

STUDYING THE RELATION BETWEEN PHYSIOLOGICAL SIGNALS AND EXPERIENCED EMOTIONS FOR NEW MUSIC LISTENING APPLICATIONS

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MUSIC & EMOTIONS & PHYSIOLOGICAL SIGNALS

MOTIVATION

MAIN

Browse

Activity

Radio

YOUR MUSIC

Songs

Albums

Artists

Local Files

PLAYLISTS

Starred

mje

hjola

Weekend Hangouts b...

1

ESM | Electronic ...

2015

New Playlist

Lay Down Your E +

JOY WELLBOY

VIRAL Iceland

TOP 50 Global

BACK IN BL...

AC/DC Rock or Bust

COOL END

BLACKCHORDS

SIDEWALKER

HALF MAN

Search

OVERVIEW CHARTS GENRES & MOODS NEW RELEASES DISCOVER

Slow down with great music.

88 Keys

A song for every key on the piano.

COZY EVENING

What could be better than an evening inside, all warm and relaxed on the couch? Let th...

HOT ALTERNATIVE

The ultimate playlist for today's hottest Alternative songs.

R&B LOVE

No music genre does love and sex like R&B. Here are some of the hottest R&B love song...

Svanlaug Ingólfssdóttir

Ari Viðar Jóhannesson 31 m

Quiet Life

Japan

Quiet Life

Hildigunnur Björgúlfsson 4 h

Fade Into You

Nashville Cast

Nashville TV Show (ABC)

Perla Steinsdóttir 4 h

Lean On (feat. MØ & DJ Snake)

Major Lazer

Top Tracks in Iceland

Kristján Jónsson 14 h

They Can't Take That Away From...

Ella Fitzgerald & Louis Armstrong

Ella Fitzgerald & Louis Armstrong

Jórunn Pála Jónasdóttir 2 d

Tremor (Sensation 2014 Anthem...)

Dimitri Vegas & Like Mike

Dum Dee Dum

Tómas Páll Máté 2 d

General Penitentiary

Michael Rose

Culture Center Pt 2.

3:27 3:45 LYRICS

Have a Great Day!

Feel great with these timelessly fun songs!

654,767 FOLLOWERS

100 MOST UPLIFTING SONGS

100 Most Uplifting Songs

Feel great with these timelessly fun songs!

715,995 FOLLOWERS

Calm Down

Calm Down

Get happy with this pick-me-up playlist full of feel good songs!

934,974 FOLLOWERS

Deep House Relax

Deep House Relax

Chilled house music and some other good tunes about all your problems.

160,179 FOLLOWERS

Feel Good Indie Rock

Feel Good Indie Rock

Play alternative rock when you're in a better mood than indie pop...

345,566 FOLLOWERS

Feelin' Good

Feel good with this positively timeless Soul playlist!

715,995 FOLLOWERS

Mood Booster

Mood Booster

Get happy with this pick-me-up playlist full of feel good songs!

934,974 FOLLOWERS

Current Practice



Current Practice



Current Practice



Current Practice



Current Practice



There must be a better way

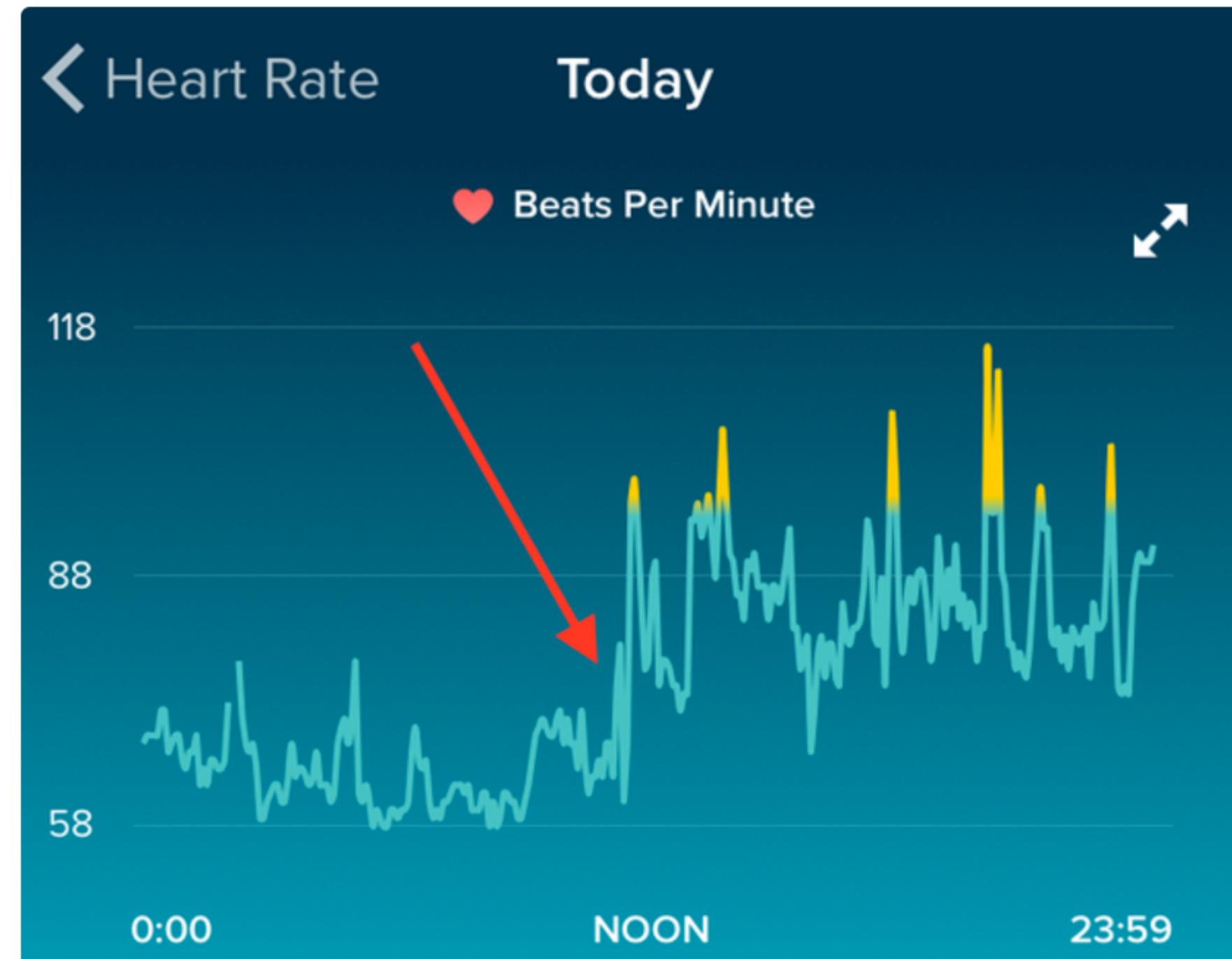
› Can we make use of physiological signals to **personalise** music recommendations for emotion regulation?



Koby
@iamkoby

[Follow](#)

Breakup, as captured by my fitbit. #breakup
#Fitbit



RETWEETS

2,337

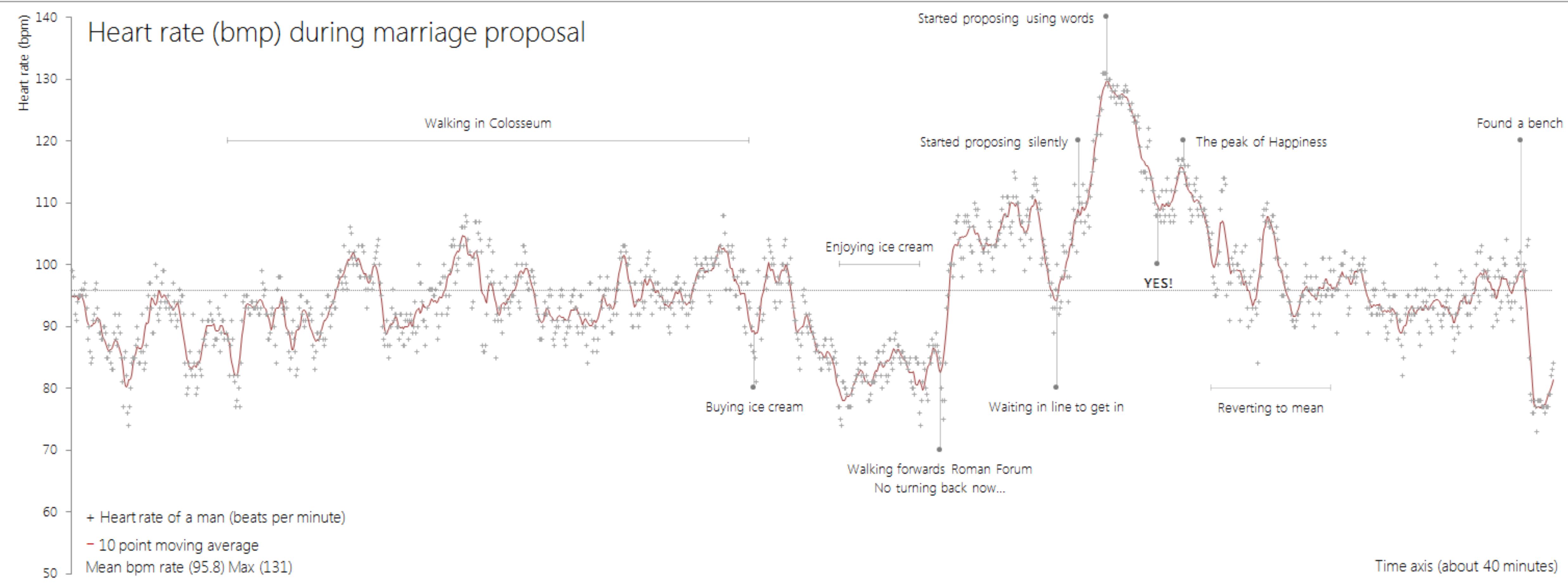
LIKES

3,126



10:55 AM - 19 Jan 2016





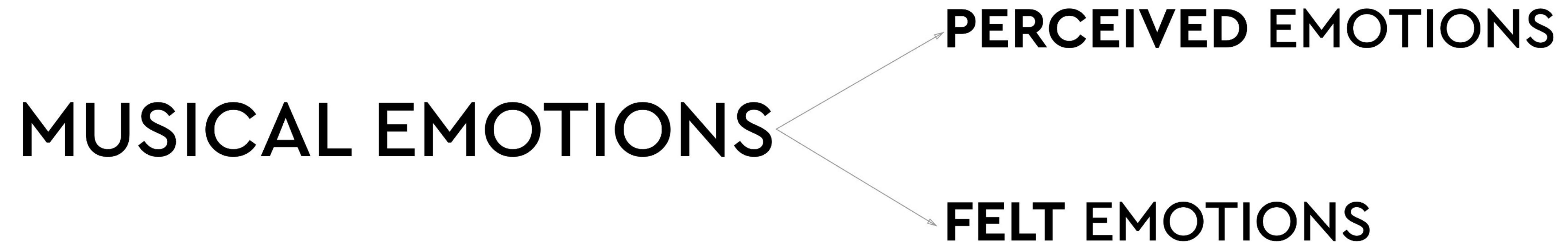
MUSIC & EMOTIONS & PHYSIOLOGICAL SIGNALS

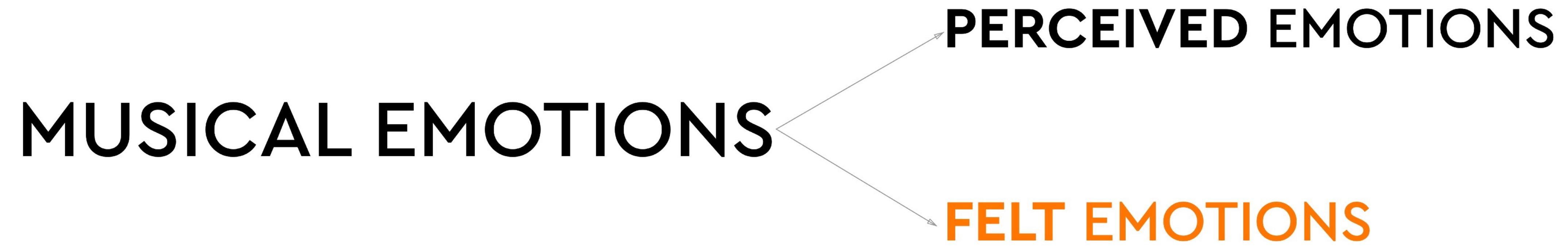
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REPRESENTS EMOTIONS

INDUCES EMOTIONS

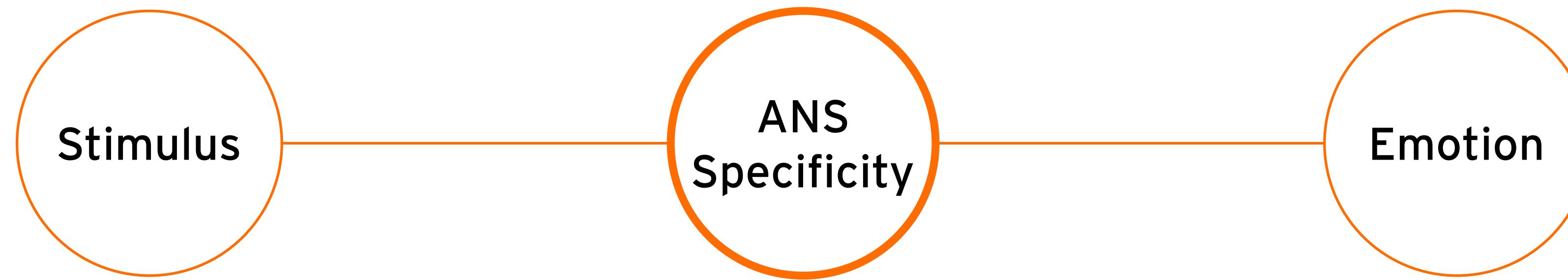
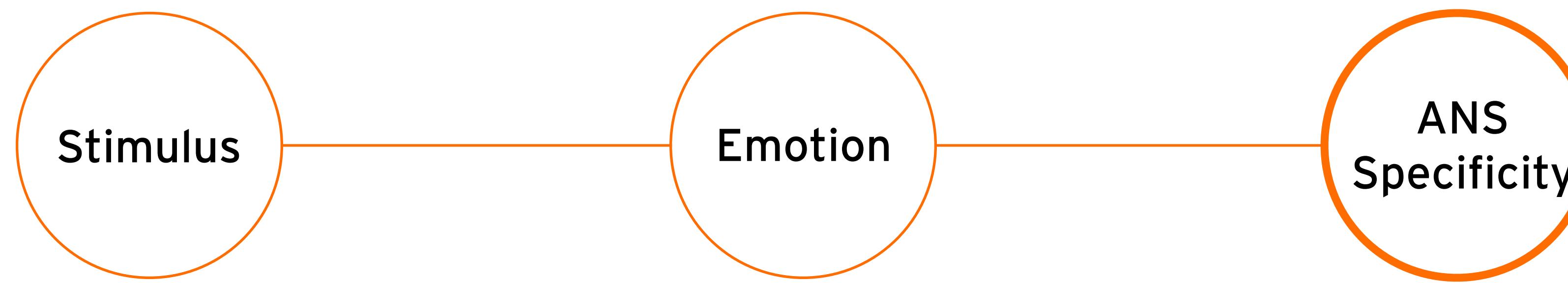




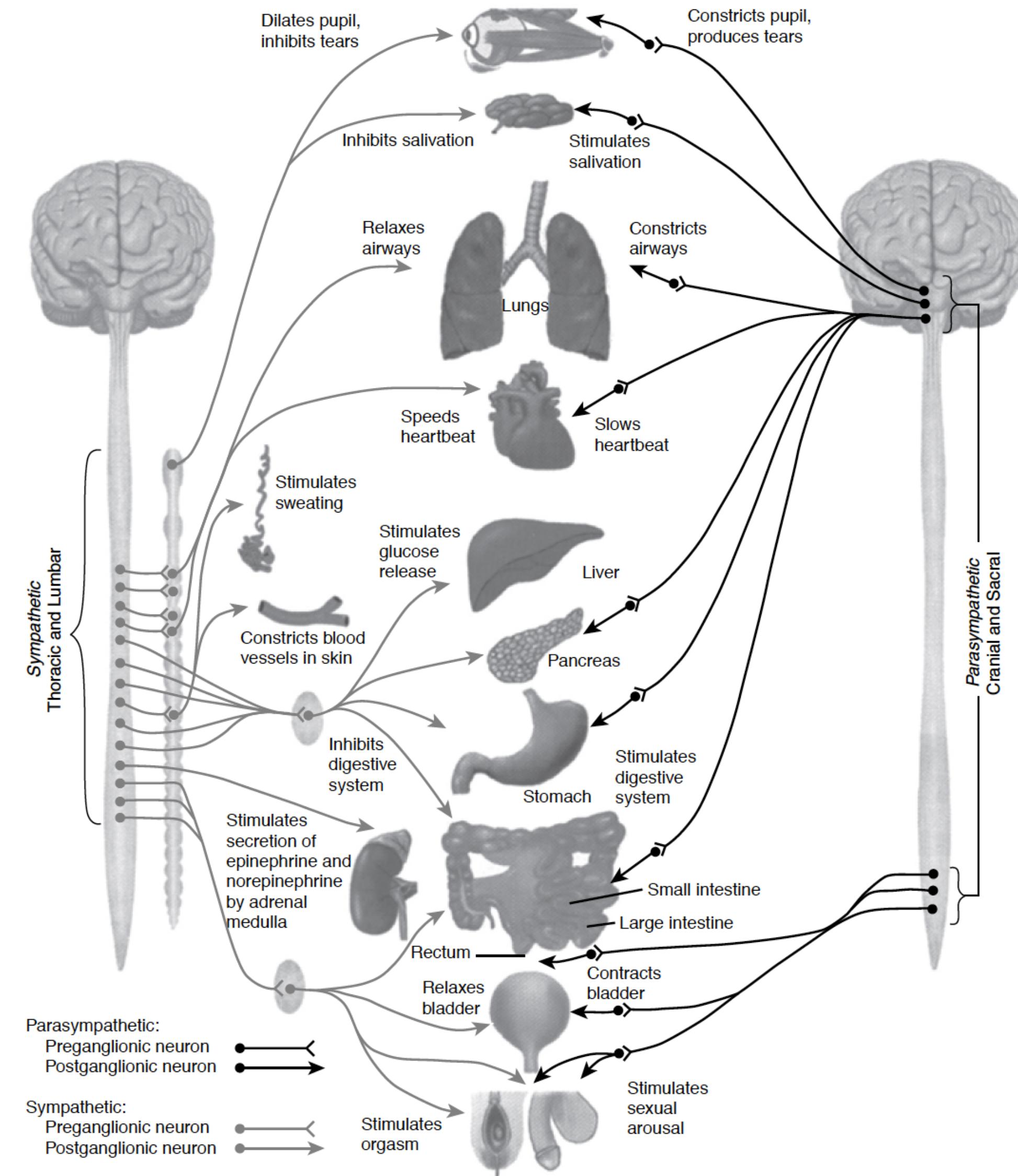
MUSIC & EMOTIONS & PHYSIOLOGICAL SIGNALS

MUSIC & EMOTIONS & PHYSIOLOGICAL SIGNALS

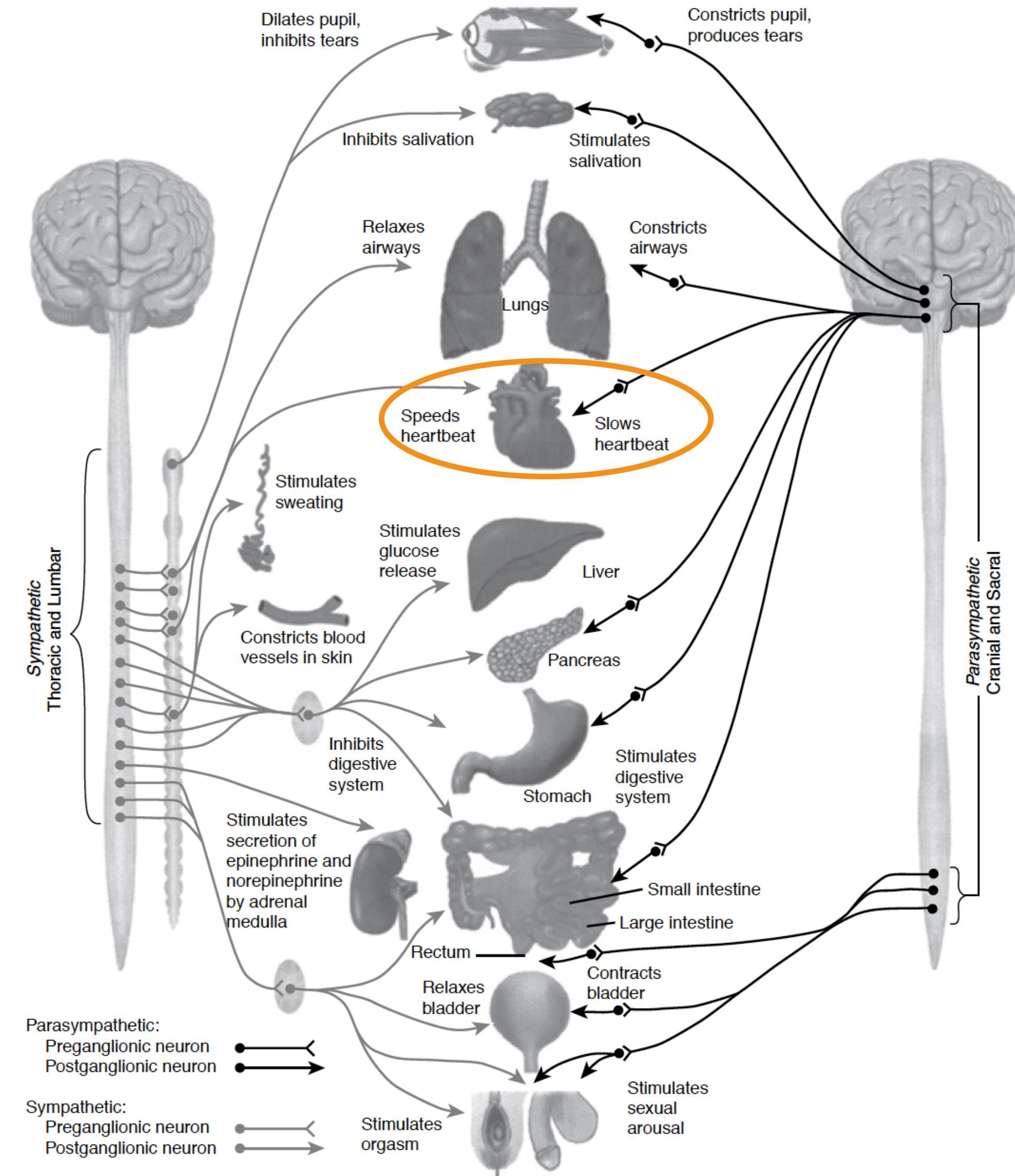
Physiology of Emotions



Autonomic Nervous System

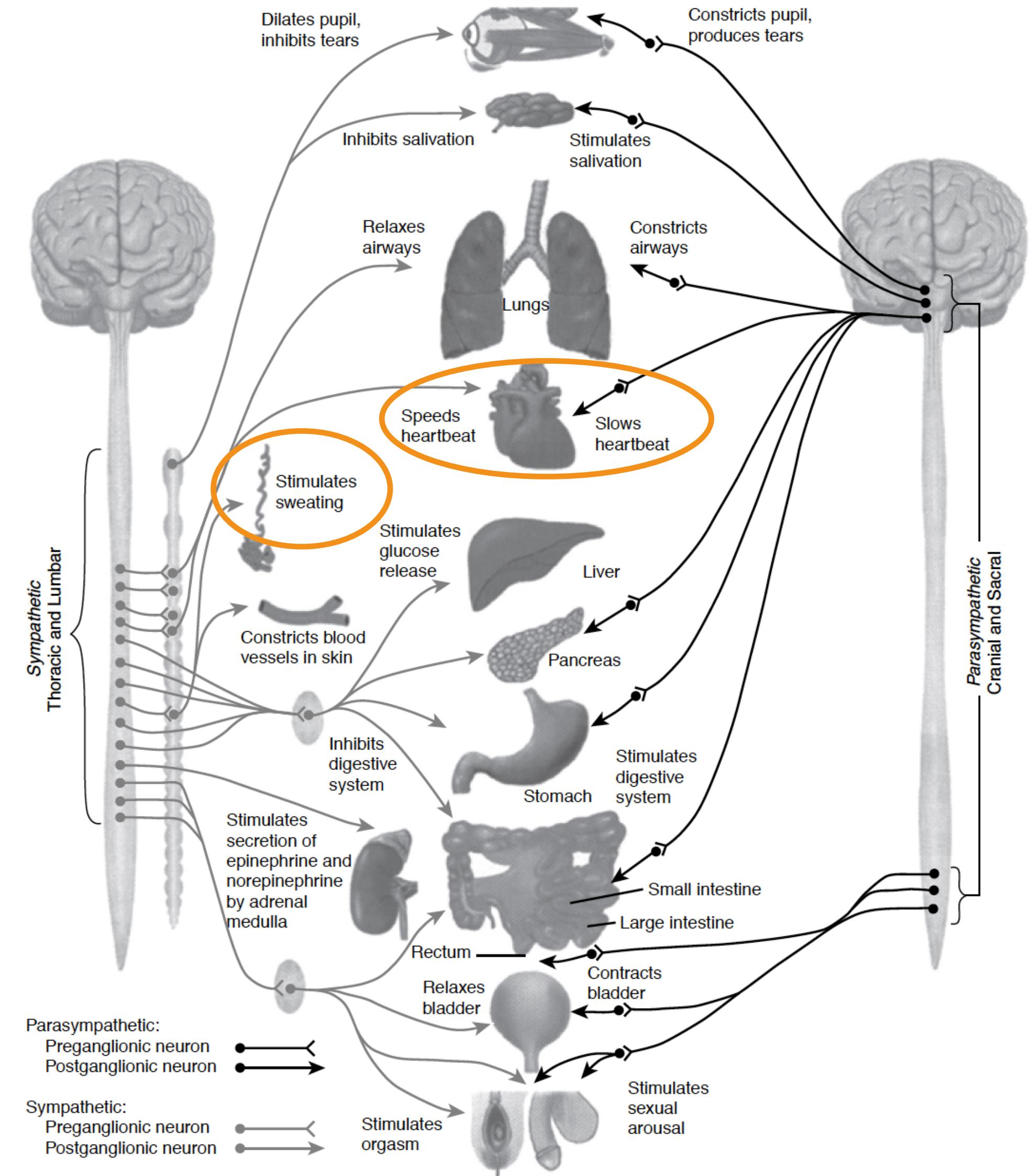


Autonomic Nervous System



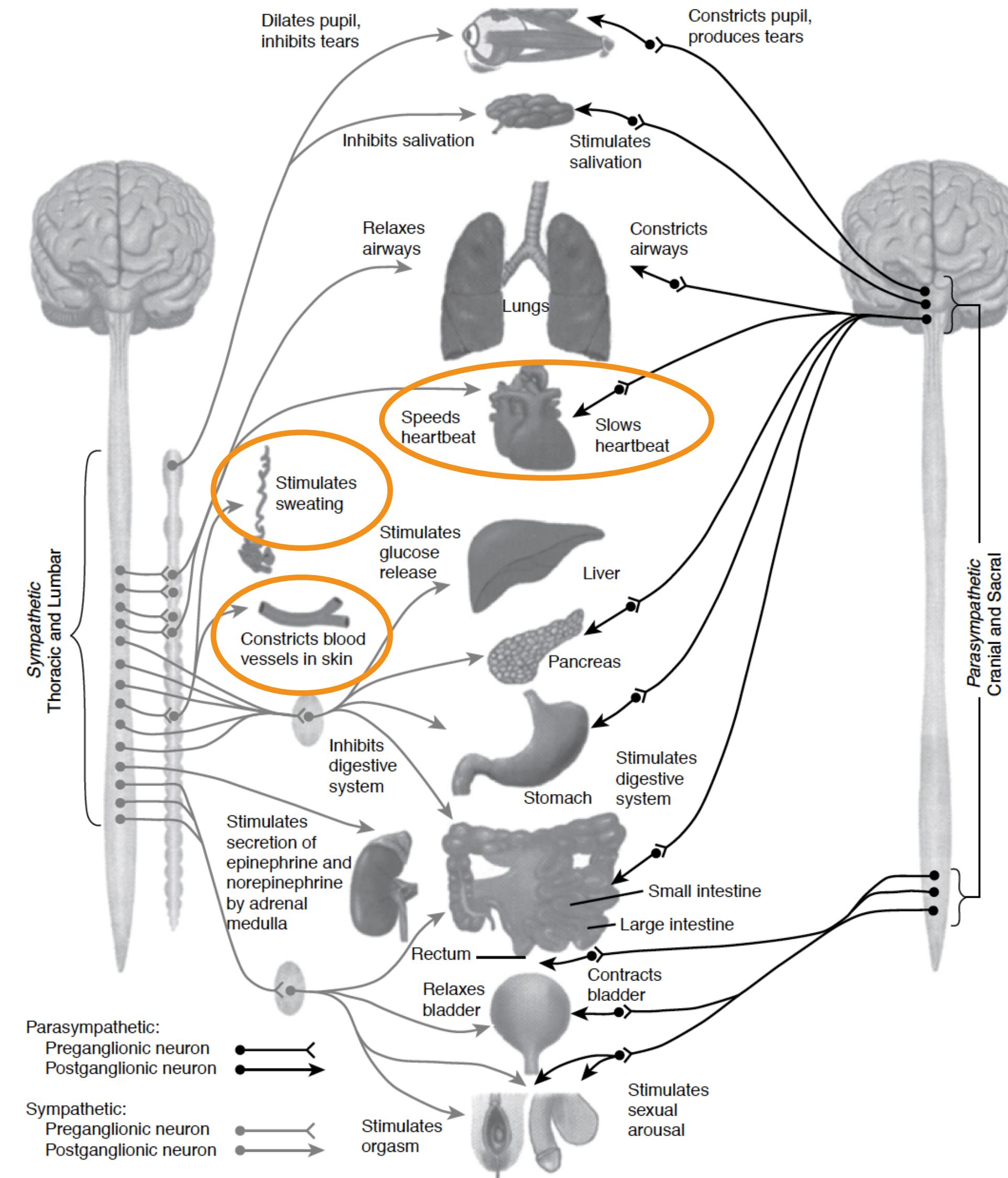
➤ Cardiac Activity
Heartbeat (BPM)

Autonomic Nervous System



- Cardiac Activity
Heartbeat (BPM)
- Skin Conductance

Autonomic Nervous System



- Cardiac Activity
Heartbeat (BPM)
- Skin Conductance
- Skin Temperature

Activity Trackers



Band



Eleven sensors include GPS, UV monitor and barometer



E4[®] wristband

UP3™
by JAWBONE®

[SHOP NOW](#)

The worlds most advanced tracker.



Sensor & Interface

Bluetooth® 4.0 BLE

Tri-axis accelerometer

Bio-impedance:

Heart rate

Respiration

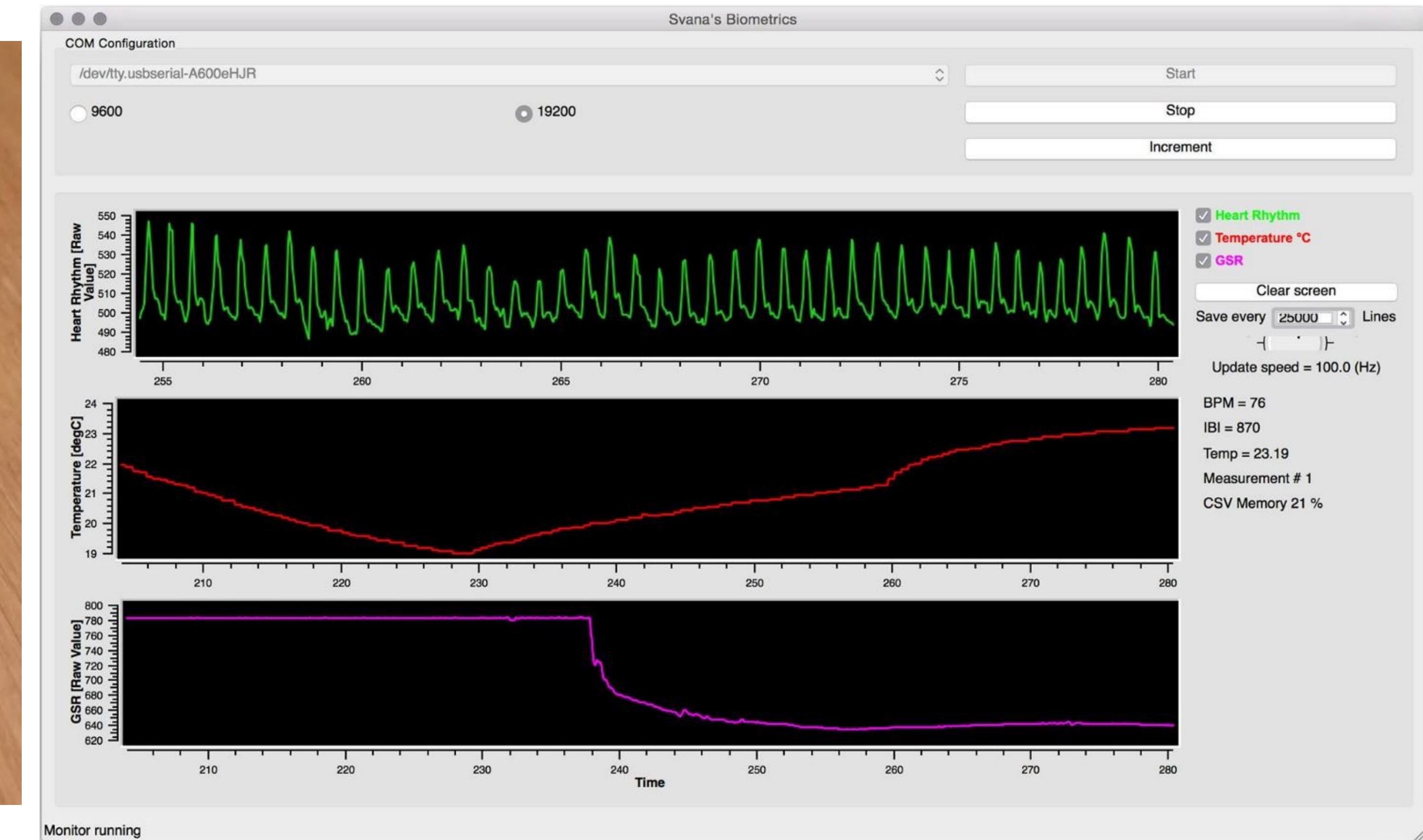
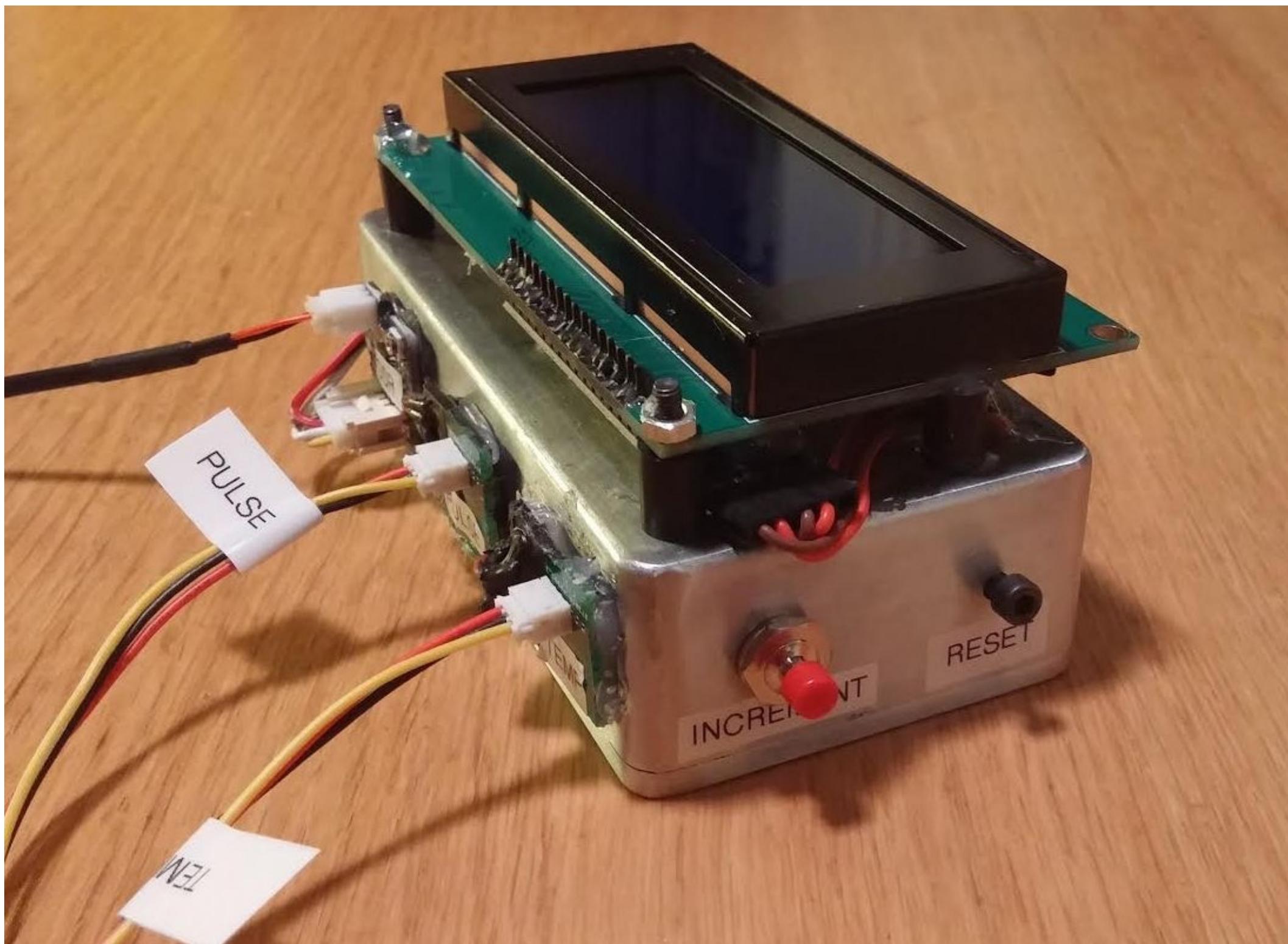
Galvanic Skin Response (GSR)

BASIS PEAK™



Device	Sampling Frequency [Hz]			Price [€]
	BVP	SC	ST	
Basis Peak	1	0.017	0.017	199
Empatica E4	64	4	4	1550
Jawbone UP3	NA	NA	NA	179
Microsoft Band	1	NA	1	199

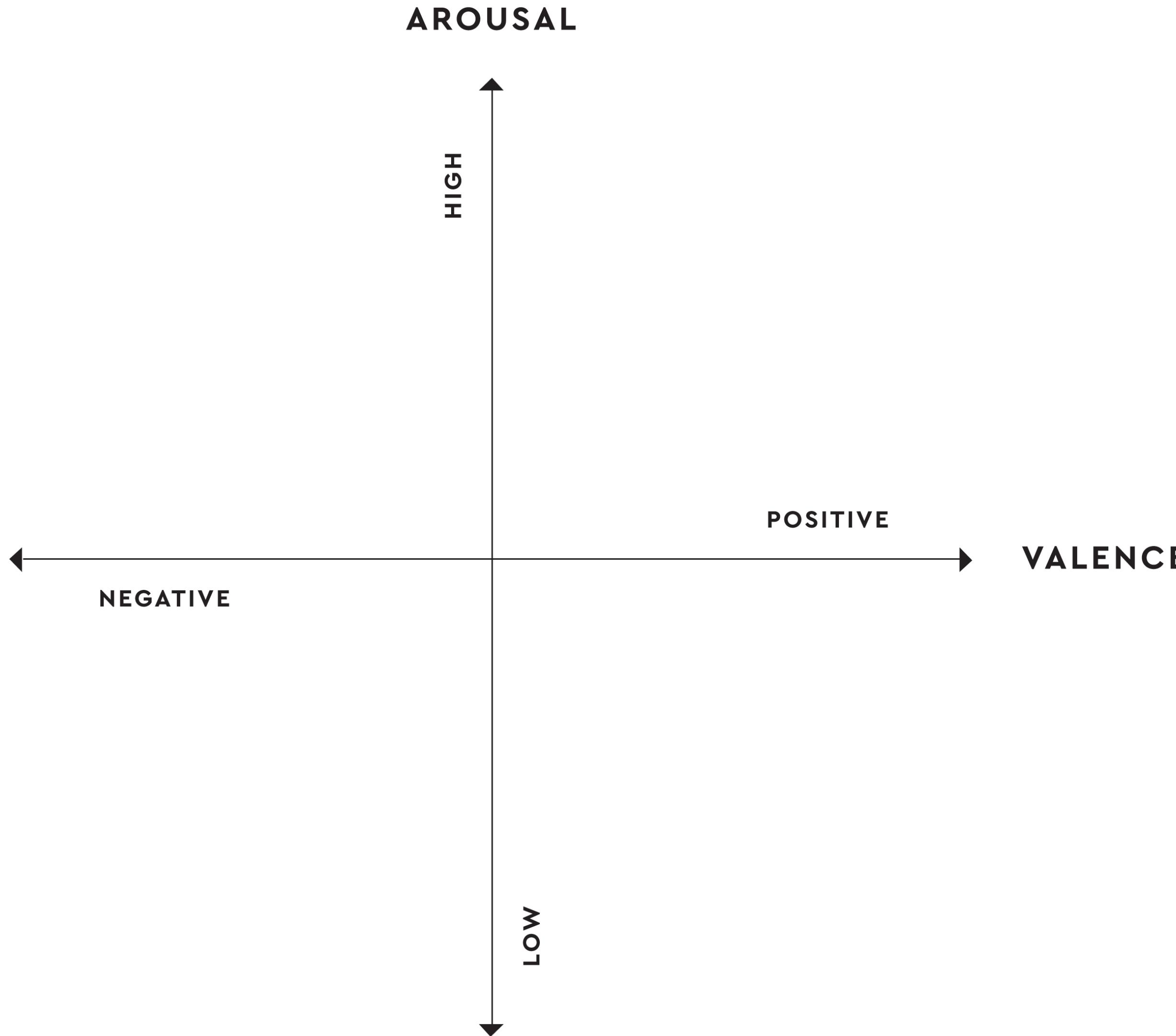
Prototype Device



MUSIC & EMOTIONS & PHYSIOLOGICAL SIGNALS

MUSIC & EMOTIONS & PHYSIOLOGICAL SIGNALS

The Study

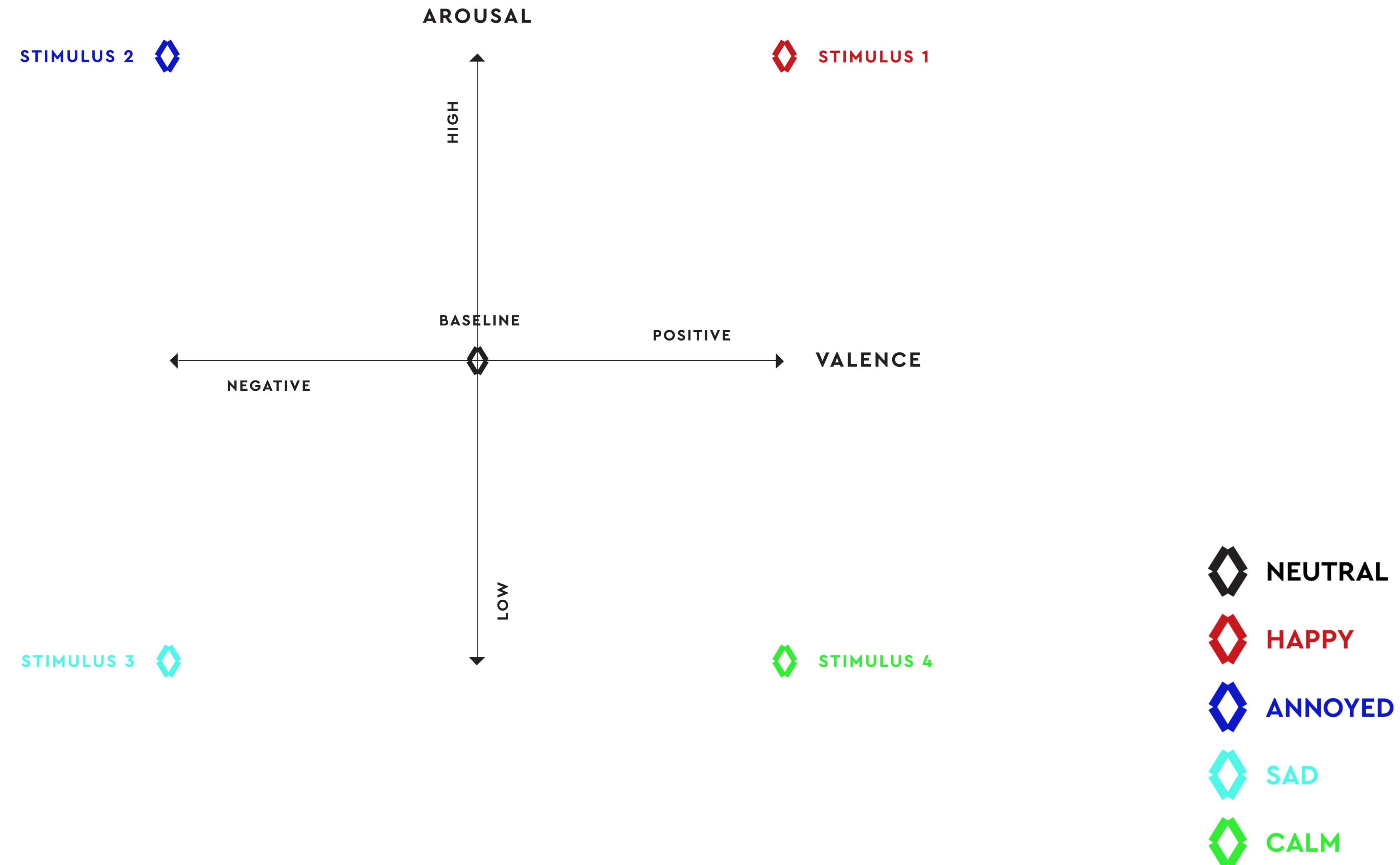


Dear participant,

Thank you for agreeing to participate in this study. Before coming in for the study I would like to ask you to pick 4 different musical songs. The criteria for the song picking is the following:

- Song 1:** A song that always makes you happy and energized.
This could be a song you find positively exciting, energizing, joyful or exuberant.
- Song 2:** A song that always annoys you and you dislike.
This could be a song you find noisy, loud or irritating.
- Song 3:** A song that always makes you feel sad or down.
This could be a song that you connect to a melancholic or a sad memory.
- Song 4:** A song that always makes you feel good and calm.
This could be a song you find blissful, pleasurable or slumberous.

Intended Emotional States



Measurements

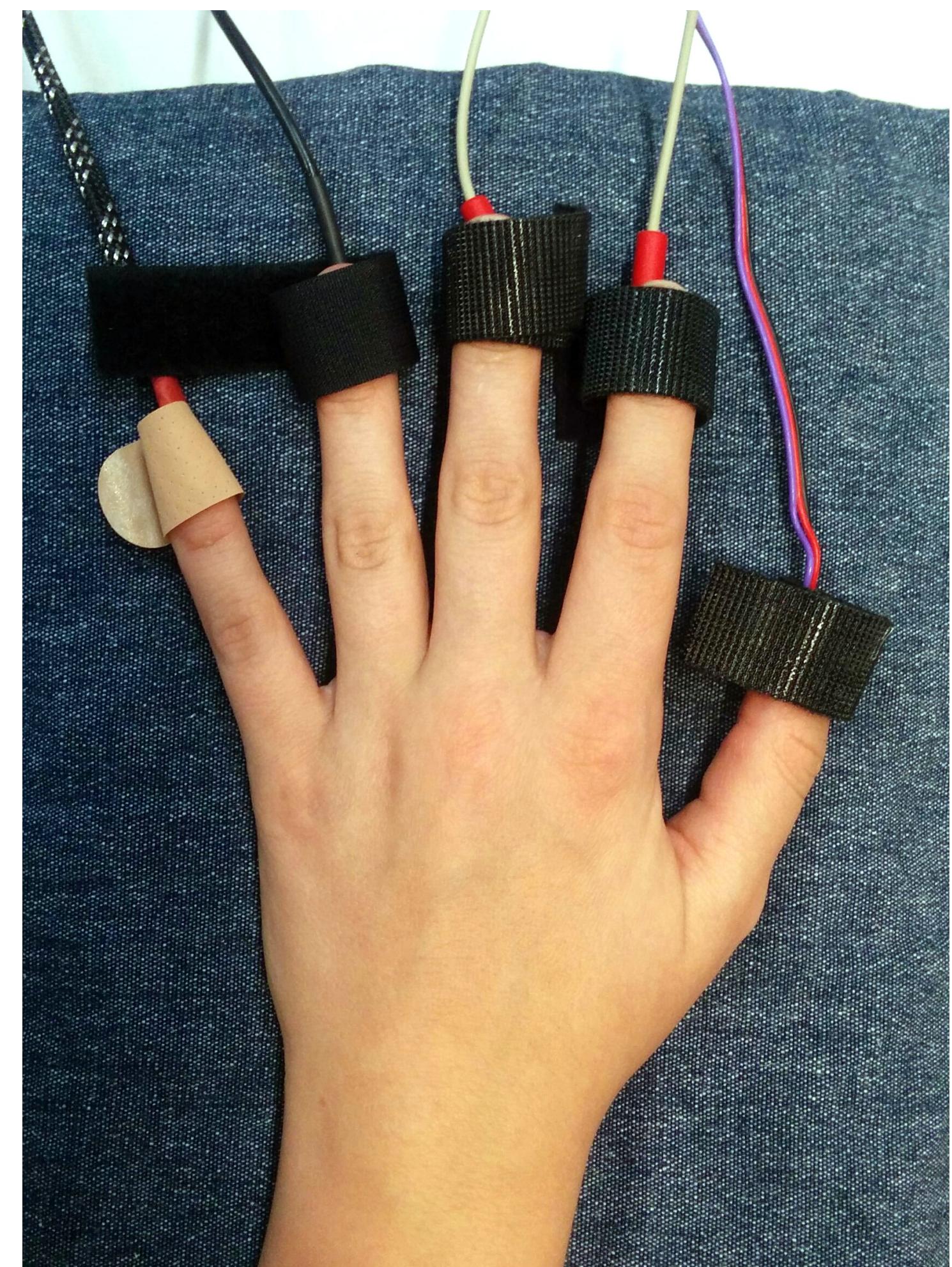
› Subjective Measurements

How do **you** feel **right now**?

Please indicate how you are feeling right now by selecting one option from each of the scales below.



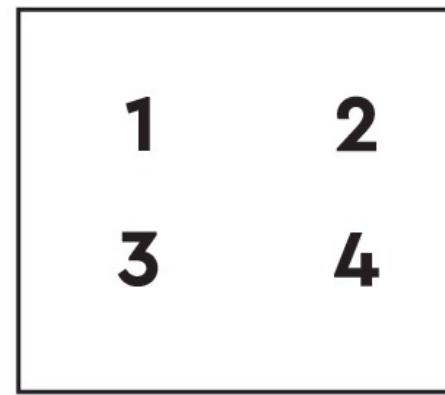
› Physiological Measurements



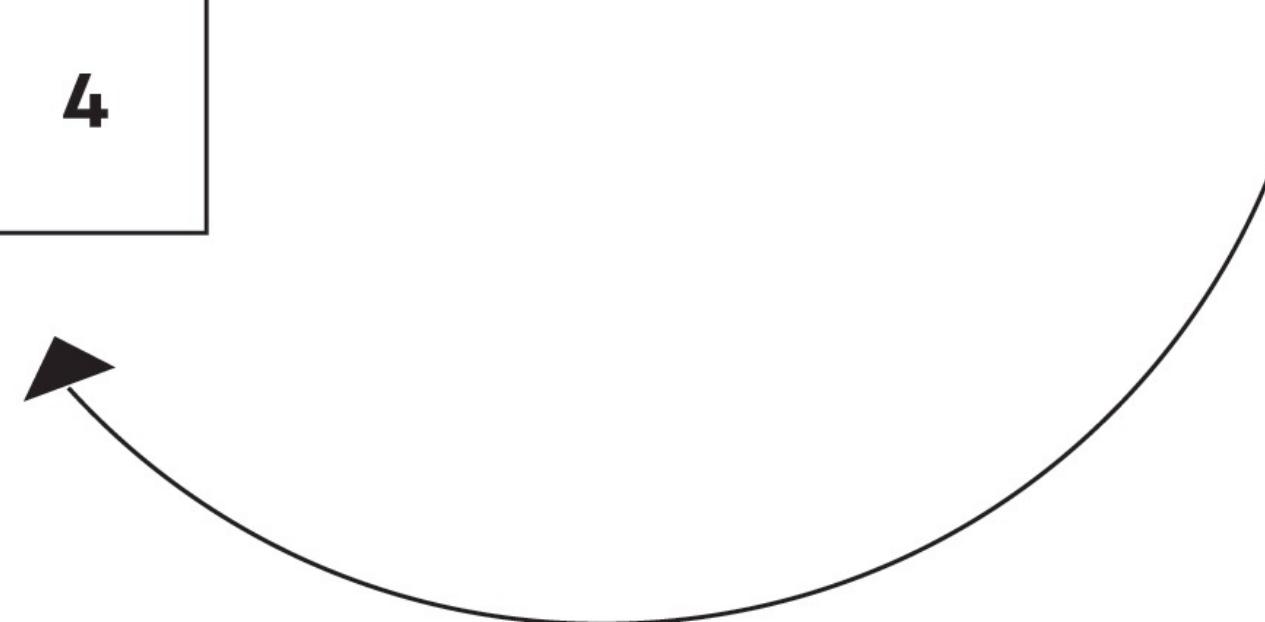
Procedure

BASELINE → **SM** → **STIMULI X** → **SM** → **NEUTRAL STIMULI** → **QUESTIONNAIRE**

180 sec

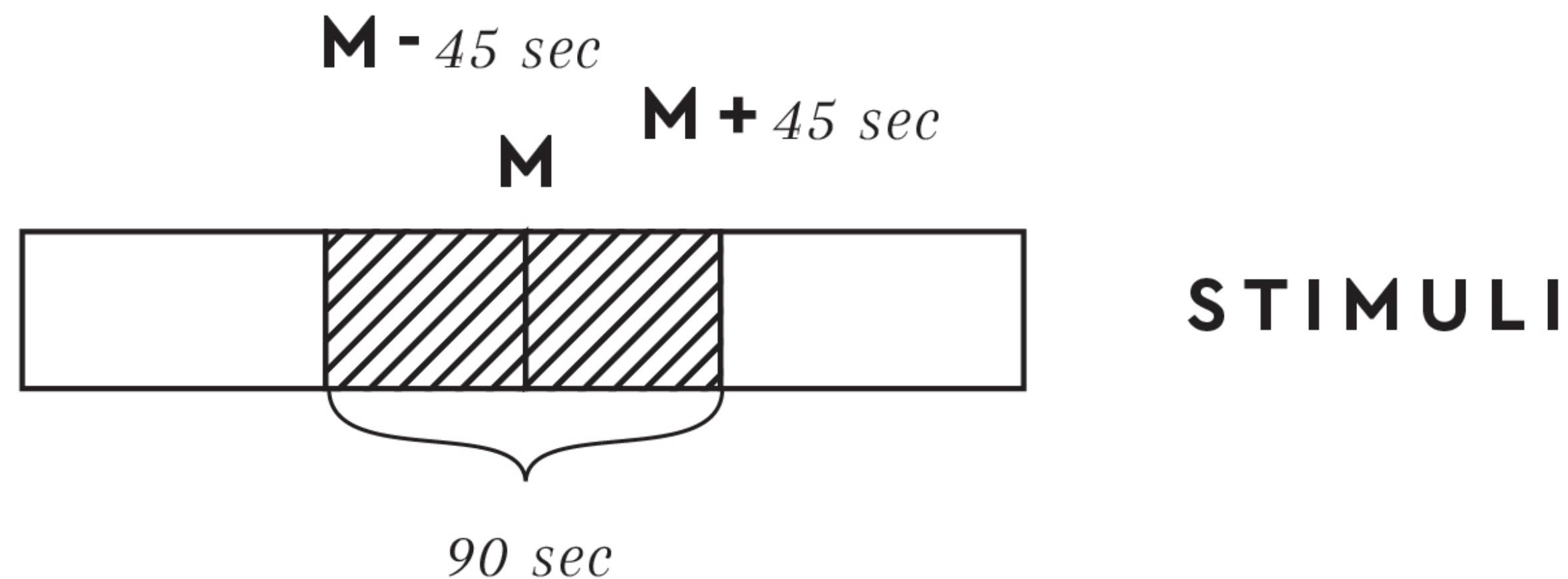
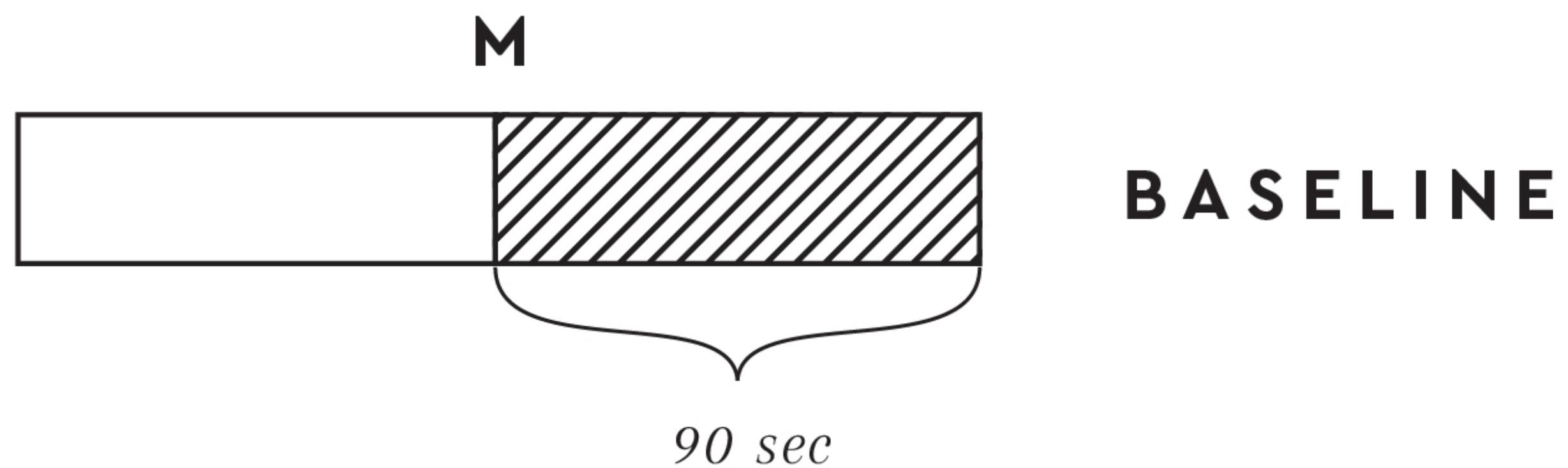


90 sec

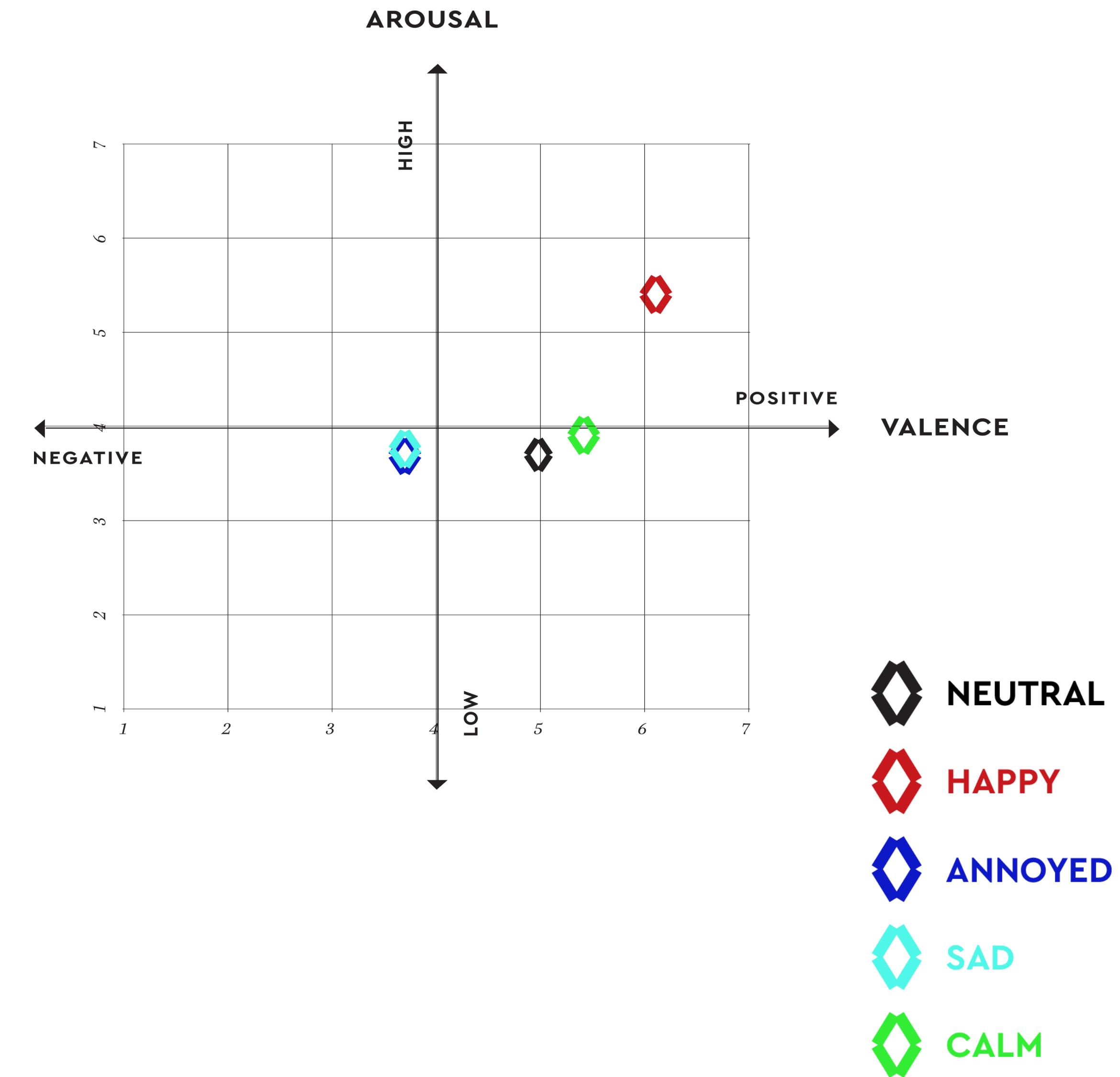
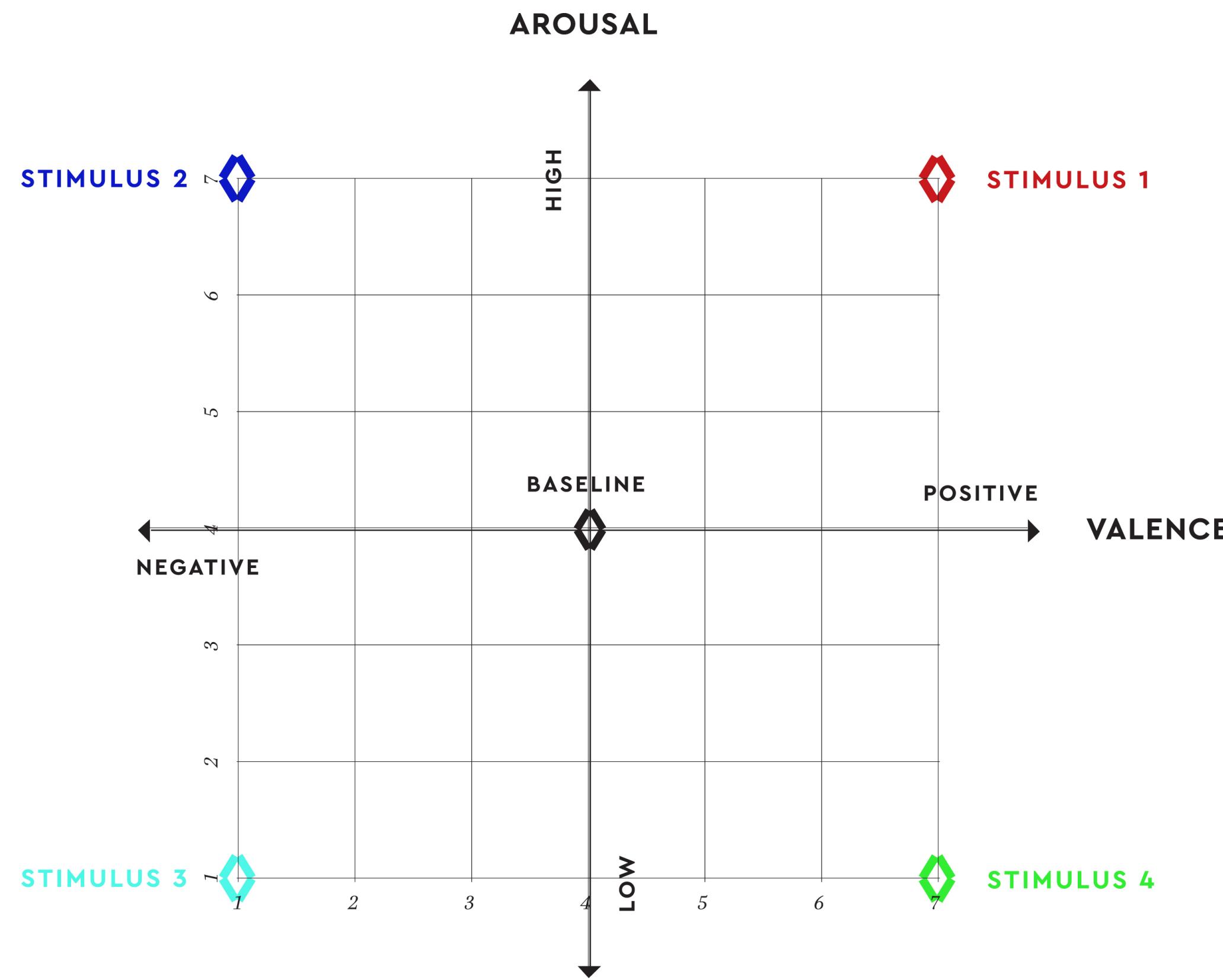


Participant	Song Order	Song 1	Length [m:s]	Song 2	Length [m:s]	Song 3	Length [m:s]	Song 4	Length [m:s]
1	1 2 3 4	Inspector Norse - Todd Terje	06:40	Ai Se Eu Te Pego - Michel Teló	02:45	Twice - Little Dragon	03:06	1/1 - Brian Eno	17:21
2	1 2 4 3	Will You Smile Again For Me - And You Will Know Us by the Trail of Dead	06:50	SOS - Rihanna	03:58	Everyday Is Like Sunday - Morrissey	09:00	Neonlicht - Kraftwerk	03:35
3	1 3 2 4	Relight My Fire - Take That	04:11	Umbrella - Rihanna	04:15	King of Sorrow - Sade	04:45	Das Spiel - Annett Louisan	03:01
4	1 3 4 2	98.6 - The Bystanders	03:19	Do the Hippogriff - The Weird Sisters	03:36	New Slang - The Shins	03:51	Leaving Port - James Horner	03:26
5	1 4 2 3	Happy - Pharrell Williams	03:52	Du Hast - Rammstein	03:54	Young and Beautiful - Lana Del Rey	03:56	Heal the World - Michael Jackson	06:24
6	1 4 3 2	Lieblingsmensch - Namika	03:10	Endseekers - Oh, Sleeper	03:06	Bring Me To Life - Evanescence	03:55	Fallin' for You - Colbie Caillat	02:59
7	2 1 3 4	Happy - Pharrell Williams	03:52	Why Does My Heart Feel So Bad - Moby	04:24	Broken - Amy Lee	04:18	Hello - Adele	04:55
8	2 1 4 3	Blank Space - Taylor Swift	04:32	The Lazy Song - Bruno Mars	03:10	Michel - Anouk	04:09	Just A Habit - Low Roar	03:28
9	2 3 1 4	Break Free - Ariana Grande	03:34	Blue - Eiffel 65	04:43	Say You Love Me - Jessie Ware	04:17	Thinkin Bout You - Frank Ocean	03:20
10	2 3 4 1	Peanut Butter Jelly - Galantis	03:23	Just Give Me a Reason - Pink	04:02	Stay - Hurts	03:55	Secrets - One Republic	03:44
11	2 4 1 3	Book Of Love - Felix Jaehn	03:18	Down With the Sickness - Disturbed	04:38	Colorblind - Counting Crows	03:23	Seerosenteich - Philipp Poisel	04:19
12	2 4 3 1	Long, Long Way From Home - Foreigner	02:55	We No Speak Americano - Yolanda	04:29	I'll Be Missing You - Puff Daddy	05:01	Carry on My Wayward son - Kansas	05:22
13	3 1 2 4	I Feel It All - Feist	03:40	Atemlos - Helene Fischer	03:38	Love Will Tear Us Apart - Joy Division	03:26	Argument - Fugazi	04:27
14	3 1 4 2	Give Me Everything - Pitbull	04:12	Avenir - Louane	03:04	100 Years - Five For Fighting	04:04	Over the Rainbow - Israel Kamakawiwi'ole	03:31
15	3 2 1 4	Animal - Miike Snow	04:23	I'm an Albatraoz - Aron Chupa	02:46	Make You Feel My Love - Adele	03:32	Sunrise - Norah Jones	03:20
16	3 2 4 1	We Will Rock You - Queen	02:02	Atemlos - Helene Fischer	03:38	Why Does My Heart Feel So Bad - Moby	04:24	Running - Northern Lite	05:53
17	3 4 1 2	These days - Take That	03:52	Hotline Bling - Drake	04:27	Oceaan - Racoon	02:42	Heading Up High - Kensington	03:52
18	3 4 2 1	4th movement - Beethoven	09:03	GDFR - Flo Rida	03:10	Open - Rhye	03:37	Apassionata - Beethoven	05:46
19	4 1 2 3	African Jazz Dance - Basil Coetzee	07:17	Ring of Fire - Johny Cash	02:35	Summer 78 - Yann Tiersen	03:50	Hold Back the River - James Bay	03:58
20	4 1 3 2	One Day- Asaf Avidan	03:32	Far Away - Deepforces	08:15	Hey There Delilah - Plain White T's	03:52	Deine Augen - Alle Farben	07:10
21	4 2 1 3	7/11 - Beyonce	03:33	Atemlos - Helene Fischer	03:38	Hello - Evanescence	03:40	Let It Go - James Bay	04:20
22	4 2 3 1	Atemlos - Helene Fischer	03:38	Happy - Pharrell Williams	03:52	Only Time - Enya	03:38	Sun Goes Down - Robin	02:59
23	4 3 1 2	Wonderful Life - Black	04:49	Die Karawane Zieht Weiter - Hhner	03:14	Moonlight Sonata - Beethoven	02:04	Feather - Nujabes	02:56
24	4 3 2 1	Happy - Pharrell Williams	03:52	Wannabe - Spice Girls	02:53	All of Me - John Legend	04:29	Insha Allah - Maher Zain	04:30

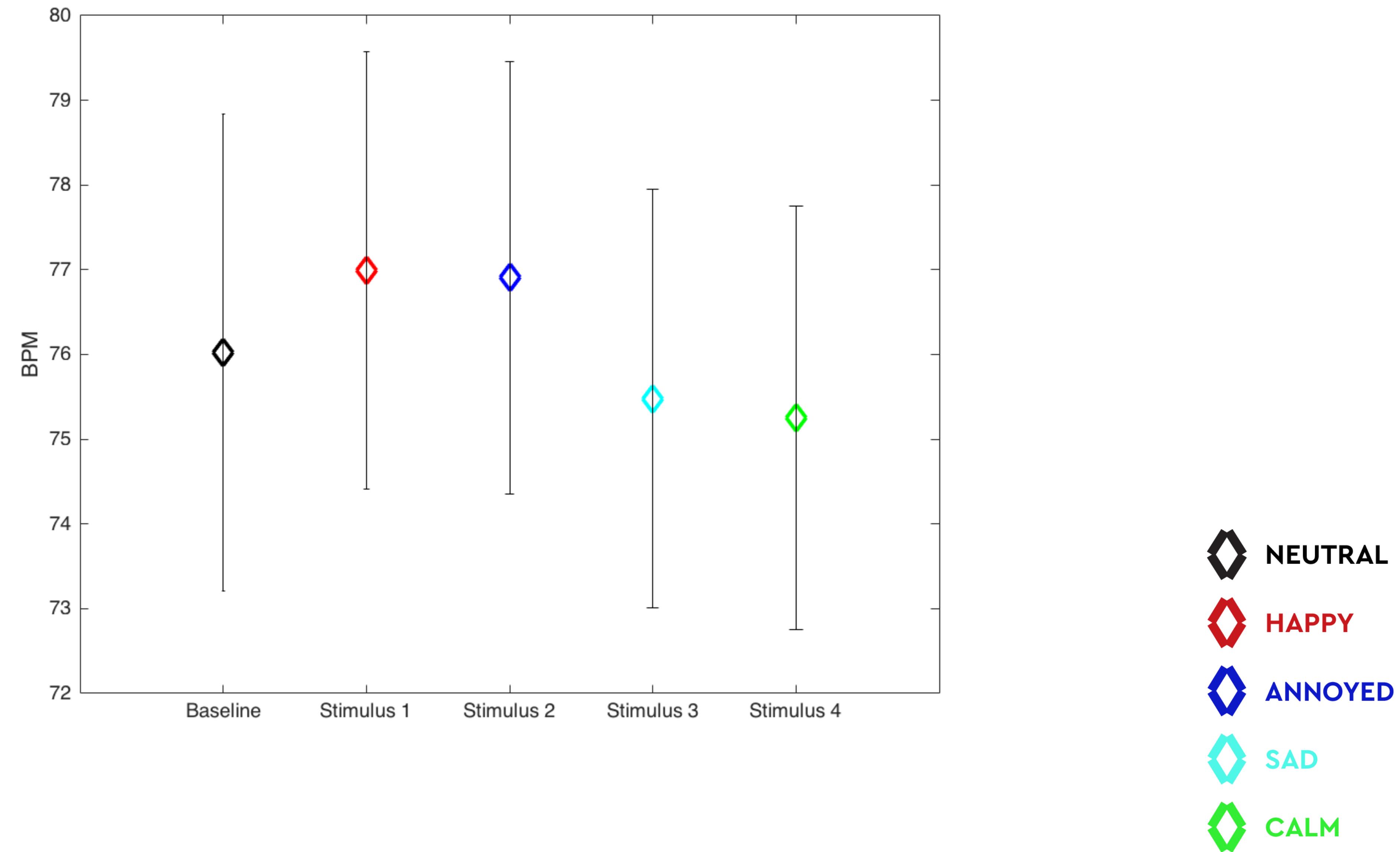
Feature Extraction



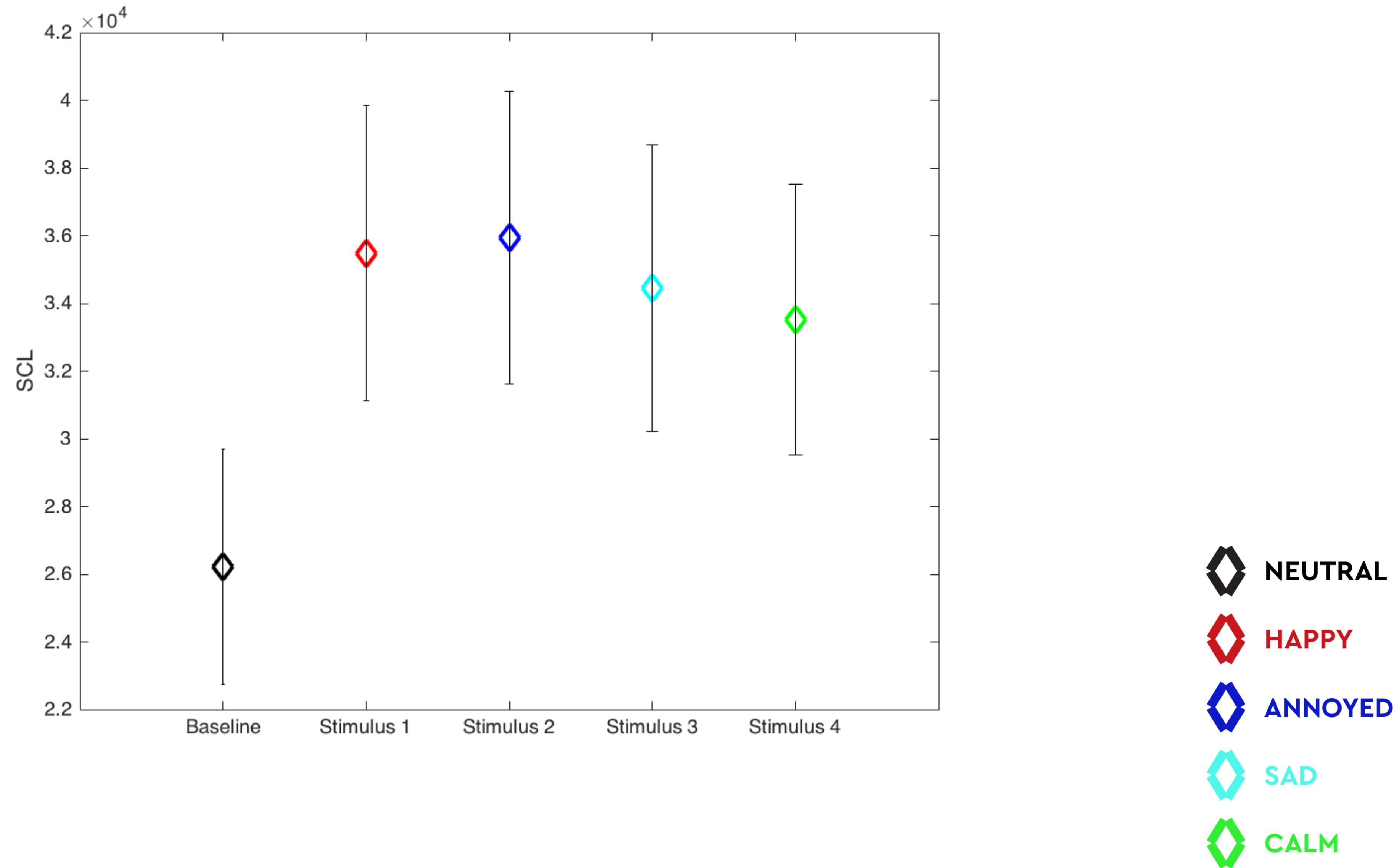
Subjective Measurements



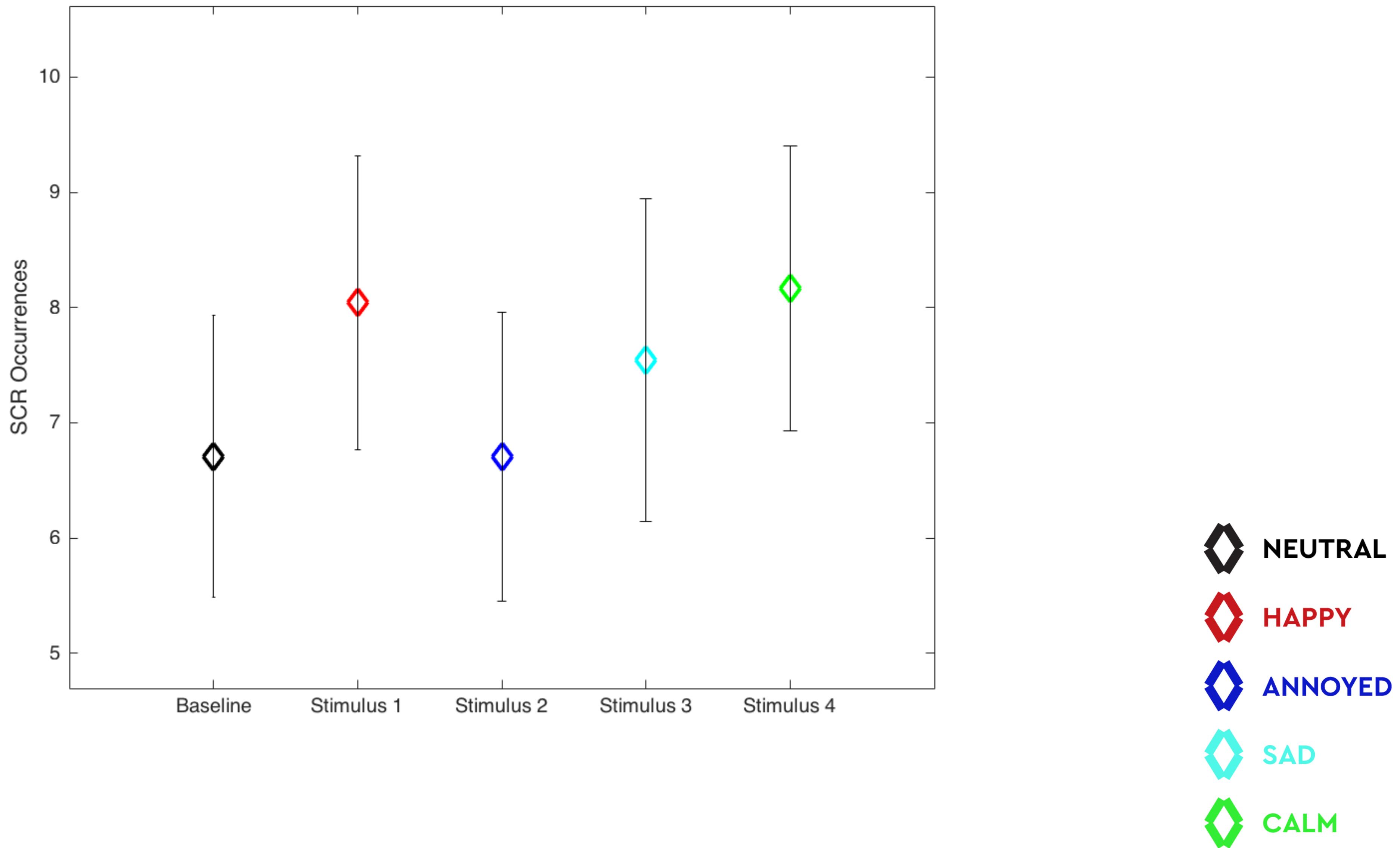
Heartbeat (BPM)



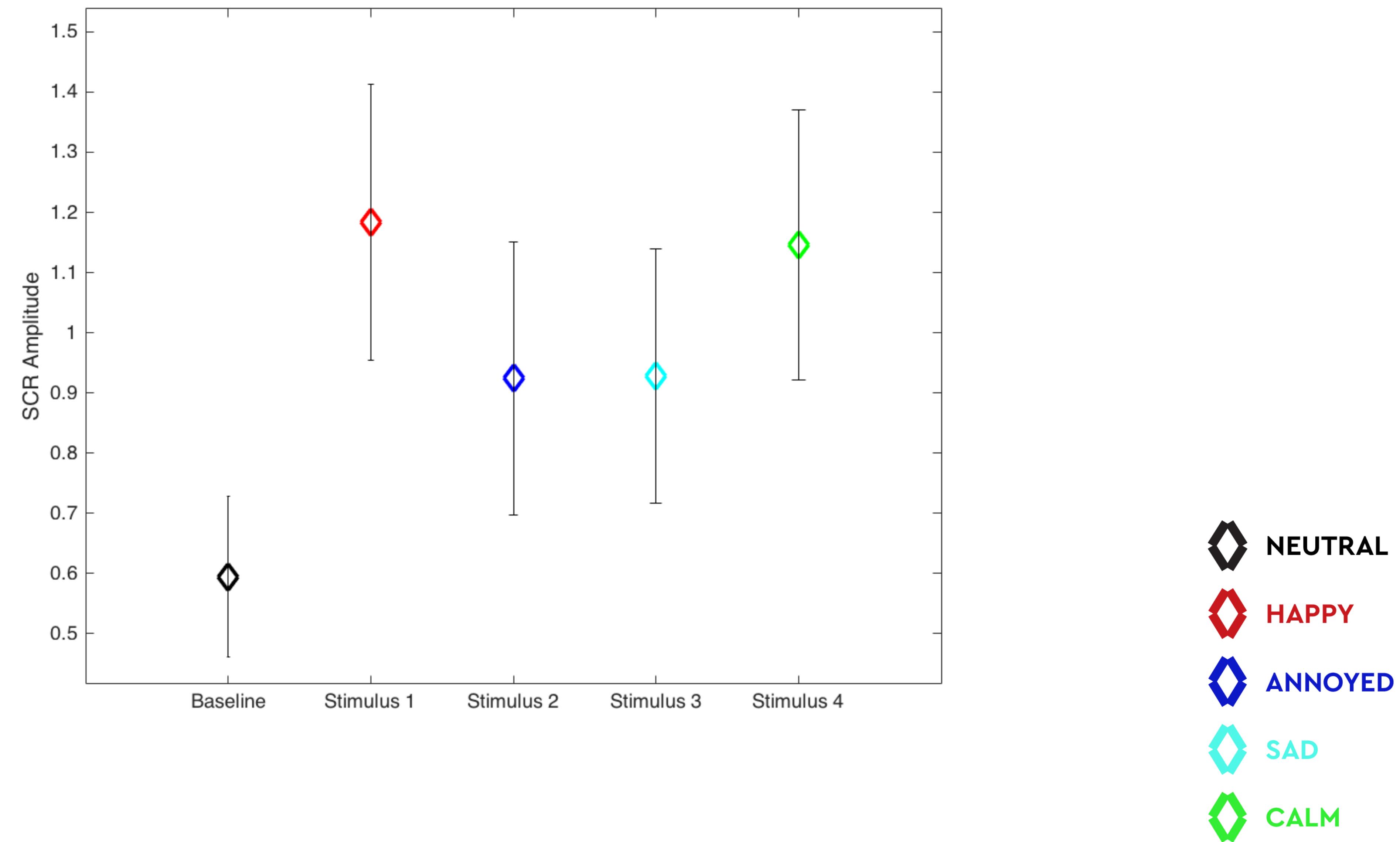
Skin Conductance Level



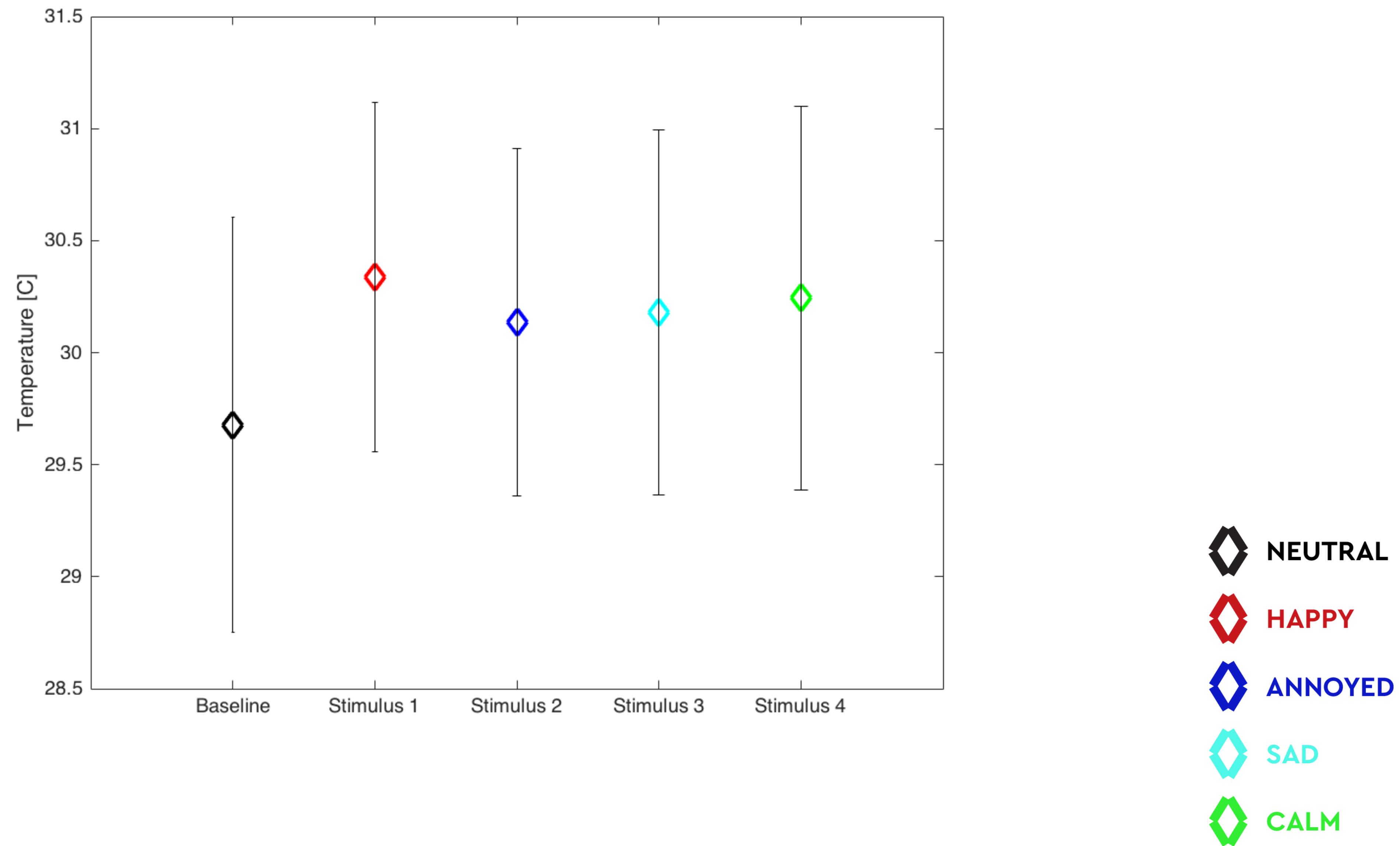
Skin Conductance Response



Skin Conductance Response Amplitude



Skin Temperature



Limitations

1. Bonferroni adjustment

2. Stimuli selection

3. Contextual motivation

4. Humidity levels

1. Bonferroni

- › Might be too strict of an adjustment
- › Fisher's least significant difference (LSD) was tried as well
- › That adjustment gave more significant differences
- › LSD does not adjust for the number of hypotheses tested and therefore we didn't proceed with that one

2. Stimuli Selection

- › What are participants choosing based on?
- › Lyrics?
- › Memory?
- › Beat?

3. Contextual Motivation



4. Humidity Levels



Questionnaire

- › People do regulate their emotions with music
- › People are interested in quantifying their emotional experiences
- › People are concerned about privacy but those concerns can be mitigated with the right information and clear benefit



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Type of Data	Sampling Frequency
BPM	For every heart beat
Raw data from pulse sensor	30 Hz
IBI	For every heart beat
Raw data from GSR sensor	30 Hz
Temperature	2 Hz
Current counter value	When incremented

Component	Current Draw
ATmega 328 microcontroller	20.3mA
Thermometer DS18B ₂₀	1.5mA
GSR sensor	5.3mA
Pulse sensor	4.2mA
LCD without/with backlight	11.8mA / 65.1mA
Total	43.1mA / 96.4mA

$$\frac{\text{Battery Capacity}}{\text{Current Draw no Backlight}} * \text{Efficiency} = \frac{1300\text{mAh}}{43.1\text{mA}} * 0.85 = 25.0 \text{ Hours}$$

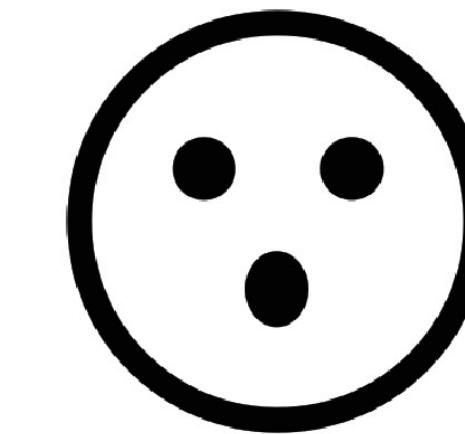
Component	Input/Output	Cost
ATmega 328	X	4 €
GSR sensor	1 AI	10 €
Pulse sensor	1 AI	25 €
Temperature sensor	1 DI	2 €
LCD screen	2 DO	5 €
2 Push buttons	2 DI	2 €
FTDI adapter	X	2 €
Aluminium case	X	5 €
Total	2 AI & 5 DI/DO	55 €



HAPPINESS



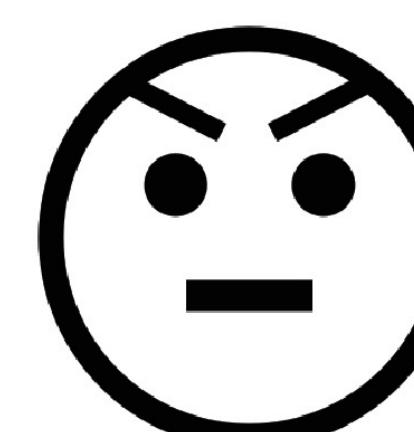
SADNESS



SURPRISE



FEAR



ANGER



DISGUST