739 --> 00:43:07,609

on the screen and they and I mean they

1080

00:43:06,409 --> 00:43:09,529

knew that it had to do with a double

1081

00:43:07,610 --> 00:43:12,440

slit but I didn't say very much about it

1082

00:43:09,530 --> 00:43:14,300

so simply just pay attention to the fact

1083

00:43:12,440 --> 00:43:17,090

that things are happening so that's

1084
00:43:14,300 --> 00:43:18,950
attention without any any knowledge of

1085
00:43:17,090 --> 00:43:21,530
the system and all of the other systems

1086
00:43:18,949 --> 00:43:22,969
we did tell people what it's about you

1087
00:43:21,530 --> 00:43:24,890
know this is a double slit and there's

1088
00:43:22,969 --> 00:43:26,689
this theory and so on when you ask

1089
00:43:24,889 --> 00:43:29,869
people after the experiment what did you

1090
00:43:26,690 --> 00:43:31,970
do for about 20 seconds they followed

1091
00:43:29,869 --> 00:43:34,279
instructions and then they found it was

1092
00:43:31,969 --> 00:43:36,259
too difficult to do that so they did a

1093
00:43:34,280 --> 00:43:39,380
huge range of different kinds of

1094
00:43:36,260 --> 00:43:42,560
strategies so in that respect it's kind

1095
00:43:39,380 --> 00:43:44,240
of a miracle that the the continuous

1096
00:43:42,559 --> 00:43:47,179
laser experiments worked as well as it

1097
00:43:44,239 --> 00:43:48,949
did so maybe it doesn't matter the exact

1098
00:43:47,179 --> 00:43:51,079
form of concentration doesn't matter too

1099
00:43:48,949 --> 00:43:52,699
much and I think that is also now what

1100
00:43:51,079 --> 00:43:55,779
we see in this quantum Zeno type of

1101
00:43:52,699 --> 00:43:57,980
experiment that it's it's more about

1102
00:43:55,780 --> 00:44:00,019
observing that something is happening

1103
00:43:57,980 --> 00:44:02,539
and not the details and in particular

1104
00:44:00,019 --> 00:44:04,099
for people doing this over the web they

1105
00:44:02,539 --> 00:44:05,779
don't they don't see anything about a

1106
00:44:04,099 --> 00:44:09,309
double slit they just see a squiggly

1107
00:44:05,780 --> 00:44:12,680
line and it works for them too so

1108
00:44:09,309 --> 00:44:15,650
extending that point we know that inside

1109
00:44:12,679 --> 00:44:16,599
experiments our intention affects the

1110
00:44:15,650 --> 00:44:19,480
outcome

1111
00:44:16,599 --> 00:44:22,900
how do you know that the outcome is

1112

00:44:19,480 --> 00:44:24,880
being affected via the mechanisms that

1113
00:44:22,900 --> 00:44:27,250
you're suggesting in terms of collapse

1114
00:44:24,880 --> 00:44:28,690
of wavefunction as you know we've done

1115
00:44:27,250 --> 00:44:31,780
experiments at the University of

1116
00:44:28,690 --> 00:44:33,940
Colorado with intention on reflection of

1117
00:44:31,780 --> 00:44:35,820
light and we find that there is an

1118
00:44:33,940 --> 00:44:39,159
effect on reflection of light and

1119
00:44:35,820 --> 00:44:41,170
moreover the more lability we give to

1120
00:44:39,159 --> 00:44:45,389
the system the more noise there is in

1121
00:44:41,170 --> 00:44:48,340
the system the greater the effect and so

1122
00:44:45,389 --> 00:44:52,179
how do we know what part of it we're

1123
00:44:48,340 --> 00:44:54,039
affecting I don't think there's a clear

1124
00:44:52,179 --> 00:44:56,469
answer to that yet I mean in particular

1125
00:44:54,039 --> 00:44:58,960
because the delayed choice version of

1126
00:44:56,469 --> 00:45:00,989

this worked there's always the

1127

00:44:58,960 --> 00:45:03,360
possibility that the analyst is

1128

00:45:00,989 --> 00:45:06,489
collapsing the system backwards in time

1129

00:45:03,360 --> 00:45:07,809
so there are ways to get around that of

1130

00:45:06,489 --> 00:45:09,519
course you have different analysts

1131

00:45:07,809 --> 00:45:11,259
involved and one of them one of my hopes

1132

00:45:09,519 --> 00:45:12,940
in this kind of experiment since we've

1133

00:45:11,260 --> 00:45:15,220
gotten such good and relatively

1134

00:45:12,940 --> 00:45:17,619
consistently good results is to inspire

1135

00:45:15,219 --> 00:45:19,029
others to do something like it because

1136

00:45:17,619 --> 00:45:20,469
that's really the only way of knowing

1137

00:45:19,030 --> 00:45:22,360
whether it's an analyst effect and

1138

00:45:20,469 --> 00:45:24,099
eventually we'll get clever enough and

1139

00:45:22,360 --> 00:45:26,680
figure out ways of answering that very

1140

00:45:24,099 --> 00:45:30,549
important question at this point I don't

1141
00:45:26,679 --> 00:45:32,799
know that's all the time we have for

1142
00:45:30,550 --> 00:45:34,900
questions right now but you may proceed

1143
00:45:32,800 --> 00:45:37,510
to rush Dean with your myriad questions

1144
00:45:34,900 --> 00:45:40,320
at the lunch break thank you very much

1145
00:45:37,510 --> 00:45:40,320
once again thank you

1146
00:45:42,500 --> 00:45:50,159
[Music]

1147
00:45:48,099 --> 00:45:50,159
you

1148
00:45:57,909 --> 00:45:59,969
you