

ULTRASOUND STIMULATION

- Ultrasound applied to BL-87, vision related acupoint
- Ultrasound stimulation indistinguishable from needling --- fMRI of visual cortex
- Wide range of ultrasound parameters produced stimulation
- No stimulation with $I < 5 \text{ W/cm}^2$

1
00:00:06,829 --> 00:00:03,830
I'd like to talk to you now about some

2
00:00:08,839 --> 00:00:06,839
of our work that I've been doing in

3
00:00:11,180 --> 00:00:08,849
conjunction with jung-bae who's an

4
00:00:12,709 --> 00:00:11,190
acupuncturist Yong is actually an

5
00:00:15,829 --> 00:00:12,719
interesting chap he was going to be here

6
00:00:17,540 --> 00:00:15,839
today but was unable to he's not only

7
00:00:19,160 --> 00:00:17,550
acupuncturist but he actually also has a

8
00:00:21,830 --> 00:00:19,170
PhD in high-energy physics from UC

9
00:00:23,689 --> 00:00:21,840
Berkeley so that's a I don't know many

10
00:00:26,390 --> 00:00:23,699
acupuncturist that are high-energy

11
00:00:28,790 --> 00:00:26,400
physicists and acupuncturist too but

12
00:00:30,820 --> 00:00:28,800
show you some of the some of our work

13
00:00:35,180 --> 00:00:30,830

it's been ongoing for a number of years

14

00:00:36,680 --> 00:00:35,190

with with acupuncture acupuncture as you

15

00:00:38,209 --> 00:00:36,690

well know is a major component of

16

00:00:40,880 --> 00:00:38,219

oriental medicine but it's been very

17

00:00:45,819 --> 00:00:40,890

difficult to reconcile with medicine

18

00:00:51,080 --> 00:00:49,160

because oriental medicine more or less

19

00:00:54,350 --> 00:00:51,090

energy based Western medicine more

20

00:00:56,600 --> 00:00:54,360

molecular based but in spite of all of

21

00:00:58,400 --> 00:00:56,610

that there are certainly a number of

22

00:01:00,490 --> 00:00:58,410

documented correlates with acupuncture

23

00:01:02,540 --> 00:01:00,500

looking at nerve pathway activation

24

00:01:03,770 --> 00:01:02,550

release of neurotransmitters and

25

00:01:07,280 --> 00:01:03,780

hormones and a variety of other

26

00:01:11,120 --> 00:01:07,290

activities our initial study with

27

00:01:12,080 --> 00:01:11,130

acupuncture goes back to 1996 1998 this

28

00:01:14,300 --> 00:01:12,090

give you a little bit of history here

29

00:01:17,330 --> 00:01:14,310

and which we looked at correlations

30

00:01:19,550 --> 00:01:17,340

between specific brain cortices and

31

00:01:20,929 --> 00:01:19,560

corresponding acupoints stimulation the

32

00:01:23,870 --> 00:01:20,939

classical functional magnetic resonance

33

00:01:26,359 --> 00:01:23,880

imaging experiment you do is to

34

00:01:28,520 --> 00:01:26,369

stimulate the visual cortex by light

35

00:01:30,440 --> 00:01:28,530

flashes so someone's in an fMRI device

36

00:01:33,050 --> 00:01:30,450

you turn on flashing lights visual

37

00:01:36,140 --> 00:01:33,060

cortex lights up we repeated those same

38

00:01:39,859 --> 00:01:36,150

experiments except no flashing lights we

39

00:01:42,380 --> 00:01:39,869

blindfolded the subject we had the

40

00:01:44,810 --> 00:01:42,390

acupuncturist stimulate B l67 an

41

00:01:48,289 --> 00:01:44,820

acupuncture point in the foot related to

42

00:01:52,190 --> 00:01:48,299

vision and yeah the visual cortex lights

43

00:01:55,789 --> 00:01:52,200

up here are some fMRI images the one on

44

00:01:57,260 --> 00:01:55,799

the left the individual is looking at

45

00:02:05,660 --> 00:01:57,270

flashing lights and the visual cortex

46

00:02:09,020 --> 00:02:05,670

lights up the center B slide is the same

47

00:02:11,479 --> 00:02:09,030

individual blindfolded acupuncture

48

00:02:13,670 --> 00:02:11,489

stimulation of B l67 acupuncture one in

49

00:02:14,330 --> 00:02:13,680

foot-related vision visual cortex lights

50

00:02:24,250 --> 00:02:14,340

up

51
00:02:26,690 --> 00:02:24,260
what you see in the brain is just noise

52
00:02:30,610 --> 00:02:26,700
these findings were published back in

53
00:02:33,620 --> 00:02:30,620
1998 and Proceedings of National Academy

54
00:02:35,990 --> 00:02:33,630
we continued on this work using

55
00:02:37,790 --> 00:02:36,000
ultrasound to really determine the

56
00:02:40,520 --> 00:02:37,800
feasibility of using ultrasound to at

57
00:02:42,920 --> 00:02:40,530
first stimulate acupuncture sought sites

58
00:02:46,370 --> 00:02:42,930
and then to actually image these

59
00:02:47,990 --> 00:02:46,380
acupuncture sites as well the ultrasound

60
00:02:49,670 --> 00:02:48,000
parameters that we use for the

61
00:02:52,729 --> 00:02:49,680
stimulation were based on work that

62
00:02:55,789 --> 00:02:52,739
we've done previously and just very

63
00:02:58,070 --> 00:02:55,799

quickly we used a focus transducer

64

00:03:01,400 --> 00:02:58,080

operating at five megahertz highly

65

00:03:03,860 --> 00:03:01,410

focused working in intensive levels

66

00:03:05,539 --> 00:03:03,870

between five to eight watts per square

67

00:03:08,990 --> 00:03:05,549

centimeter

68

00:03:11,990 --> 00:03:09,000

the ultrasound stimulation was applied

69

00:03:14,570 --> 00:03:12,000

to this acupuncture point the o-67

70

00:03:15,830 --> 00:03:14,580

vision related acupuncture point and it

71

00:03:17,229 --> 00:03:15,840

turns out that the ultrasound

72

00:03:20,090 --> 00:03:17,239

stimulation is actually

73

00:03:23,449 --> 00:03:20,100

indistinguishable from applying a needle

74

00:03:24,979 --> 00:03:23,459

to that same acupuncture point it also

75

00:03:26,630 --> 00:03:24,989

turns out that a wide range of

76
00:03:29,210 --> 00:03:26,640
ultrasound parameters could produce the

77
00:03:31,190 --> 00:03:29,220
simulation but lower levels of

78
00:03:33,590 --> 00:03:31,200
ultrasound those below about five watts

79
00:03:35,120 --> 00:03:33,600
per square centimeter would not produce

80
00:03:38,569 --> 00:03:35,130
a stimulation by the way these

81
00:03:41,180 --> 00:03:38,579
ultrasound levels are above those that

82
00:03:42,620 --> 00:03:41,190
are used diagnostically but below those

83
00:03:47,390 --> 00:03:42,630
that are known produced any kind of

84
00:03:50,379 --> 00:03:47,400
deleterious effects we moved on to try

85
00:03:52,400 --> 00:03:50,389
to image acupuncture points and

86
00:03:53,890 --> 00:03:52,410
conventional imaging conventional

87
00:03:55,940 --> 00:03:53,900
ultrasound imaging failed miserably

88
00:03:58,250 --> 00:03:55,950

operating at three and a half seven half

89

00:04:01,039 --> 00:03:58,260

ten megahertz typical ultrasound imaging

90

00:04:03,199 --> 00:04:01,049

device is imaging of acupuncture points

91

00:04:07,160 --> 00:04:03,209

was really unremarkable we understand

92

00:04:08,449 --> 00:04:07,170

why but due to the fact that acupuncture

93

00:04:10,750 --> 00:04:08,459

points appear to have the same

94

00:04:13,009 --> 00:04:10,760

reflectivity as a surrounding tissue

95

00:04:15,680 --> 00:04:13,019

however measurements at somewhat higher

96

00:04:19,279 --> 00:04:15,690

frequencies 50 megahertz Center

97

00:04:21,979 --> 00:04:19,289

frequencies showed the enhanced ultra

98

00:04:24,800 --> 00:04:21,989

sound attenuation through an acupuncture

99

00:04:27,320 --> 00:04:24,810

point and without going any kind of

100

00:04:28,220 --> 00:04:27,330

details let me just suffice it to say

101

00:04:30,860 --> 00:04:28,230

given the time

102

00:04:33,830 --> 00:04:30,870

constraints that the slide at the top is

103

00:04:36,500 --> 00:04:33,840

kind of a reflected signal through soft

104

00:04:39,380 --> 00:04:36,510

tissue these are these are 11

105

00:04:42,710 --> 00:04:39,390

millimeters in depth and moving over to

106

00:04:45,040 --> 00:04:42,720

acupuncture site what we see is enhanced

107

00:04:47,960 --> 00:04:45,050

attenuation over that acupuncture site

108

00:04:52,370 --> 00:04:47,970

highly distinguished from just normal

109

00:04:55,250 --> 00:04:52,380

soft tissue this in fact led us to

110

00:04:58,490 --> 00:04:55,260

develop a data acquisition system

111

00:05:01,280 --> 00:04:58,500

operating at 50 megahertz on which we

112

00:05:03,650 --> 00:05:01,290

digitize the reflected signals we refer

113

00:05:05,450 --> 00:05:03,660

to those as a lines send out a pulse of

114

00:05:08,240 --> 00:05:05,460

ultrasound look at the reflections that

115

00:05:10,070 --> 00:05:08,250

come back that's known as an a-line we

116

00:05:13,670 --> 00:05:10,080

recorded a two-dimensional grid of these

117

00:05:15,260 --> 00:05:13,680

a lines and then calculated using some

118

00:05:17,570 --> 00:05:15,270

signal processing techniques that we had

119

00:05:19,490 --> 00:05:17,580

developed years ago in our lab along

120

00:05:22,190 --> 00:05:19,500

each line to measure the attenuation of

121

00:05:25,280 --> 00:05:22,200

each acupuncture point and then to

122

00:05:29,510 --> 00:05:25,290

reconstruct that and here is what a this

123

00:05:32,120 --> 00:05:29,520

bee l67 actually looks like the top of

124

00:05:34,490 --> 00:05:32,130

the skin is up here scales here in

125

00:05:38,110 --> 00:05:34,500

millimeters three dimensionally and what

126

00:05:42,170 --> 00:05:38,120

you see are basically foci of constant

127

00:05:44,690 --> 00:05:42,180

attenuation or elasticity defining that

128

00:05:46,820 --> 00:05:44,700

acupuncture point and with a little

129

00:05:48,890 --> 00:05:46,830

visualization or if I take off my

130

00:05:50,420 --> 00:05:48,900

classes it actually actually looks like

131

00:05:52,520 --> 00:05:50,430

a three-dimensional acupuncture point

132

00:05:53,780 --> 00:05:52,530

and maybe if your vision is as bad as

133

00:05:55,850 --> 00:05:53,790

mine you can take off your glasses and

134

00:05:57,380 --> 00:05:55,860

it'll look much better but I'll show you

135

00:05:59,750 --> 00:05:57,390

some images later that are actually much

136

00:06:01,640 --> 00:05:59,760

much better than this curiously enough

137

00:06:04,190 --> 00:06:01,650

these acupuncture points don't stay in

138

00:06:06,220 --> 00:06:04,200

the same place they move around this is

139

00:06:09,260 --> 00:06:06,230

a typical size of the acupuncture point

140

00:06:11,630 --> 00:06:09,270

this is in a particular individual of a

141

00:06:14,000 --> 00:06:11,640

12-day period and notice you start out

142

00:06:16,340 --> 00:06:14,010

here and over 12 days the acupuncture

143

00:06:18,800 --> 00:06:16,350

point comes out over here and this

144

00:06:21,920 --> 00:06:18,810

process is actually it turns out well

145

00:06:24,890 --> 00:06:21,930

known to many many acupuncturist I was a

146

00:06:27,380 --> 00:06:24,900

little surprised to find this out but

147

00:06:30,530 --> 00:06:27,390

the acupuncture points do actually

148

00:06:33,920 --> 00:06:30,540

change in size and shape over time and

149

00:06:35,660 --> 00:06:33,930

they move around a little bit well a

150

00:06:38,480 --> 00:06:35,670

summary so far acupuncture points

151
00:06:40,250 --> 00:06:38,490
correspond to regions of enhanced

152
00:06:41,490 --> 00:06:40,260
elasticity increased ultrasound

153
00:06:43,500 --> 00:06:41,500
attenuation

154
00:06:46,250 --> 00:06:43,510
they change in size shape and even

155
00:06:49,050 --> 00:06:46,260
location over short periods of time and

156
00:06:50,490 --> 00:06:49,060
using quantitative ultrasound methods we

157
00:06:53,310 --> 00:06:50,500
can actually image these acupuncture

158
00:06:56,250 --> 00:06:53,320
points and ultrasound at higher

159
00:07:00,090 --> 00:06:56,260
intensities can actually stimulate those

160
00:07:04,320 --> 00:07:00,100
points a couple of references we first

161
00:07:07,700 --> 00:07:04,330
reported on this at the 20th annual

162
00:07:11,400 --> 00:07:07,710
meeting back in La Jolla in 2001 and

163
00:07:14,340 --> 00:07:11,410

some additional work at the meeting at

164

00:07:17,340 --> 00:07:14,350

University of Virginia in 2002 and this

165

00:07:21,570 --> 00:07:17,350

was also published 2004 in medical

166

00:07:23,790 --> 00:07:21,580

acupuncture and in acoustic imaging the

167

00:07:24,780 --> 00:07:23,800

objectives of the ongoing study and what

168

00:07:26,760 --> 00:07:24,790

I'd really like to talk to you about

169

00:07:29,520 --> 00:07:26,770

today is to obtain ultra sound

170

00:07:32,100 --> 00:07:29,530

attenuation images of acupuncture points

171

00:07:34,260 --> 00:07:32,110

during the stimulation of those points

172

00:07:36,210 --> 00:07:34,270

and also to investigate communication

173

00:07:40,830 --> 00:07:36,220

between acupuncture points along the

174

00:07:43,260 --> 00:07:40,840

same Meridian here we built a new data

175

00:07:46,140 --> 00:07:43,270

acquisition system that was a actually

176
00:07:50,630 --> 00:07:46,150
at 50 megahertz transducer array it's 10

177
00:07:53,659 --> 00:07:50,640
by 10 elements each element is about a

178
00:07:55,740 --> 00:07:53,669
two tenths of a millimeter square

179
00:07:58,440 --> 00:07:55,750
operating center frequencies of 50

180
00:08:01,590 --> 00:07:58,450
megahertz so it's a 10 by 10 array so it

181
00:08:03,900 --> 00:08:01,600
means a hundred elements we're going to

182
00:08:06,360 --> 00:08:03,910
record these individual a lines from

183
00:08:08,940 --> 00:08:06,370
each transducer and digitize them at 200

184
00:08:10,740 --> 00:08:08,950
megahertz and we're going to fire each

185
00:08:14,480 --> 00:08:10,750
one of these hundred elements at the

186
00:08:17,790 --> 00:08:14,490
same time record information and then

187
00:08:20,130 --> 00:08:17,800
put together the data to reconstruct an

188
00:08:23,580 --> 00:08:20,140

attenuation image or elasticity image of

189

00:08:26,090 --> 00:08:23,590

the acupuncture points now each element

190

00:08:29,010 --> 00:08:26,100

of this array is connected to a separate

191

00:08:30,659 --> 00:08:29,020

pulsar and receiver so if you come into

192

00:08:34,110 --> 00:08:30,669

our lab you'll see a rack of a hundred

193

00:08:35,790 --> 00:08:34,120

pcs it's kind of brute force but it does

194

00:08:38,670 --> 00:08:35,800

work actually we have a hundred and one

195

00:08:40,800 --> 00:08:38,680

pcs because one PC basically controls

196

00:08:43,649 --> 00:08:40,810

the process and the other hundred pcs

197

00:08:46,829 --> 00:08:43,659

record the data from each one of these

198

00:08:49,920 --> 00:08:46,839

elements in the array each PC has about

199

00:08:51,900 --> 00:08:49,930

five gigabytes of fast memory and so in

200

00:08:54,210 --> 00:08:51,910

about three seconds when we turn this

201
00:08:55,300 --> 00:08:54,220
thing on we record about a half a

202
00:08:58,449 --> 00:08:55,310
terabyte of data

203
00:09:02,559 --> 00:08:58,459
so this will keep graduate students busy

204
00:09:04,090 --> 00:09:02,569
for a long period of time and in fact

205
00:09:06,249 --> 00:09:04,100
the the images that are going to show

206
00:09:08,710 --> 00:09:06,259
you are sort of jumpy they don't move

207
00:09:10,809 --> 00:09:08,720
smoothly and they don't smooth move move

208
00:09:12,340 --> 00:09:10,819
smoothly because of the limited number

209
00:09:15,189 --> 00:09:12,350
of graduate students I have to work on

210
00:09:16,540 --> 00:09:15,199
this stuff okay

211
00:09:18,759 --> 00:09:16,550
here's what an acupuncture point looks

212
00:09:21,030 --> 00:09:18,769
like this is BL 67 this is about a

213
00:09:23,290 --> 00:09:21,040

millimeter or so in dimension here and

214

00:09:25,150 --> 00:09:23,300

now let's see what happens when you

215

00:09:27,460 --> 00:09:25,160

actually stimulate that acupuncture

216

00:09:29,889 --> 00:09:27,470

point top of the skin is here we're

217

00:09:32,019 --> 00:09:29,899

about three millimeters in depth from

218

00:09:33,670 --> 00:09:32,029

the scan let's see what happens when we

219

00:09:34,749 --> 00:09:33,680

actually stimulate this acupuncture

220

00:09:37,150 --> 00:09:34,759

point you get the same thing whether

221

00:09:39,879 --> 00:09:37,160

it's a needle or a pulse of ultrasound

222

00:09:42,160 --> 00:09:39,889

the point actually twists around the

223

00:09:45,730 --> 00:09:42,170

needle actually twisting around the

224

00:09:46,900 --> 00:09:45,740

needle as you stimulate now the

225

00:09:50,290 --> 00:09:46,910

acupuncture point that we're stimulating

226

00:09:53,470 --> 00:09:50,300

is B l67 in the foot here and now what

227

00:09:56,170 --> 00:09:53,480

I'd like to do is stimulate this

228

00:09:58,239 --> 00:09:56,180

acupuncture point and then let's take