

# GRAPH ROOTS

a data science project visualizing music

DYLAN VAN BRAMER





# WHAT IS graphroots?

**WHAT?** a data science/art/math-y sort of thing made specifically for Grassroots 2023!

**WHY?** I love graphs! waves! data! music! people, so I combined them all here. I want people to interact with the graphs (and almost definitely learn that their opinion is way more valuable than any "analysis").

**WHO?** YOU! When you flip through this book, take notes! draw things! have fun!

I made it, along with help from my housemates, brother, and partner. I used the Spotify API, Plotly, Spotipy, and numpy.  
pandas

**HOW?** Through a grant from the Milstein Program in Technology + Humanity, and the generosity of Grassroots for space in the Art Barn, I took this up as a fun personal project!

# about DYLAN



## SELF PORTRAIT

Name: Dylan Van Bramer

Pronouns: She/her

Age: 19

Wop,  
Cat!

What I'm excited  
for at Grassroots:

Meeting cool people;  
getting to know the  
area more by interacting with its music,  
dance, and art; dancing with  
my friends

Favorite type  
of music:

anything FUNKY, floaty, or folky  
(and punk rock)

Things I like: TREES (my favorite right now is a honey locust), fresh veggies, music of all sorts, reading in hammocks, machine learning, and dreams

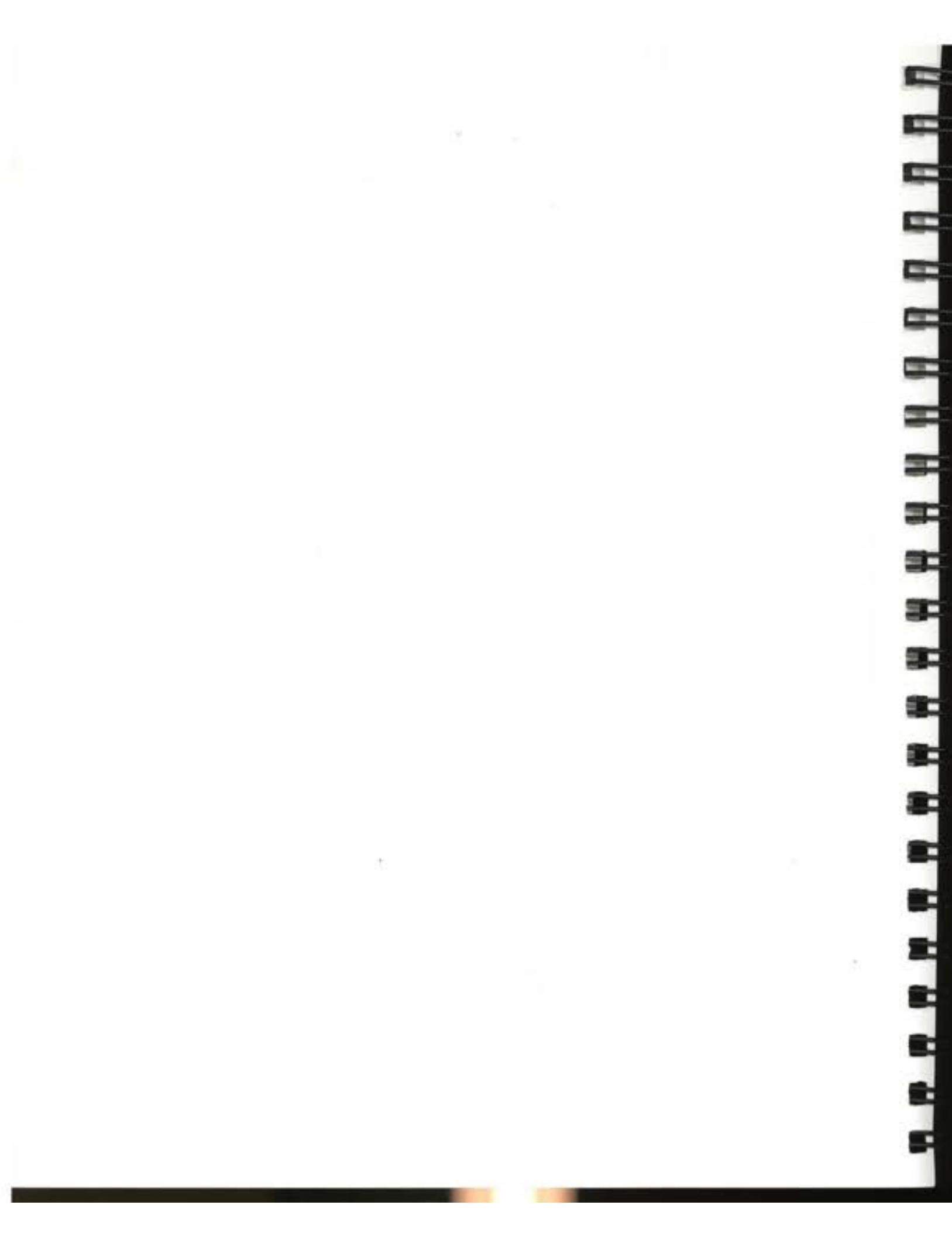
How to contact me:

Email: dcv26@cornell.edu

I'd love to chat - if you'd like to hear more about the process, maybe make one of these installations again, or just say "hey!"

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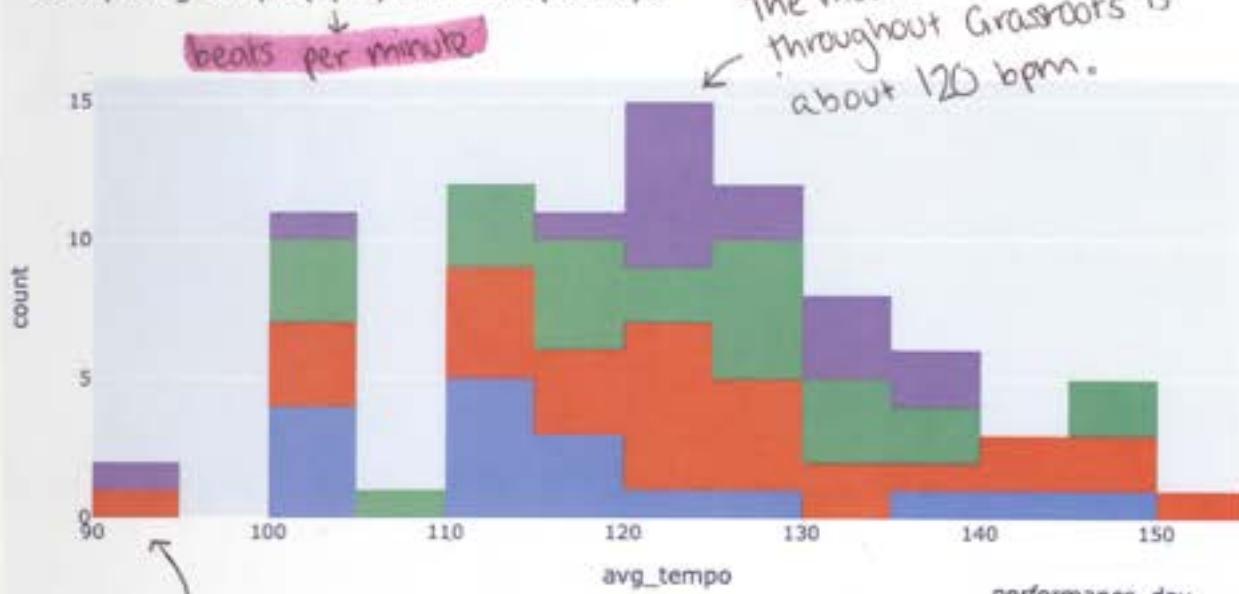
- 1 TEMPO
  - 2,3 TEMPO over TIME.
  - 4 PROCESS
  - 5,6,7,8 ACOUSTICNESS
  - 9 Why is this all on paper?
  - 10 KEY
  - 11 TIME SIGNATURE
  - 12,13 DANCEABILITY
  - 14 (what does that even mean?)
  - 15 RAW DATA
  - 16 SOME RELATIONSHIPS
  - 17 DURATION
  - 18,19 ENERGY
  - 20 EMAIL GATHERING
  - > 20+ drawing, writing, collaging, etc.  
by you & other attendees
- There's graph  
paper, brown paper,  
scissors, & glue in  
the crates below!)



# temPO @ grass roots



Comparing Tempo (bpm) Over Multiple Days



Do these numbers seem realistic?

Or do you think Spotify (and I!) got it wrong?

120 bpm is 2 beats per second, or about your heart rate when you're snappy to music.

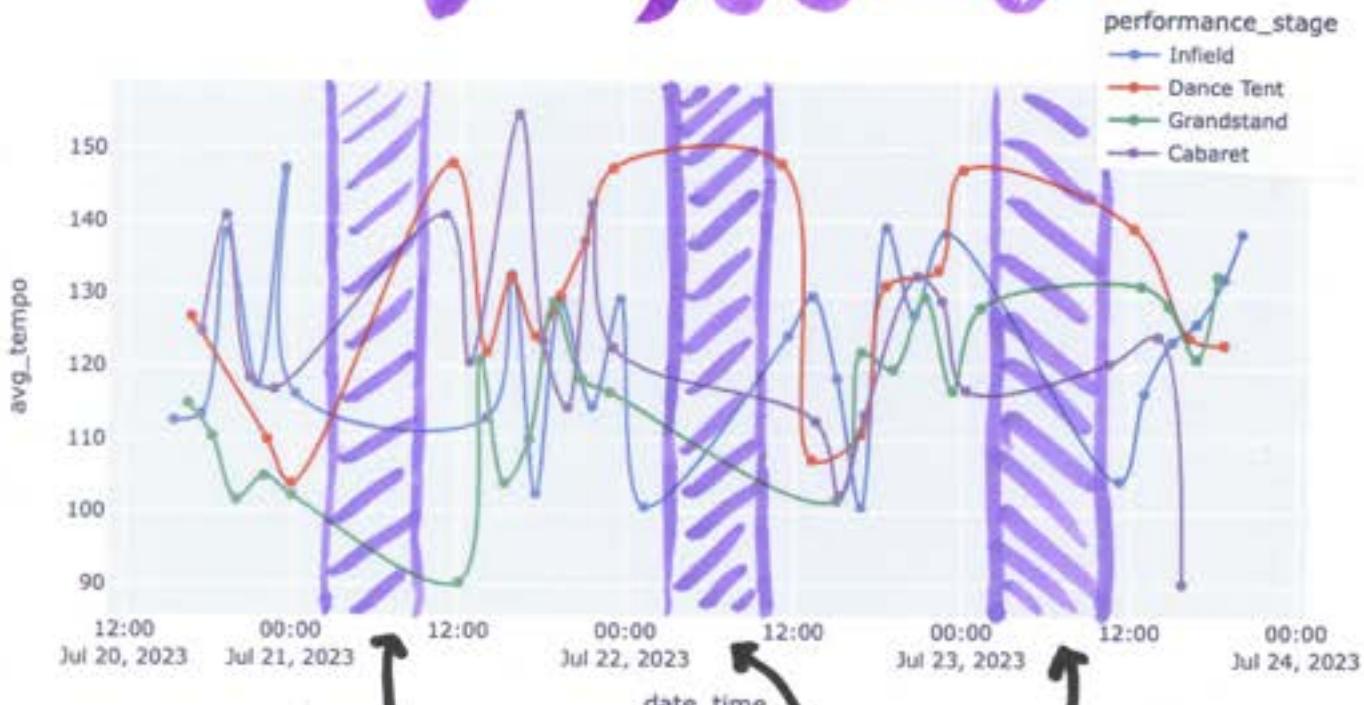
↑ go cool ♥

performance\_day

- 1
- 2
- 3
- 4

1 = Thursday  
2 = Friday  
3 = Saturday  
4 = Sunday

# Tempo as a function of time



**SLEEP:** it's interesting to note that the graph still attempts to show tempo patterns when there is no data. Keep that in mind for future graphs!

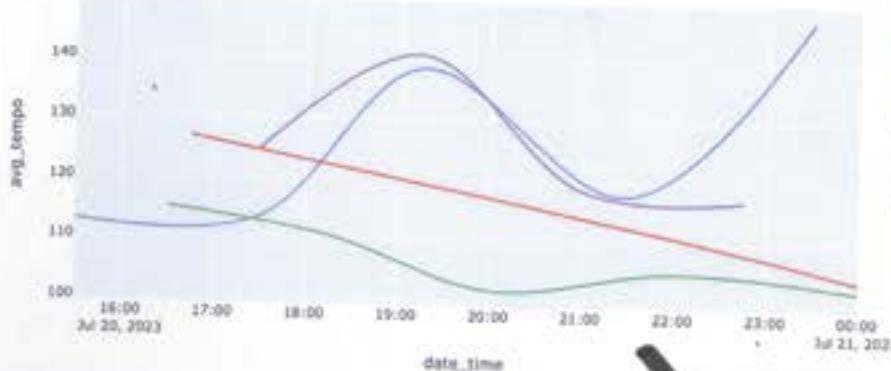
**NEXT PAGE**

Shows the data separately for each day, eliminating these sleepy/no data zones

- Infield
- Dance Tent
- Grandstand
- Cabaret

# LABELS

Thursday

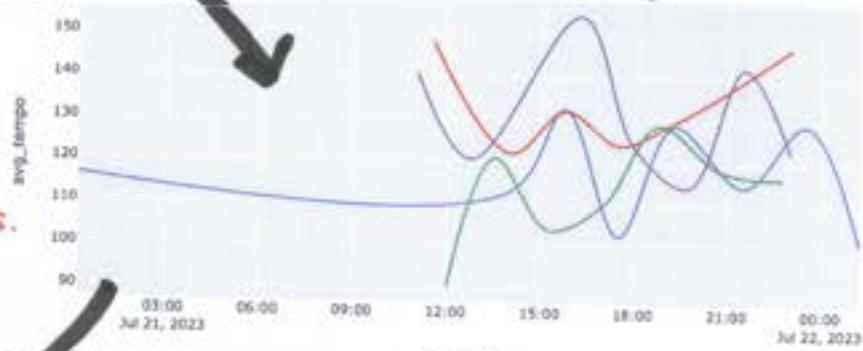


**NOTE:** Different scales  
of tempo AND time between  
graphs. So, these are only really  
good for observations on ONE  
day, not comparisons.

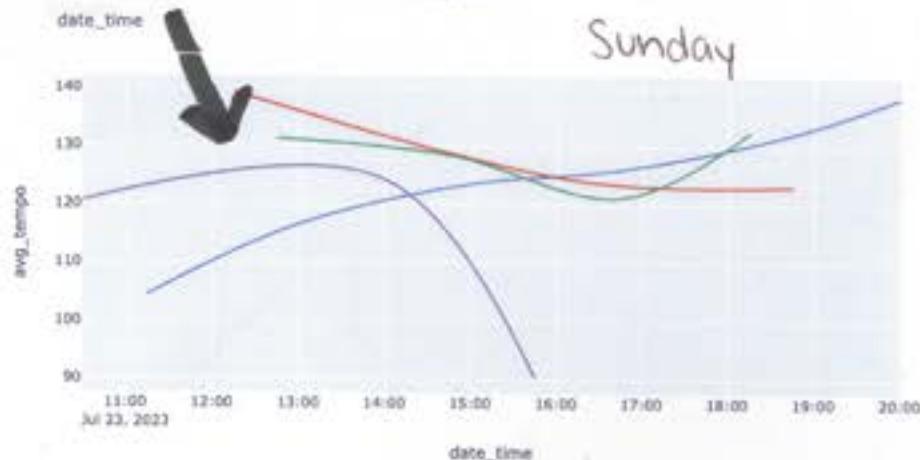
Saturday



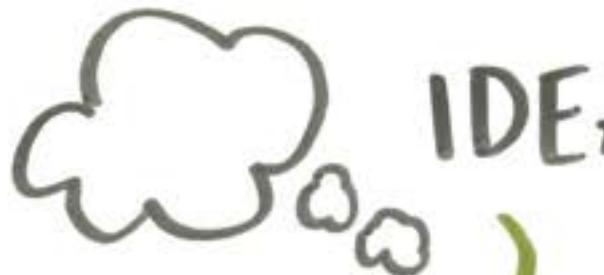
Friday



Sunday



# P R O C E S S



## IDEA

→ See page a  
for more information!

## LINEUP

Used the 2023 schedule  
to see which artists  
perform when.



For information  
on using "averages"  
instead of individual  
songs, see p. 15

For more on  
the problems  
w/ using Spotify,  
see p. 7



## SPOTIFY

of the artists'

Used their interface  
to access analysis  
of music.

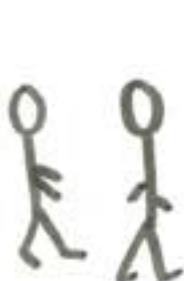
## CALCULATIONS

To see the data structure I ended  
up with, see p. 15

$$\frac{3+2+x}{\Sigma n}$$



## GRAPHS



## DISPLAY!

# acousticness

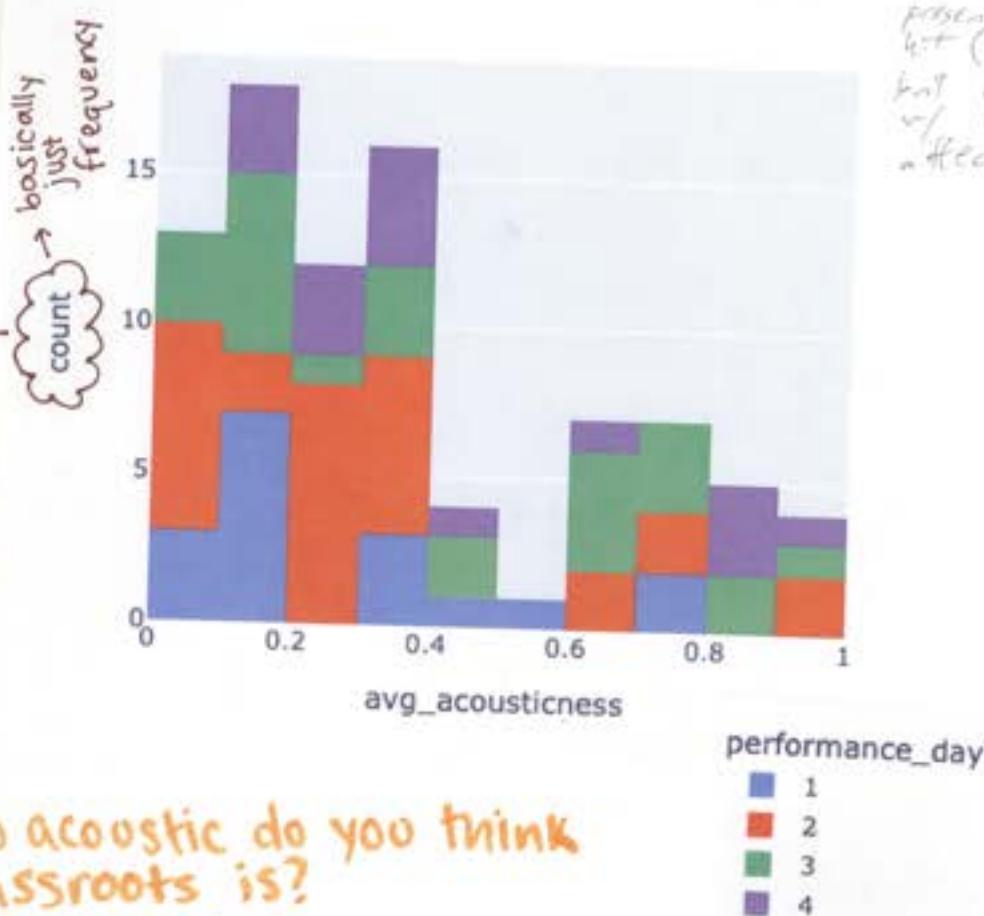
Along with basic analysis like tempo, Spotify returns some fun features, like:  
"a confidence measure from 0.0 to 1.0 of whether the track is acoustic"



↓  
not having  
electrical  
amplification

Comparing Acousticness Over Multiple Days

"Count" refers to how many performances this is true for.  
For more on calculation, see page 9.



↑ wonder if the presence of a drum set (mostly acoustic but often assesed w/ electric mics) affects this

How acoustic do you think Grassroots is?

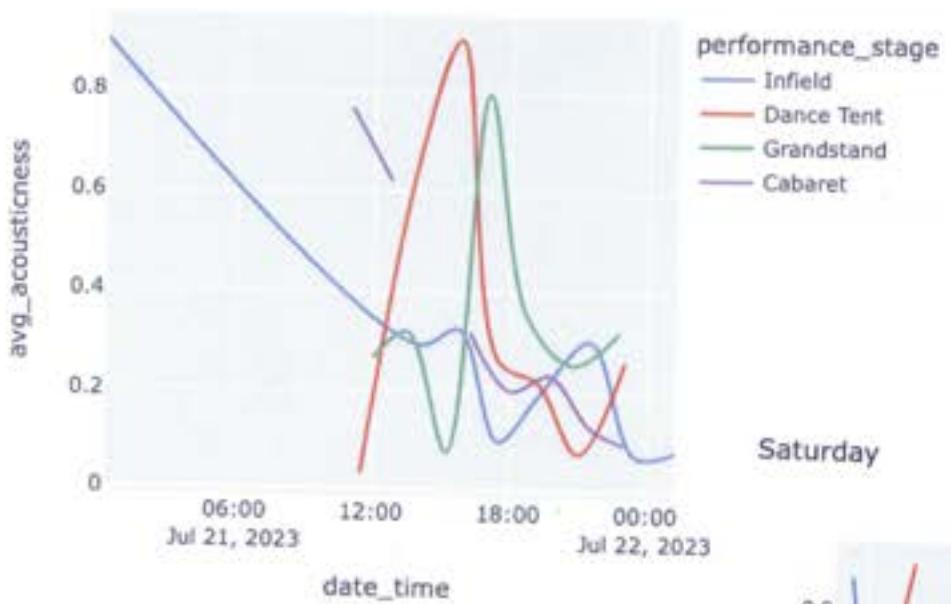
Very! It's cool.

does if New Year stage were included it would skew the data  $\Rightarrow$  0

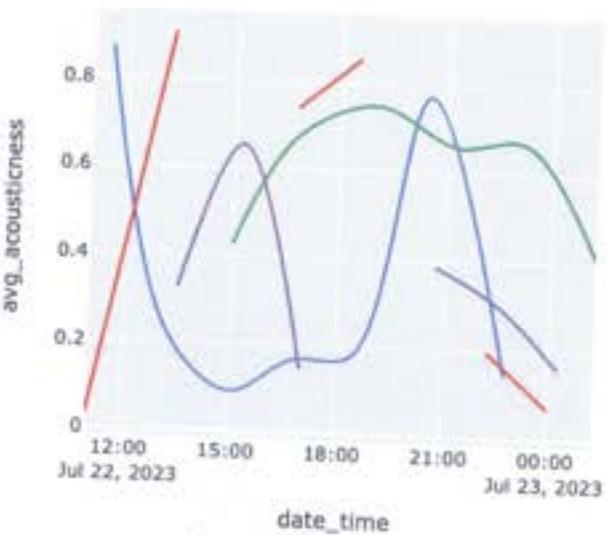
That's one of the great things about it!!

# ↑ Acousticness → OVER TIME

Friday



Saturday



What other metrics would be interesting to graph over time?

loudness  
(decibels)

types of  
instruments used

★ Original Music  
vs.  
covers ★ ↑ YAS

*i* informative  
What are more ethical ways  
of getting data like this?

talk to  
musicians

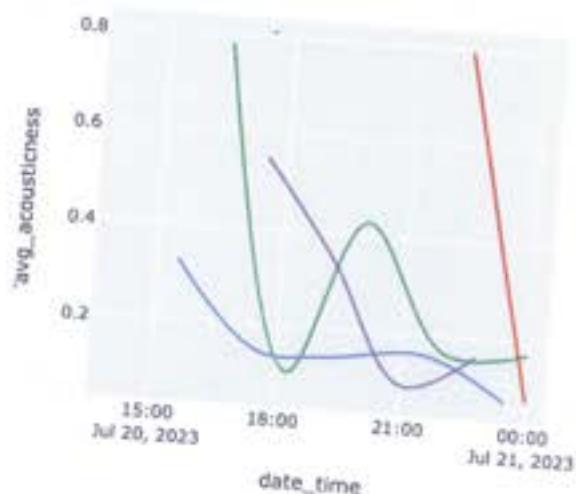
talk to  
audience

record data  
from performances !!!

→ yes

↓  
the data doesn't really  
exist prior to the festival!

Thursday



Sunday

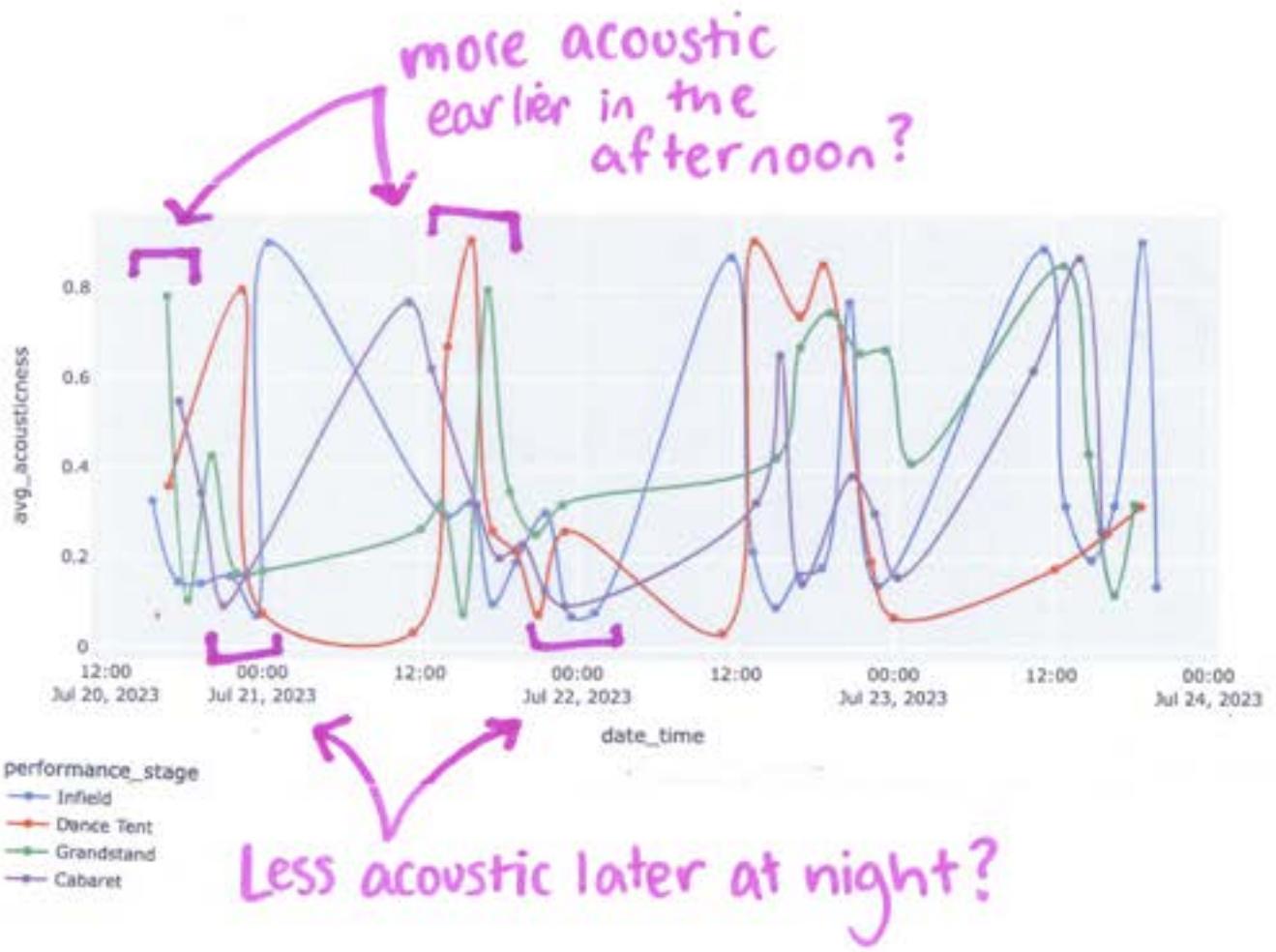


## So little data...

All the data here was taken from Spotify. There's some issues with that (feel free to add more, and think about better methods of data acquisition)

- NOT all artists have music on Spotify, so we're missing lots there
- Spotify is known to treat artists poorly, so sourcing from them is ethically... meh

★ SPOTIFY MAY NOT INCLUDE LIVE JAMS,  
WELL... CERTAINLY NOT!



# > ON TANGIBILITY <

it felt sort of funny to write code just to have it hidden (not printed). It was scary to make exactly ONE copy of this work. But it felt (and still feels) great to make it tangibly. [I want these pages to get yellowed. I'd much rather know that people flipped through this book than seeing that you clicked on a link.] I think that data science, tech, and appreciation for physicality can (and MUST!!) coexist. Hopefully this project is a testament to that! **YAS**

(Sort of hypocritically; but not quite, I'll be scanning this book after Grossroots. If you'd like a digitized version sent to your email [could be fun to see all the interaction], write your email on p. 20)

**NOTES:**  
I see you ^

\* this is so lovely ♥



# KEY

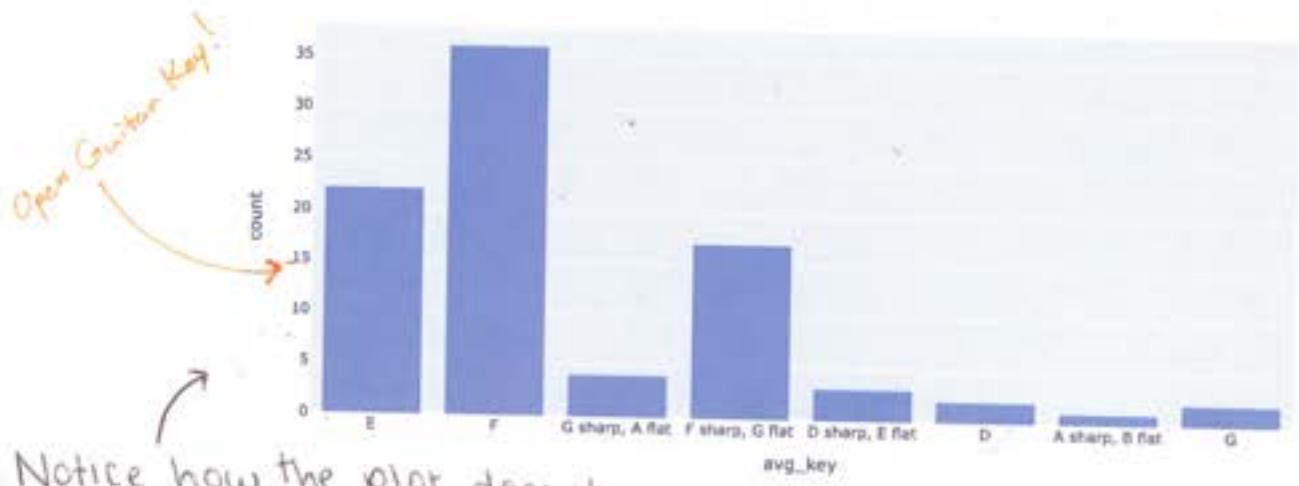
So, we should try each song individually instead of averaging.

Not a great metric here because it's categorical data! You can't just "average" C and D to get C# (which is unfortunate, music would be a lot easier!).

↑  
Facts

C should be the most common, but in Spotify's system, it's "encoded" as 0. So, when we average any other non-C songs, we probably won't get C. Even 10 songs in C and one in B b wouldn't give us a C!!

why should it be the most common?

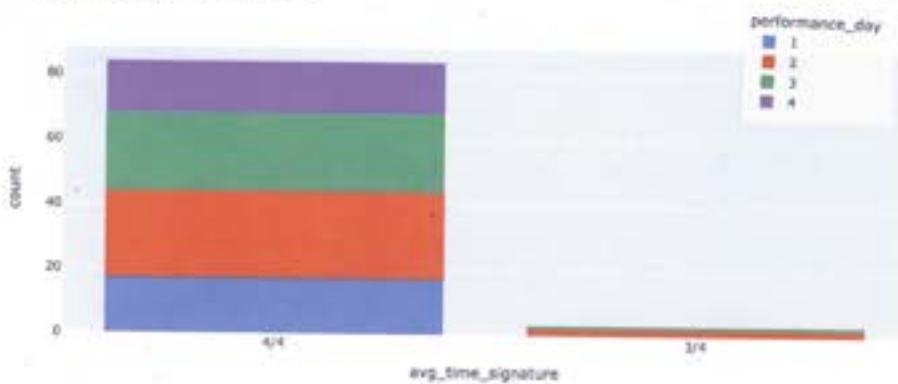


Notice how the plot doesn't go in the right order (not F, F#, G, G#, ...). There's more thinking to do with categorical data! (and I didn't do the thinking, oops!) 10

# time signature

Also not super helpful since I averaged the data...

Artists' Typical Time Signatures



Time sig. looks

numerical, but it's more categorical data!

$$\rightarrow \frac{3}{4} \neq \frac{6}{8} \text{ and } \frac{2}{2} \neq \frac{4}{4}$$

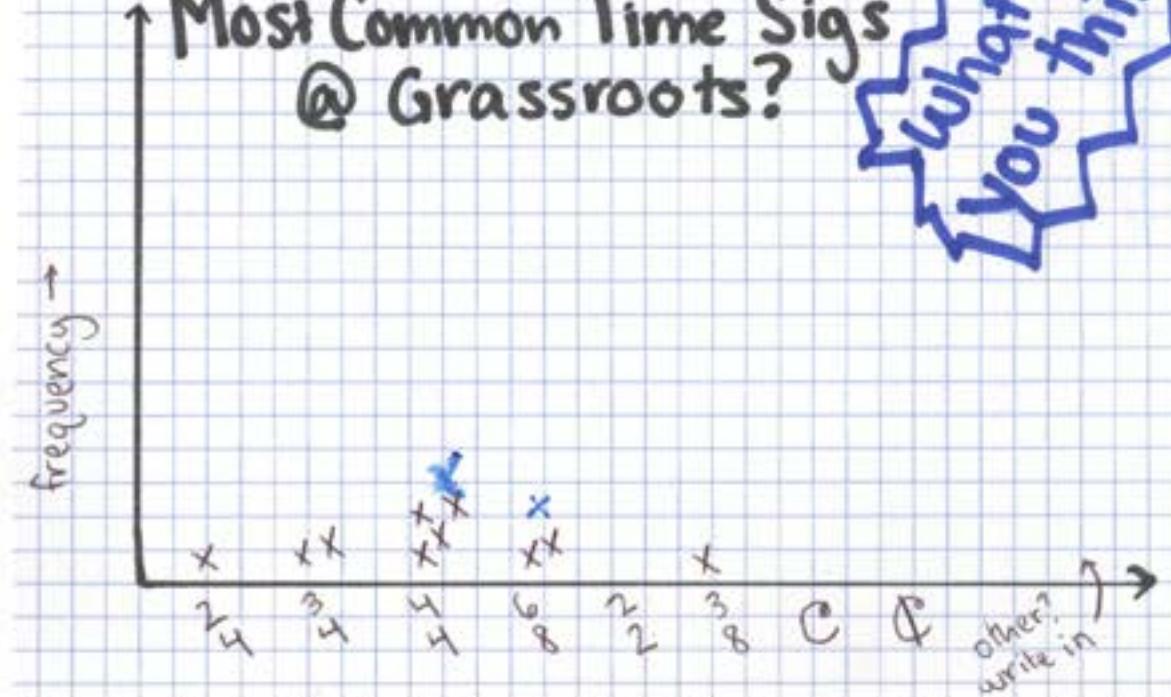
Any musicians?

why is that?

- it's kinda subjective - different to know  
if you hear the same song  
as different numerically equivalent  
as different time signatures. The  
two distinct time signatures  
 $\frac{2}{4}$  vs  $\frac{4}{4}$  vs  $\frac{2}{2}$  distinction is subtle -  
especially for country music

Most Common Time Sigs @ Grassroots?

add some x's



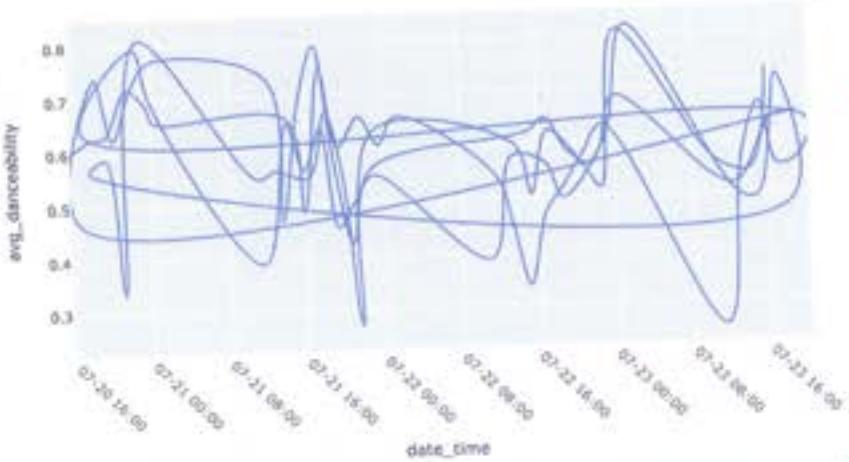
What do you think?

# Danceability!

"based on a combination of ... tempo, rhythm stability, beat strength, & overall regularity"

This chart has a → bunch of crazy lines spanning multiple days. It's a fun graph, but we don't get much meaning from it.

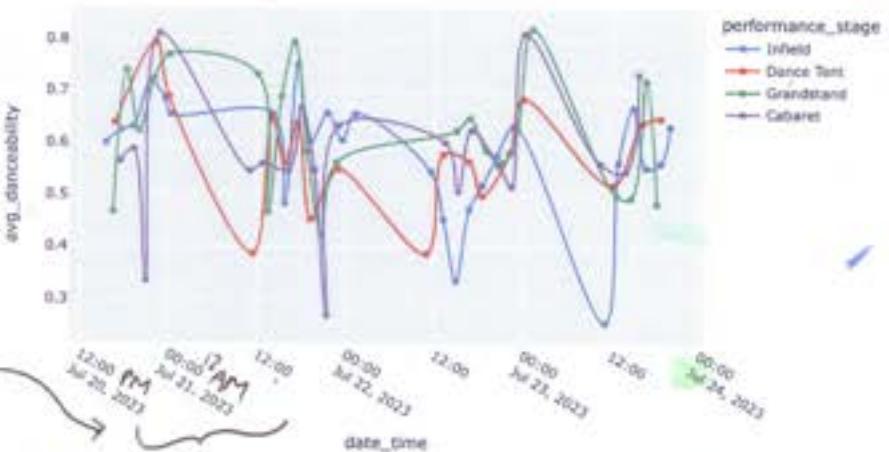
Scatter plot?



With the stage labels, the graph knows to separate certain data, and so we have less crazy, swoopy lines. It's also much easier for us as humans to see what's going on @ any point. ↓

## 24 Hour Times

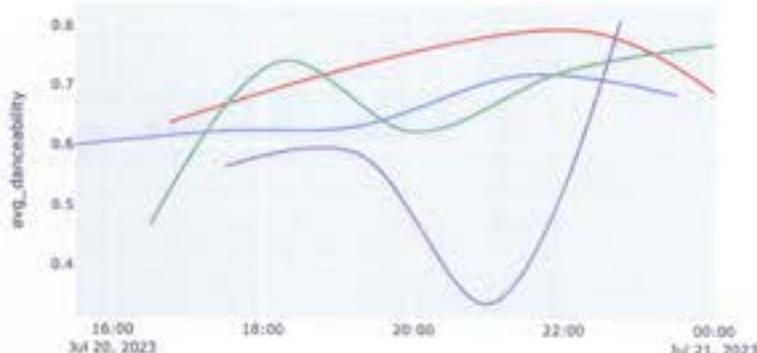
→ used to  
simplify dates?  
make sure data  
is displaying in  
the correct order!



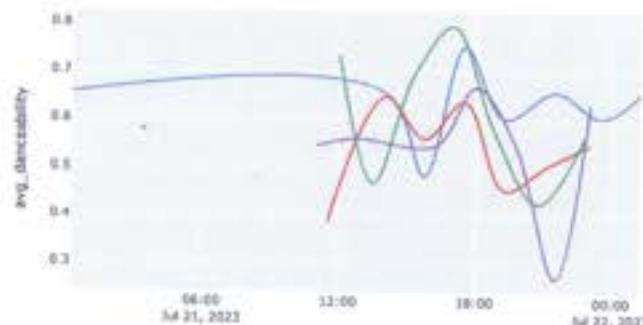
MORE LABELS

MORE  
UNDERSTANDING

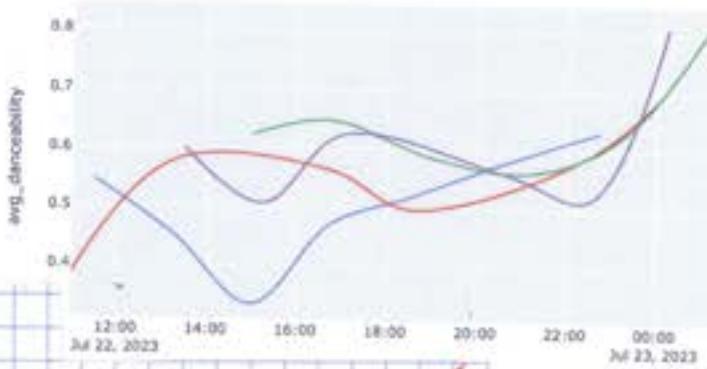
Thursday



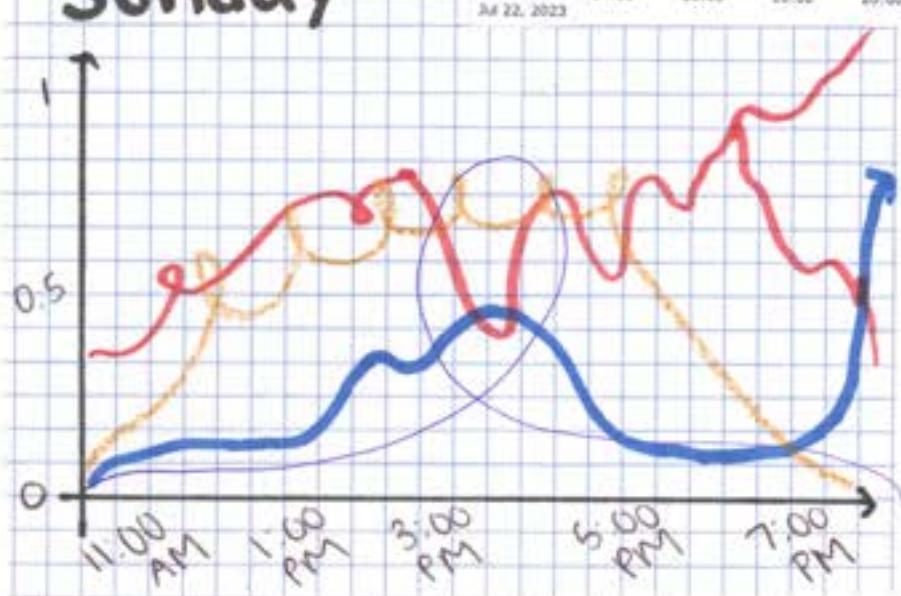
Friday



Saturday



# Sunday



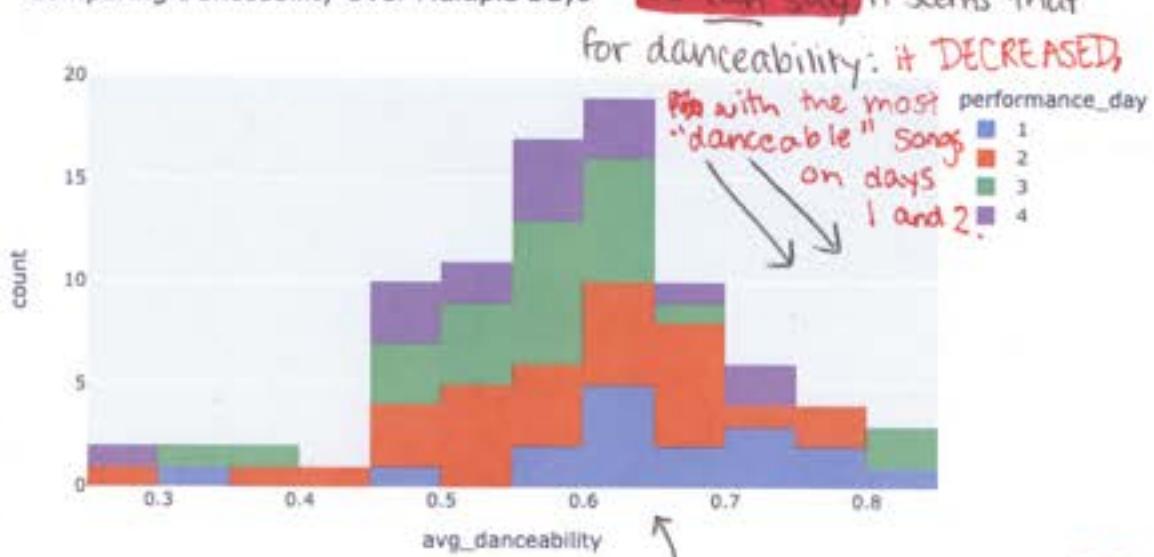
← Fill in either what you'd predict OR what you can tell from the charts on p. 12.

# DANCE

it's relative

This data is hard to interpret: 1) since it's on a scale from 0-1, it really has no meaning when we don't look at patterns over time, 2) danceability is inherently relative!! Maybe I prefer to dance to something with NO beat regularity.

Comparing Danceability Over Multiple Days



So, while it's fun to say "most songs at Grassroots have danceability of ~0.6, this doesn't mean too much."

Compare against stage? time?

If you were to describe what makes music danceable, what would you include?

not too much spoken word

creative bass line

# ÷ ON NUMBERS =

.CSV  
 excel file  
 numpy array

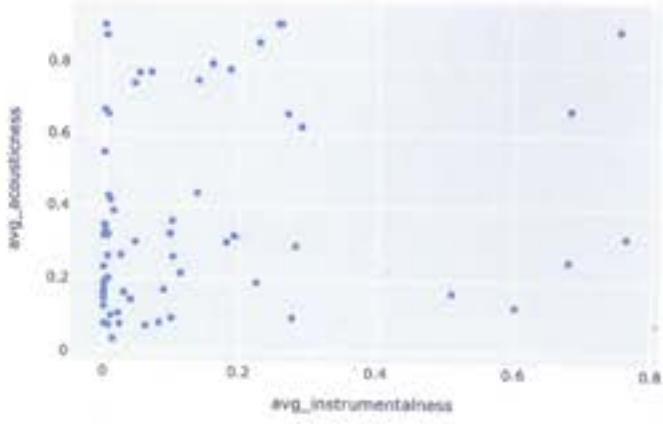
MY DATA COULD BE STORED AS

nested list  
 Dictionary  
 pandas DataFrame

performance_start	performance_end_time	performance_id	artist_name	artist_url	avg_danceability	avg_tempo	avg_dominant	avg_acousticness	avg_energy	avg_instrumentalness	avg_liveness	avg_speechiness	avg_time_signature	avg_valence
infid	2/29/20 12:00	1:00 PM N	Belle George Hengeland	https://open.spotify.com/artist/0000000000000000	0.4991	0.3384	0.4442	0.00011138	0.4484	0.0	0.42	0.00017963	0.5	0.2
infid	2/29/20 12:00	1:00 PM N	Lola Belle	https://open.spotify.com/artist/0000000000000000	0.4991	0.3402	0.4442	0.00012149	0.4492	1.00	0.4232	0.0001	0	0.4
infid	2/29/20 12:00	1:00 PM N	Gwen	https://open.spotify.com/artist/0000000000000000	0.5001	0.3412	0.4452	0.00013159	0.7045	0.00012149	0.7779	0.0001	0	0.4
infid	2/29/20 12:00	1:00 PM N	Donna the Buffalo	https://open.spotify.com/artist/0000000000000000	0.5001	0.3422	0.4462	0.00014169	0.7045	1.00	0.7003	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Robots Pyramid	https://open.spotify.com/artist/0000000000000000	0.5001	0.3432	0.4472	0.00015179	0.4523	1.00	0.7003	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	North Frank & The Indiana Zebulon Band	https://open.spotify.com/artist/0000000000000000	0.5001	0.3442	0.4482	0.00016189	0.7944	0.00015189	0.3694	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Jones Family Family	https://open.spotify.com/artist/0000000000000000	0.5001	0.3452	0.4492	0.00017199	0.2185	1.00	0.3295	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Fall Creek String Band	https://open.spotify.com/artist/0000000000000000	0.5001	0.3462	0.4502	0.00018199	0.7358	0.00016199	0.1324	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	North Dakota	https://open.spotify.com/artist/0000000000000000	0.5001	0.3472	0.4512	0.00019199	0.9807	0.00017199	0.8608	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Reva Knott	https://open.spotify.com/artist/0000000000000000	0.5001	0.3482	0.4522	0.00019999	0.7514	0.00018199	0.3793	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Asperger & Disease	https://open.spotify.com/artist/0000000000000000	0.5001	0.3492	0.4532	0.00020999	0.8126	0.00019199	0.7523	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	The Mavrikis	https://open.spotify.com/artist/0000000000000000	0.5001	0.3502	0.4542	0.00021999	0.7994	0.00018199	0.3794	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Amika	https://open.spotify.com/artist/0000000000000000	0.5001	0.3512	0.4552	0.00022999	0.7579	0.00017199	0.5179	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Middle Tiger	https://open.spotify.com/artist/0000000000000000	0.5001	0.3522	0.4562	0.00023999	0.7025	0.00016999	0.7017	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Tyler Abbott	https://open.spotify.com/artist/0000000000000000	0.5001	0.3532	0.4572	0.00024999	0.5043	0.00015999	0.8001	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Flying Devils of South Carolina	https://open.spotify.com/artist/0000000000000000	0.5001	0.3542	0.4582	0.00025999	0.2967	0.00014999	0.5098	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Vicious Fates	https://open.spotify.com/artist/0000000000000000	0.5001	0.3552	0.4592	0.00026999	0.7993	0.00013999	0.5137	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Phantom Seats & Vans	https://open.spotify.com/artist/0000000000000000	0.5001	0.3562	0.4602	0.00027999	0.8105	0.00012999	0.5209	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	The Legendary Gymnast	https://open.spotify.com/artist/0000000000000000	0.5001	0.3572	0.4612	0.00028999	0.4039	0.00011999	0.5159	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Worxhead	https://open.spotify.com/artist/0000000000000000	0.5001	0.3582	0.4622	0.00029999	0.7754	0.00010999	0.3659	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Blame the Buffalo	https://open.spotify.com/artist/0000000000000000	0.5001	0.3592	0.4632	0.00030999	0.7349	0.00009999	0.3775	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	The Comb Devils	https://open.spotify.com/artist/0000000000000000	0.5001	0.3602	0.4642	0.00031999	0.7519	0.00008999	0.5137	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Wynie Roberts	https://open.spotify.com/artist/0000000000000000	0.5001	0.3612	0.4652	0.00032999	0.7104	0.00007999	0.5209	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Eve Rodriguez Band	https://open.spotify.com/artist/0000000000000000	0.5001	0.3622	0.4662	0.00033999	0.3347	0.00006999	0.5169	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	SingTales & More Cold Miracle	https://open.spotify.com/artist/0000000000000000	0.5001	0.3632	0.4672	0.00034999	0.7396	0.00005999	0.3794	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Earthbound	https://open.spotify.com/artist/0000000000000000	0.5001	0.3642	0.4682	0.00035999	0.4554	0.00004999	0.3657	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Kidko & Roots	https://open.spotify.com/artist/0000000000000000	0.5001	0.3652	0.4692	0.00036999	0.3836	0.00003999	0.3529	0.0001	0	0.4
infid	2/29/20 21:00	9:00 PM	Dance the Buffalo	https://open.spotify.com/artist/0000000000000000	0.5001	0.3662	0.4702	0.00037999	0.7160	0.00002999	0.7775	0.0001	0	0.4
Device Test	4/29/20 10:00	9:00 PM N	Scout Girls	https://open.spotify.com/artist/0000000000000000	0.5001	0.3672	0.4712	0.00038999	0.8075	0.00001999	0.7637	0.0001	0	0.4
Device Test	5/29/20 10:00	9:00 PM N	Buddy & The Bros	https://open.spotify.com/artist/0000000000000000	0.5001	0.3682	0.4722	0.00039999	0.7037	0.00000999	0.5159	0.0001	0	0.4
Device Test	5/29/20 10:00	9:00 PM N	Luke D & The Cardboard	https://open.spotify.com/artist/0000000000000000	0.5001	0.3692	0.4732	0.00040999	0.7775	0.00000999	0.7775	0.0001	0	0.4

The Top 10: Grassroots Schedule only has the order of artists, no specific set lists. So, instead I took each artist's 10 most popular tracks (most likely to be played) and averaged the values of those songs. If I were to do it again, I would just use all songs, because:

Major Issue: averaging songs gets rid of unique values, so we end up with more "average" values and no fun extremes. See pages 10-11 for examples of how this is harmful, especially with categorical values.

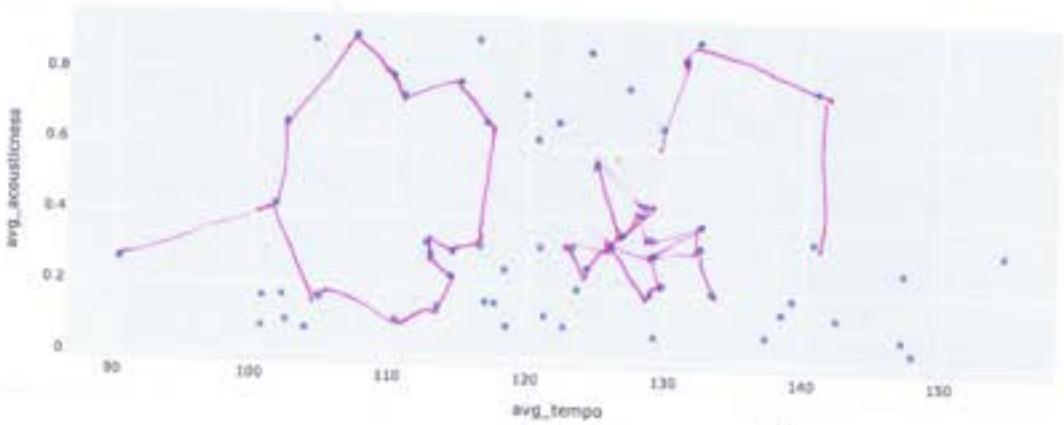
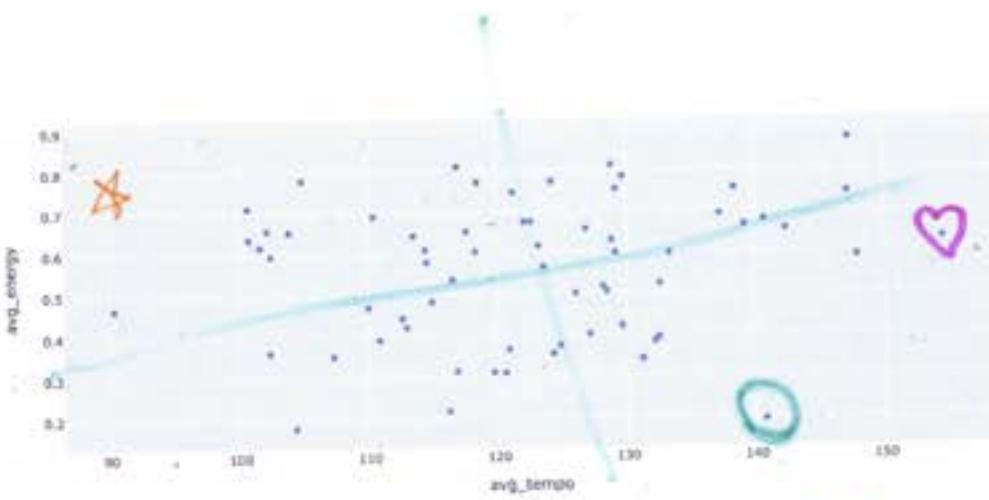


# RELATIONS

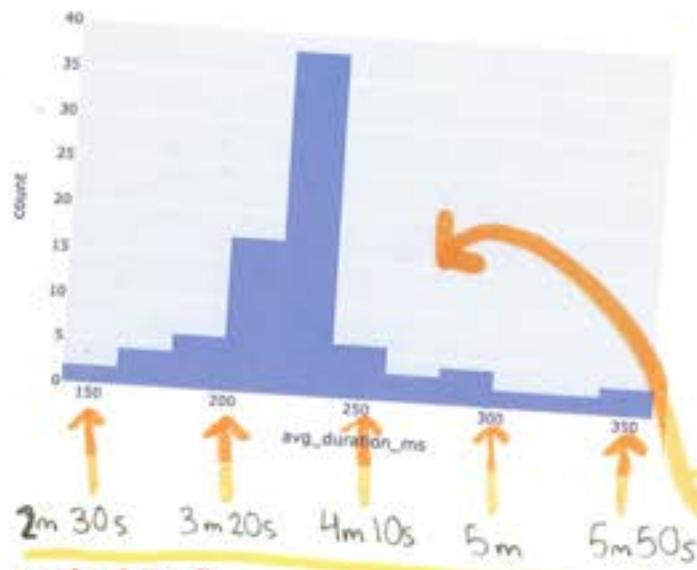
(or lack thereof)

Are energy, acousticness, tempo, & instrumentalness related? Let's see.

Draw on these:  
a trend line,  
a data point you  
think is bad, etc.



# DURATION



UNITS are so important!

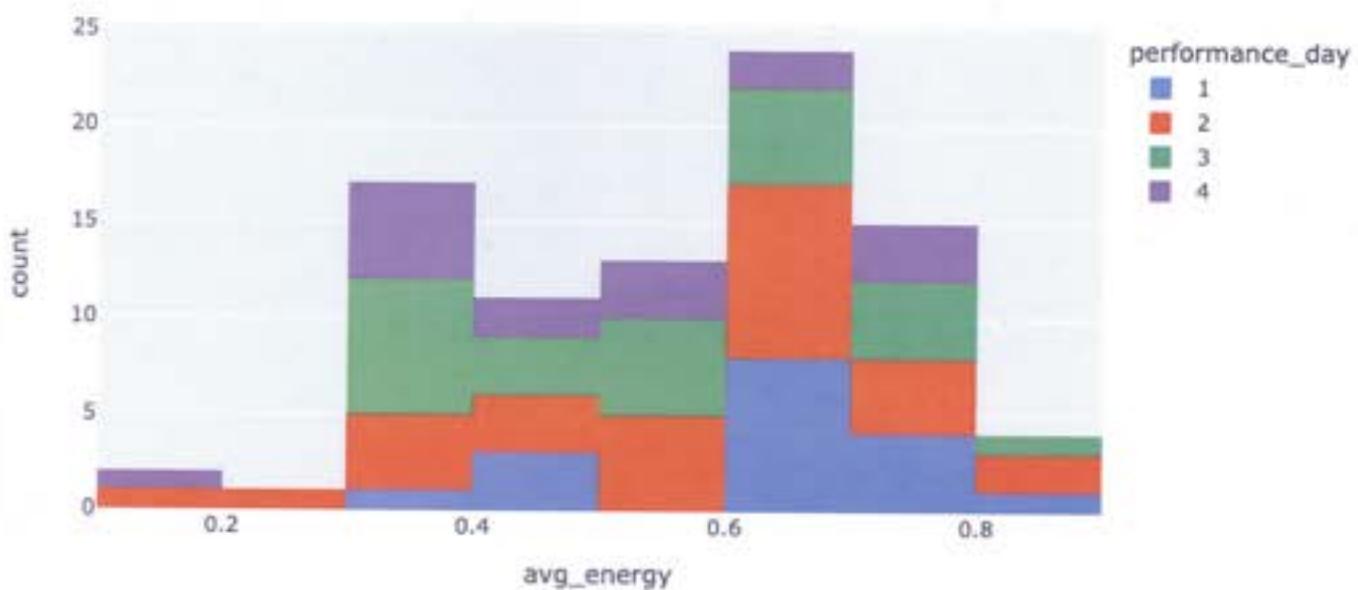
I accidentally labeled this as milliseconds, but it's actually just seconds. If it were ms, each would only be  $\frac{1}{2}$  second long!

Most songs are between 3 and 4 minutes long when recorded. Of course, when artists perform them live, they can be significantly longer or shorter.

Why are these such average durations?

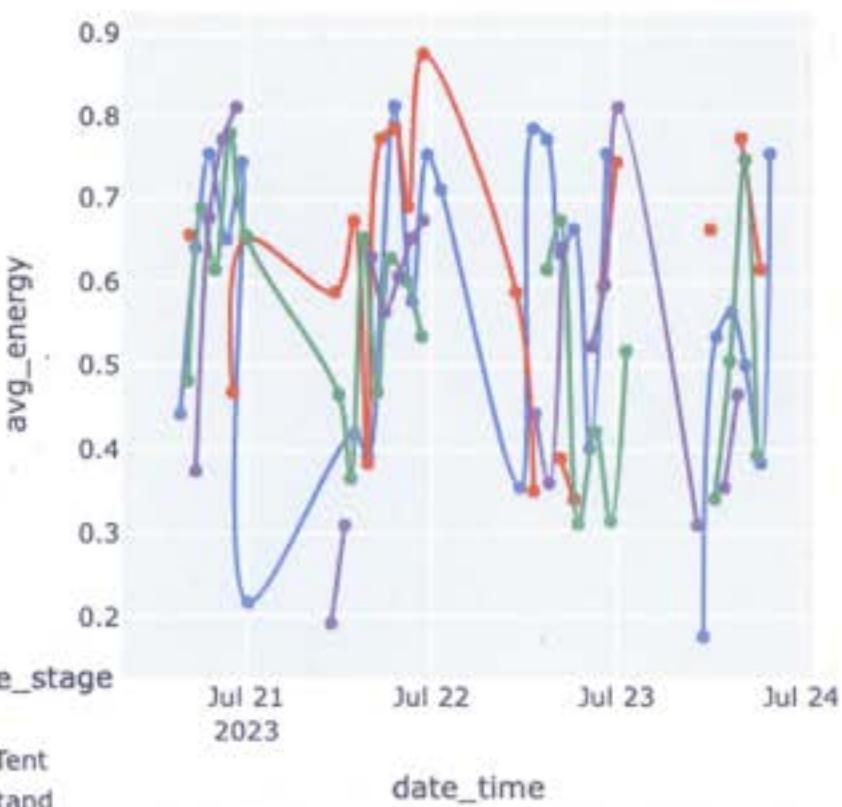
Surely, there's got to be an answer! cultural inertia? short format recordings historically limited (45") duration. Perhaps our attention/action spans are stuck with that duration.

## Comparing Energy Over Multiple Days



"perceptual measure of intensity and activity. perceptual features include dynamic range, perceived loudness, timbre, onset rate, and general entropy."

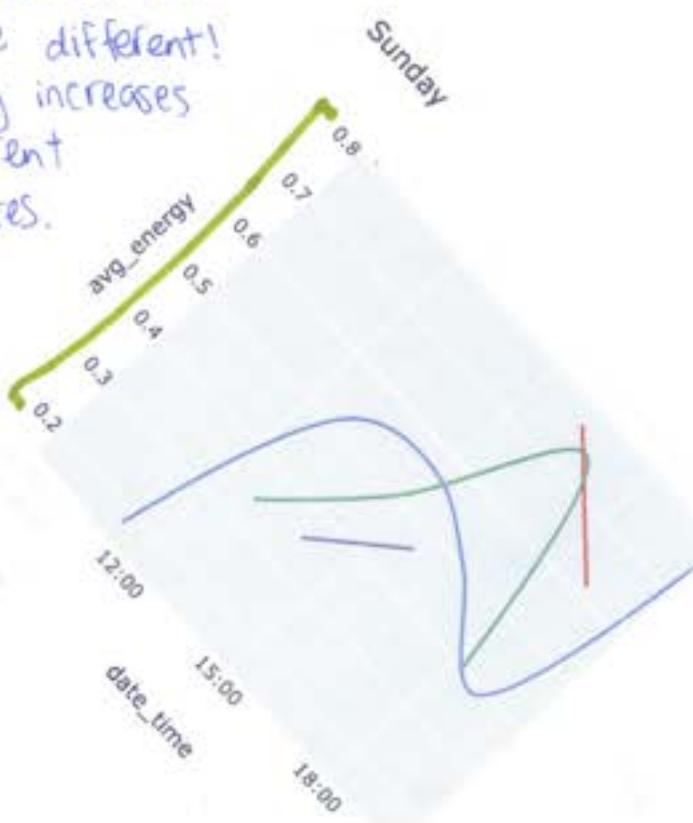
→ Faster, louder, noisier  
 Bach → Death metal



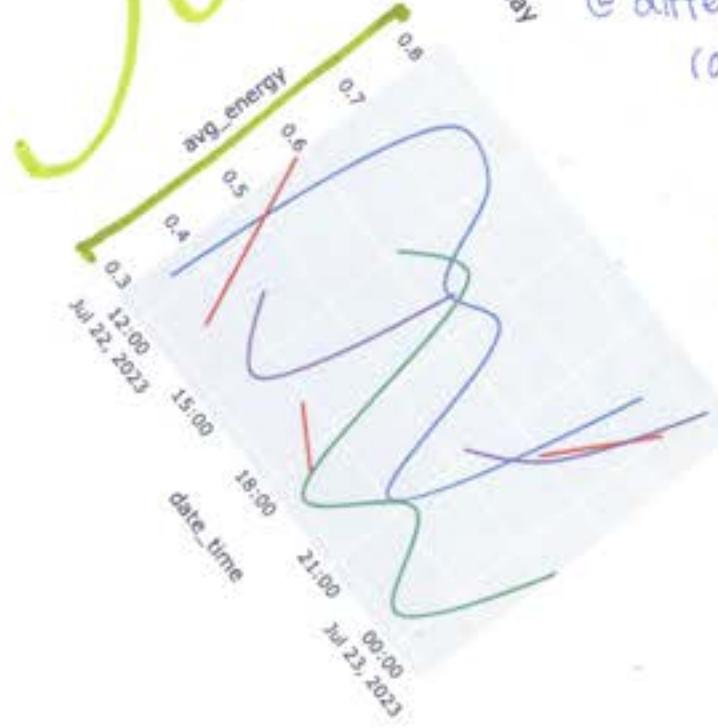


Overall, the energy seems to increase throughout the day, each day.  
Note, though, that the scales are different!  
So, energy increases @ different rates.

Saturday



Sunday





WRITE YOUR

# email



For a digitized final copy of this!

sc4flett@umich.edu

debraeileen@gmail.com

vainbramer4@gmail.com

elliotjwalsch@gmail.com FEB 11

CLANGER@ITHACA.EDU

jamie@ny.com

verzelkm200@gmail.com

SENNAMCMASTER@gmail.com

12345678910@gmail.com

Alina + Guthrie  
ferias.mtl@gmail.com

Hey Dylan, super cool project!  
from two folks who work in music  
(and analytics) talk soon!

sdesouza@skidmore.edu

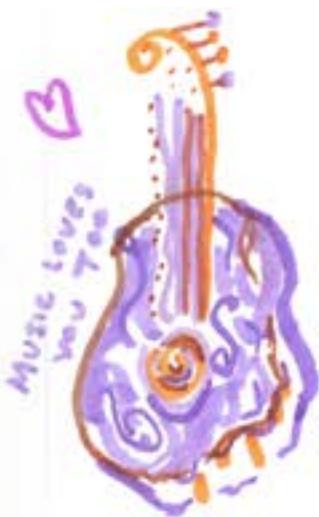
Olivia.R.VINCENT@gmail

hello@bethanyparisi.com

lb747@cornell.edu

who@alum.mit.edu

erica.tauzer@gmail.com



[ Enter anything here... ]



I seriously don't understand  
why we don't have ~~domesticated~~ raccoons  
as pets yet :)



I was HERE  
I still remember half



write ur  
initial if  
u are cool!

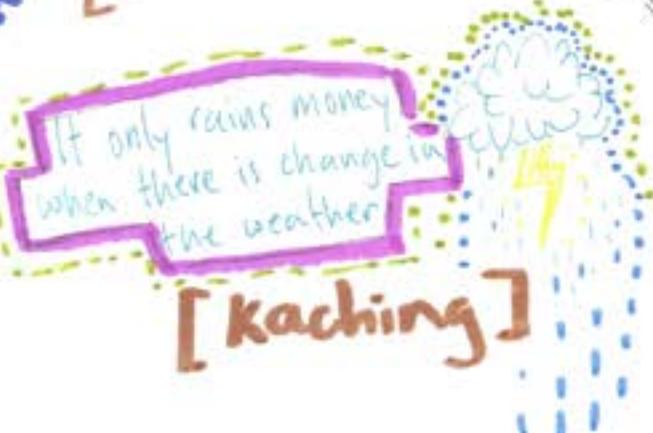
J.L.  
P.S. I'm cool



[ rosebud ]

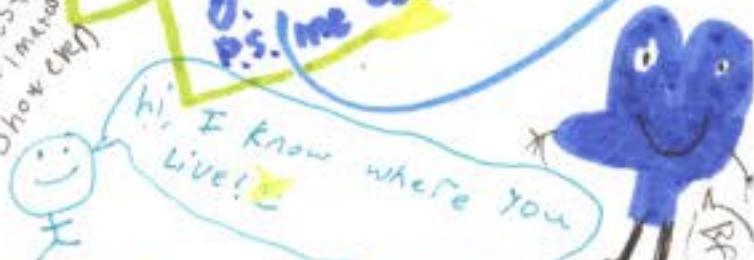


BFDI  
in YouTube  
the best  
animal  
show ever



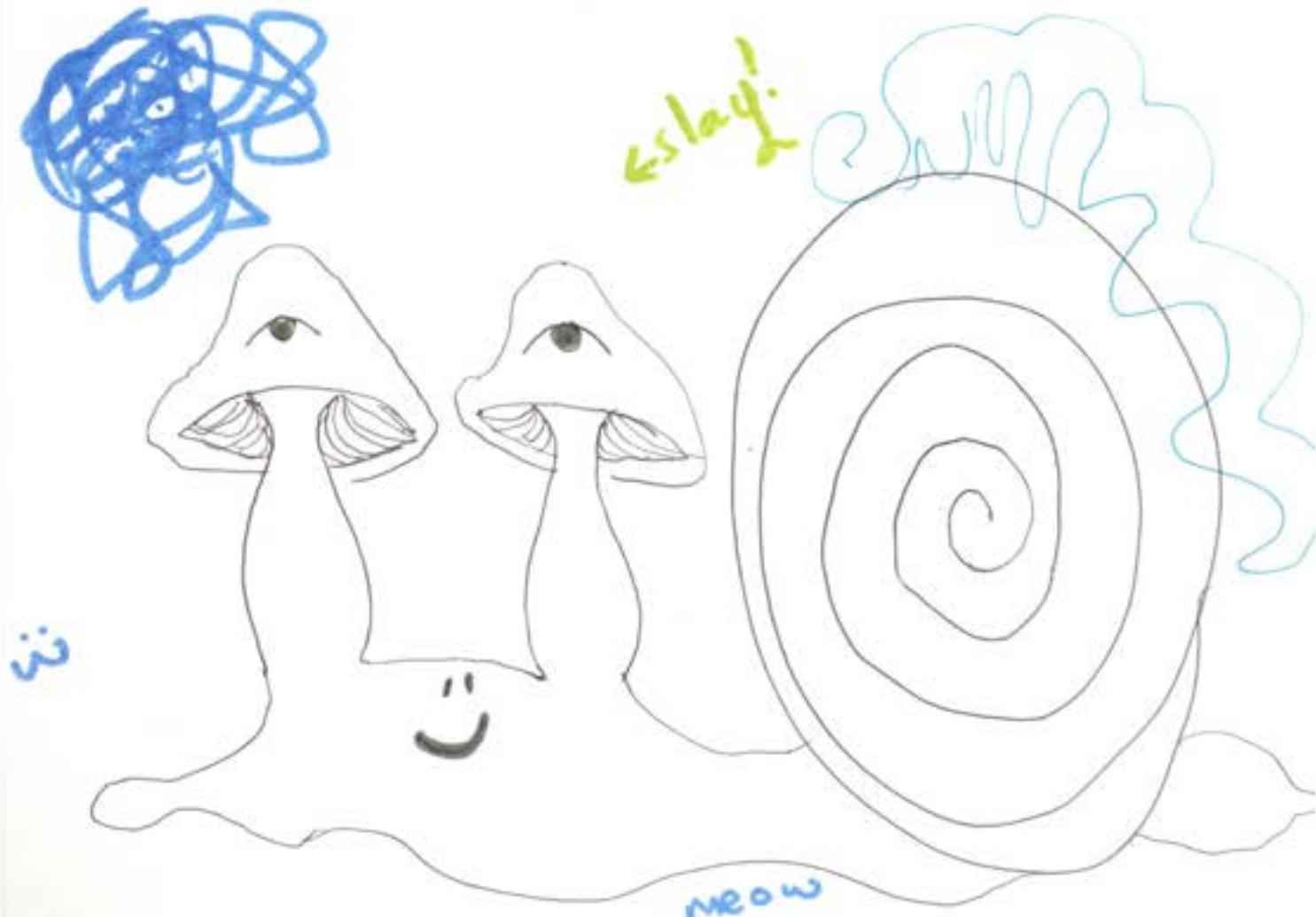
[ kaching ]

tree roots



I LOVE THIS... now you...

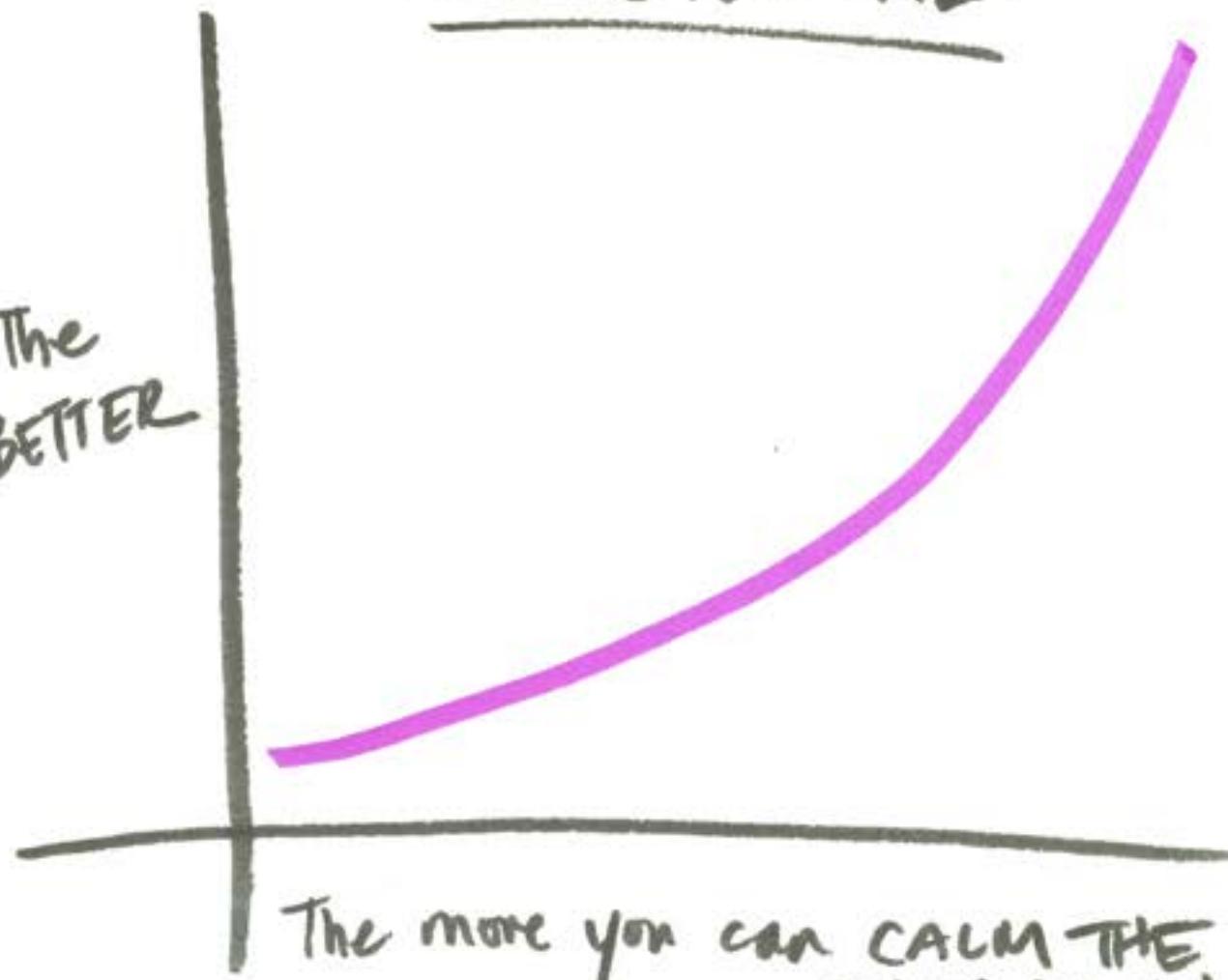




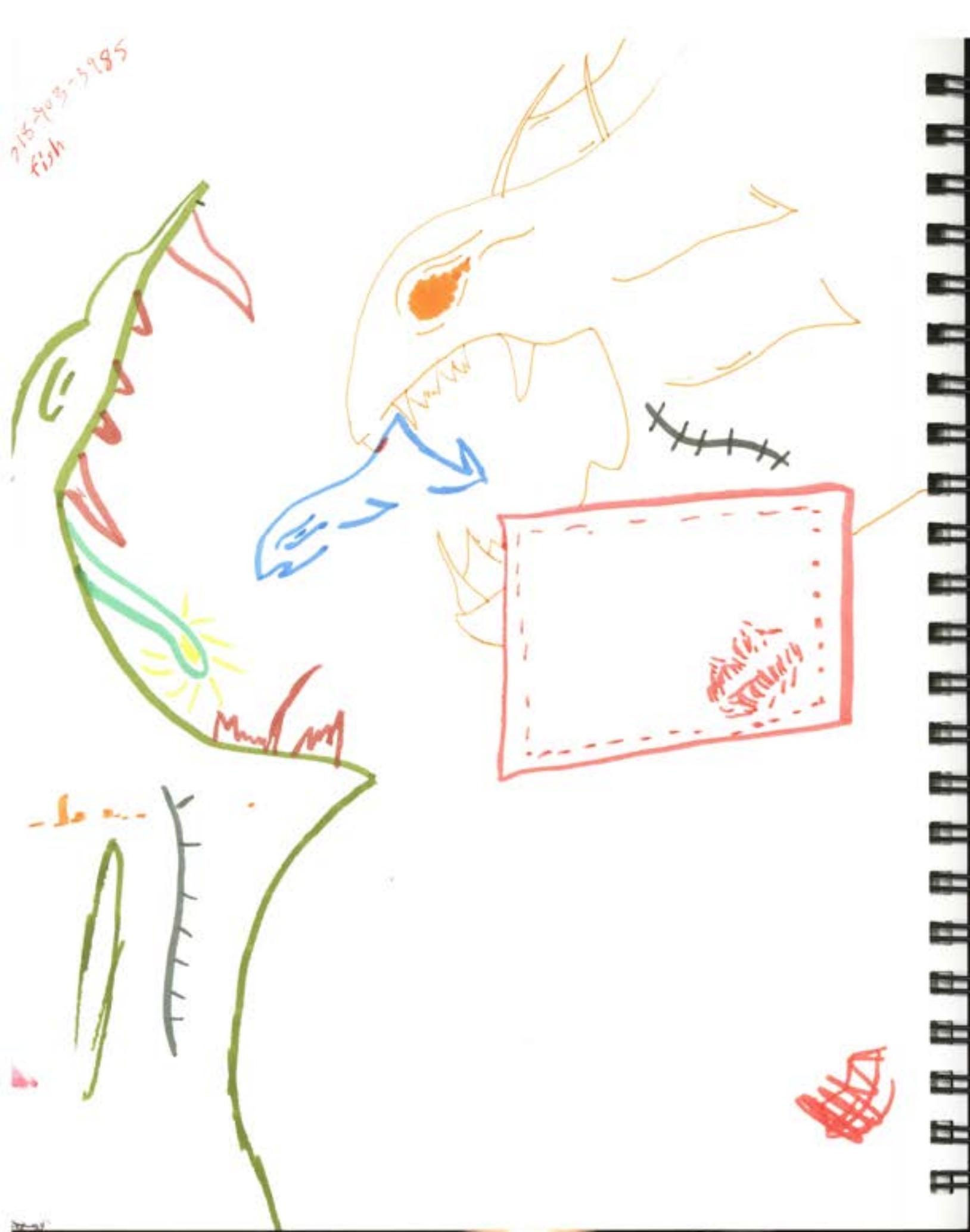


# IN GENERAL

The  
BETTER



XOYO  
♥=







"SAMS" SAMUS REMEMBER THE NAME!

THE URGE TO WRITE ON WALLS

COMES FROM A LACK OF COLOR AND CREATIVITY  
IN THE WORLD. GIVE A MAN A BLANK WALL  
AND A MARKER AND THE DESIRE TO  
DISRUPT THE BLAND UNIFORMITY  
COMES NATURALLY

-SAMUS REMEMBER IT...

Sunny  
was  
here!

you are the light  
of the world

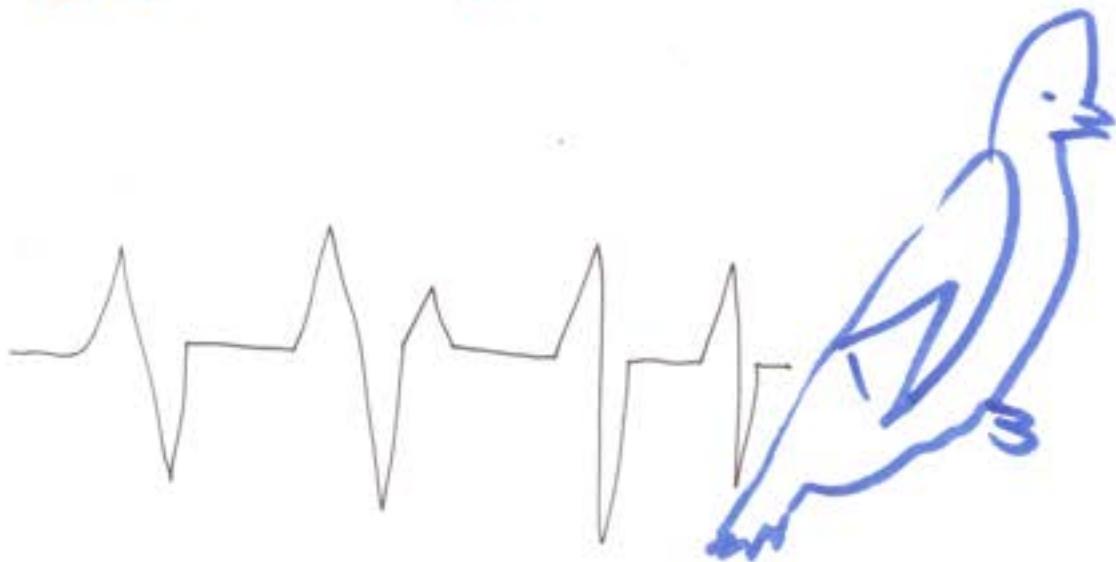
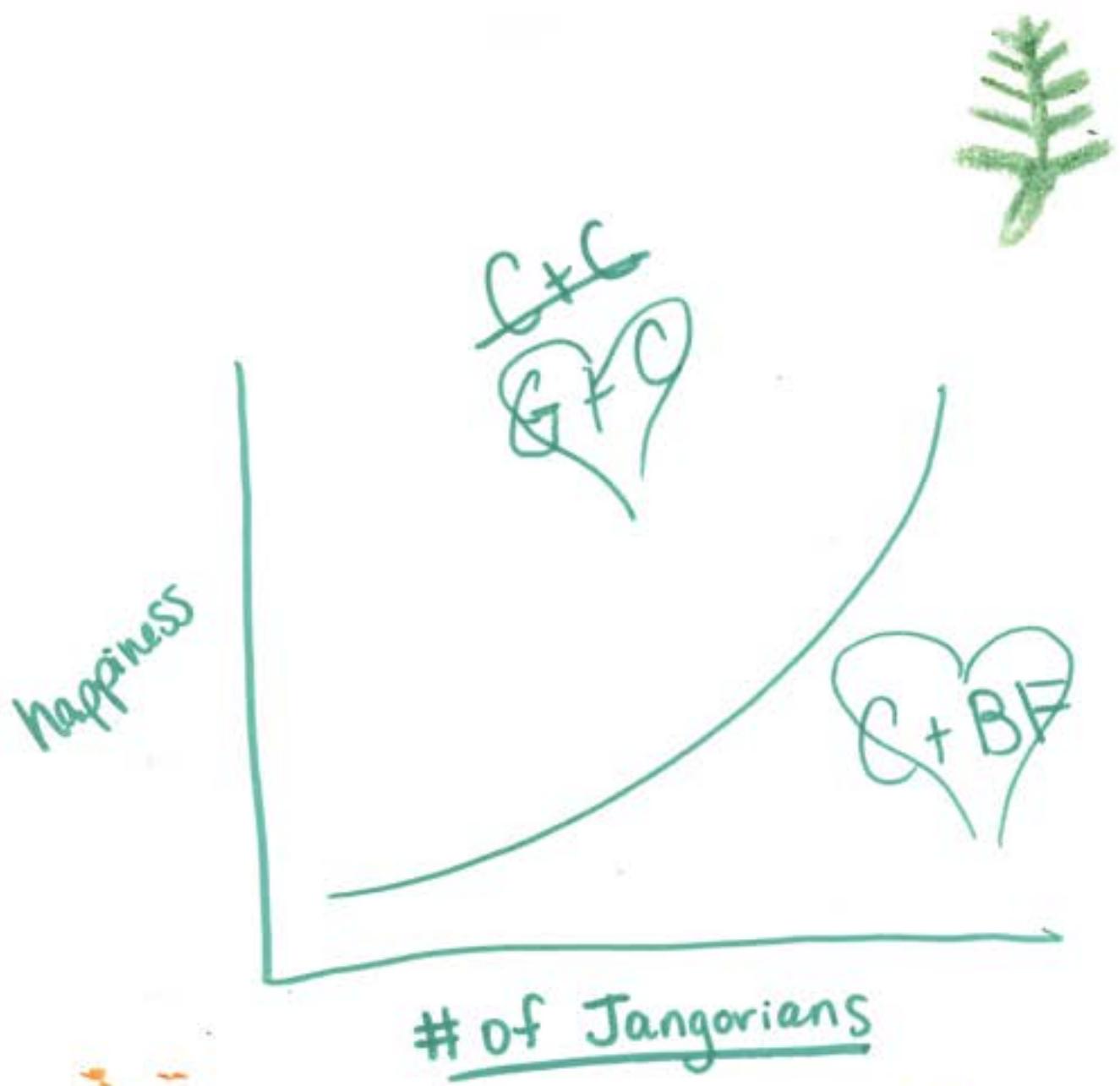
STURE  
BRICHARD  
CITY





GIVE YOUR  
BURDEN TO THE  
LORD  
AND THEY WILL  
TAKE CARE OF YOU.

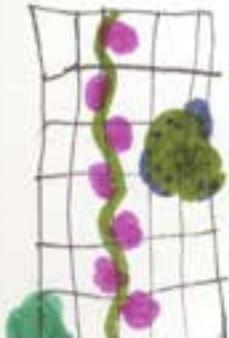






# PLANTS = PEACE!

Draw a plant if you love  
the Earth! 



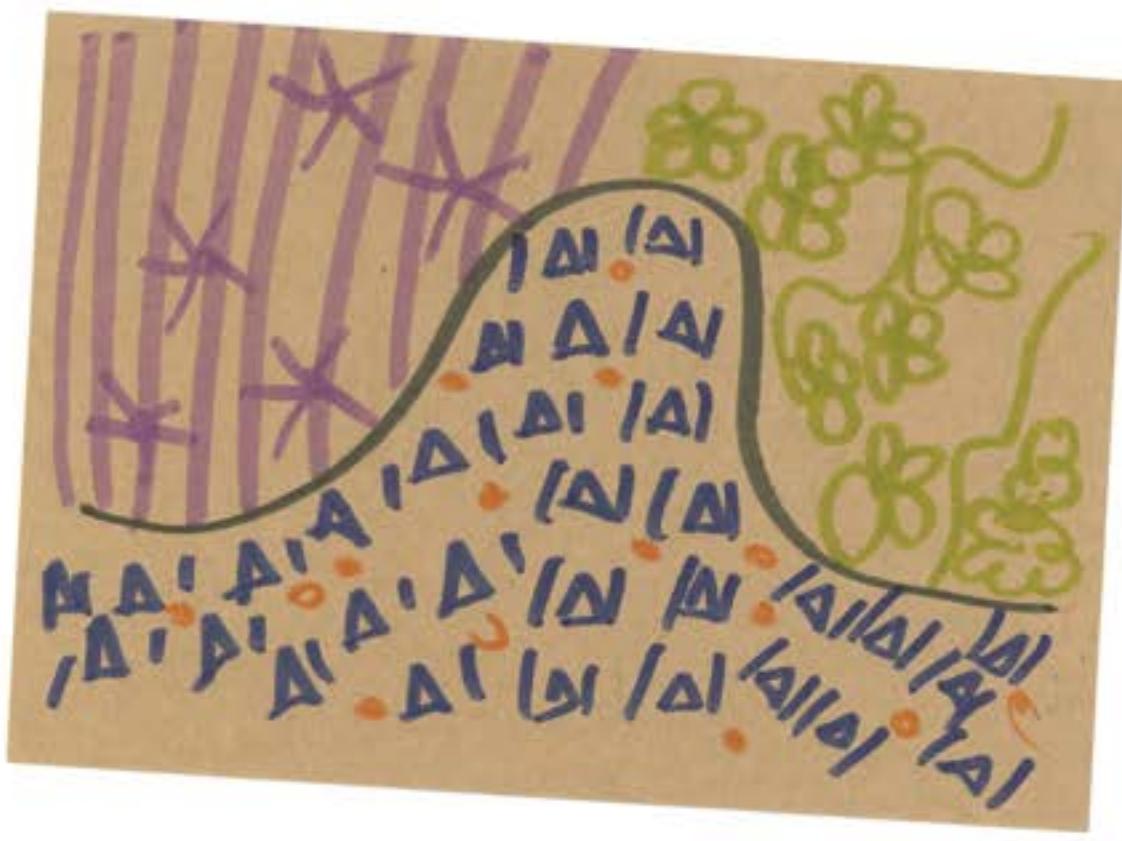
You are amazing!

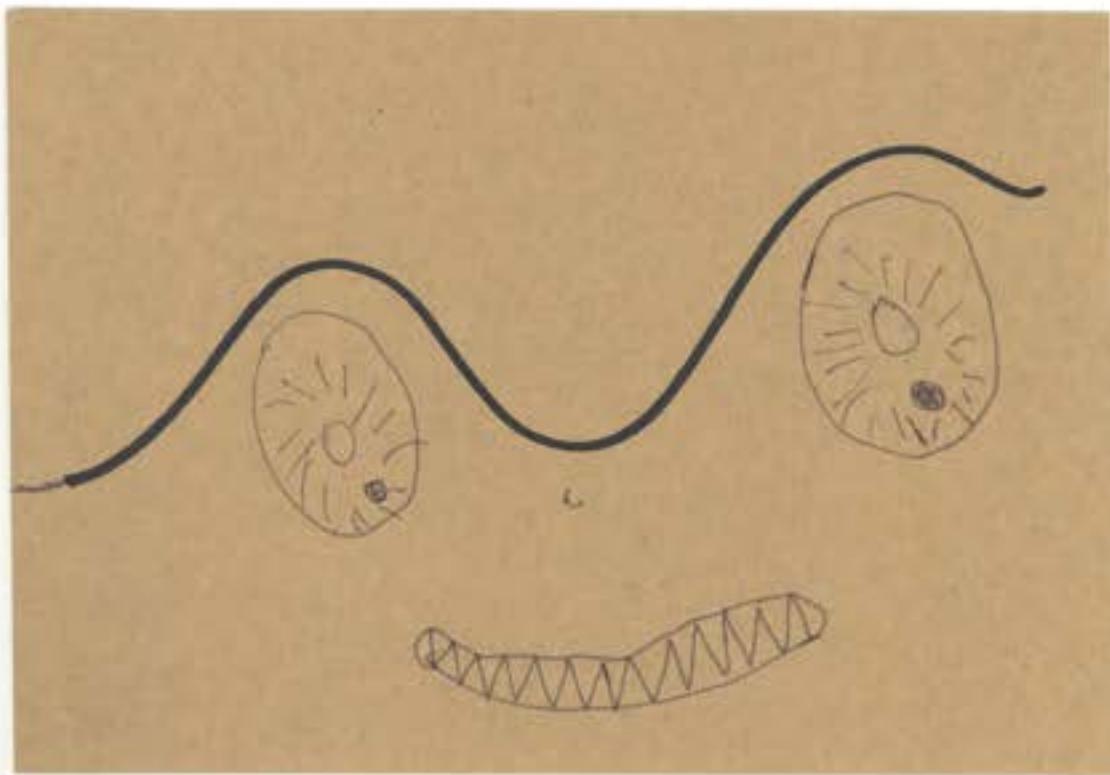
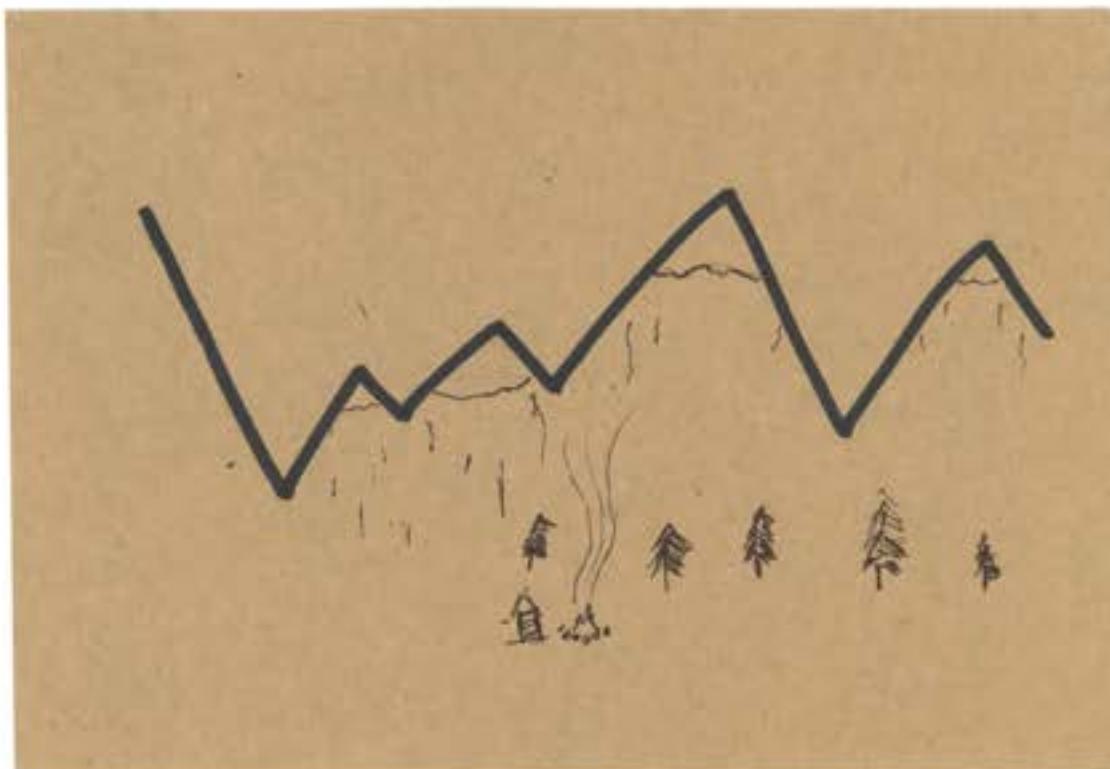


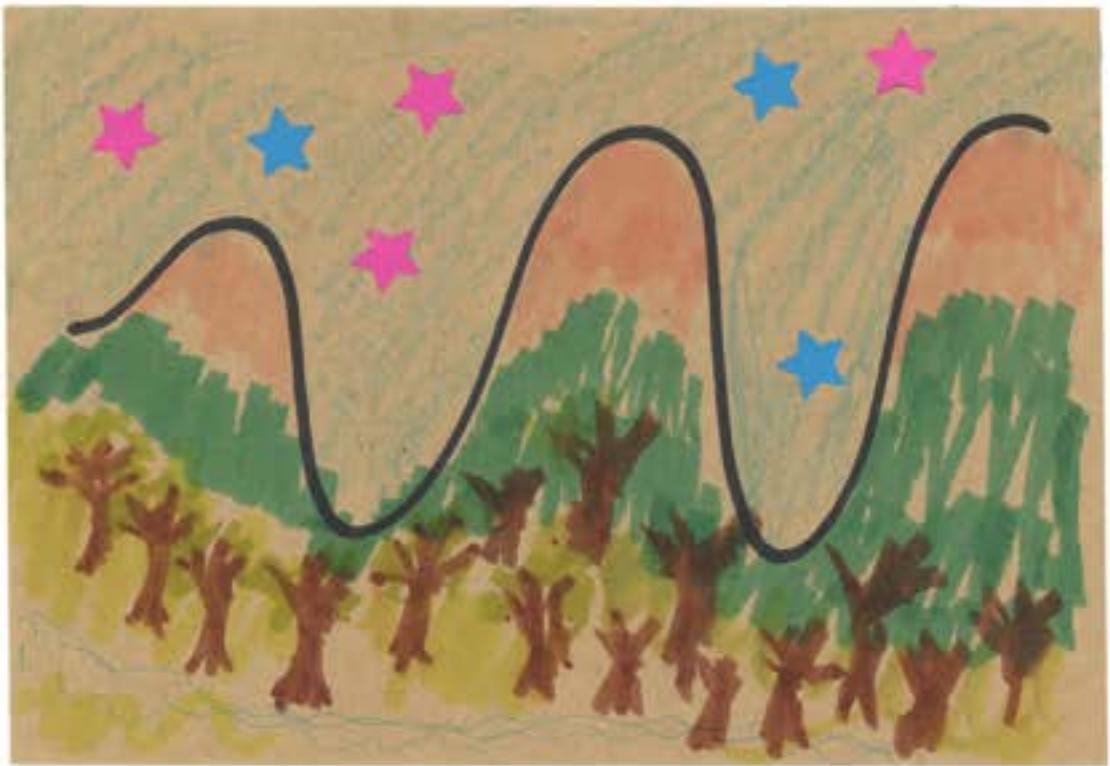
you are amazing  
Much LOVE From  
Florida!  
Derek Donell

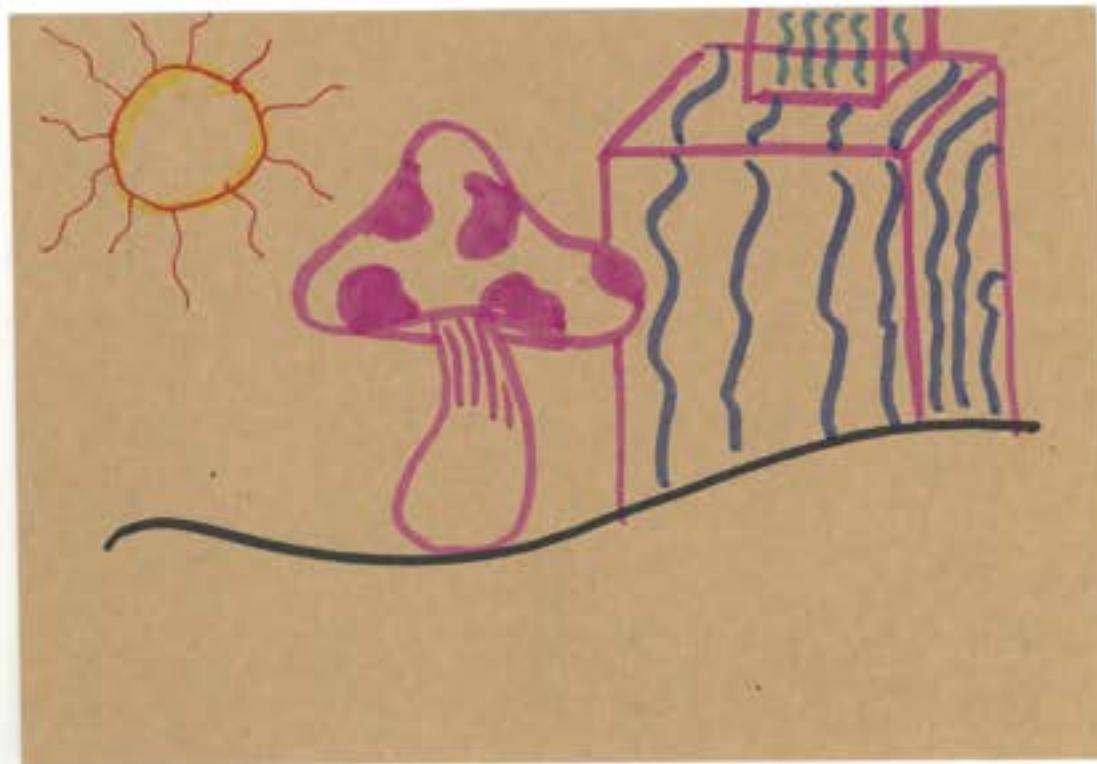
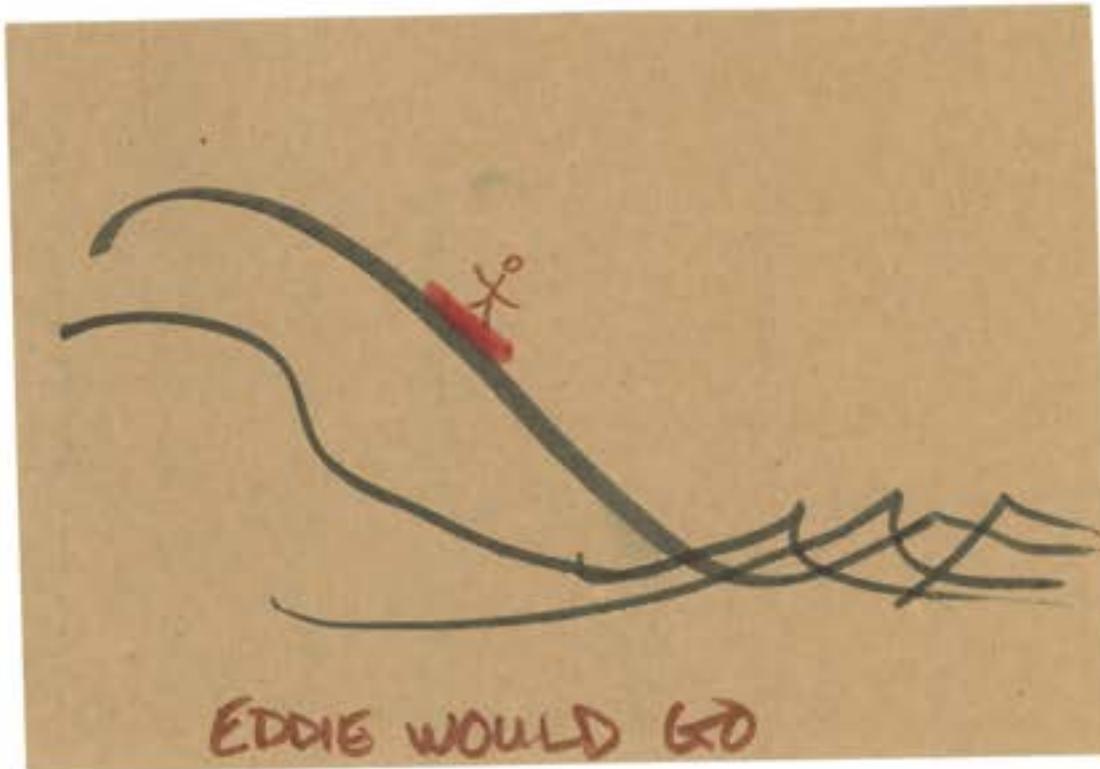












LAROOON'S  
MAKES THE  
BODY FEEL



AL



I ❤

MAOOGY

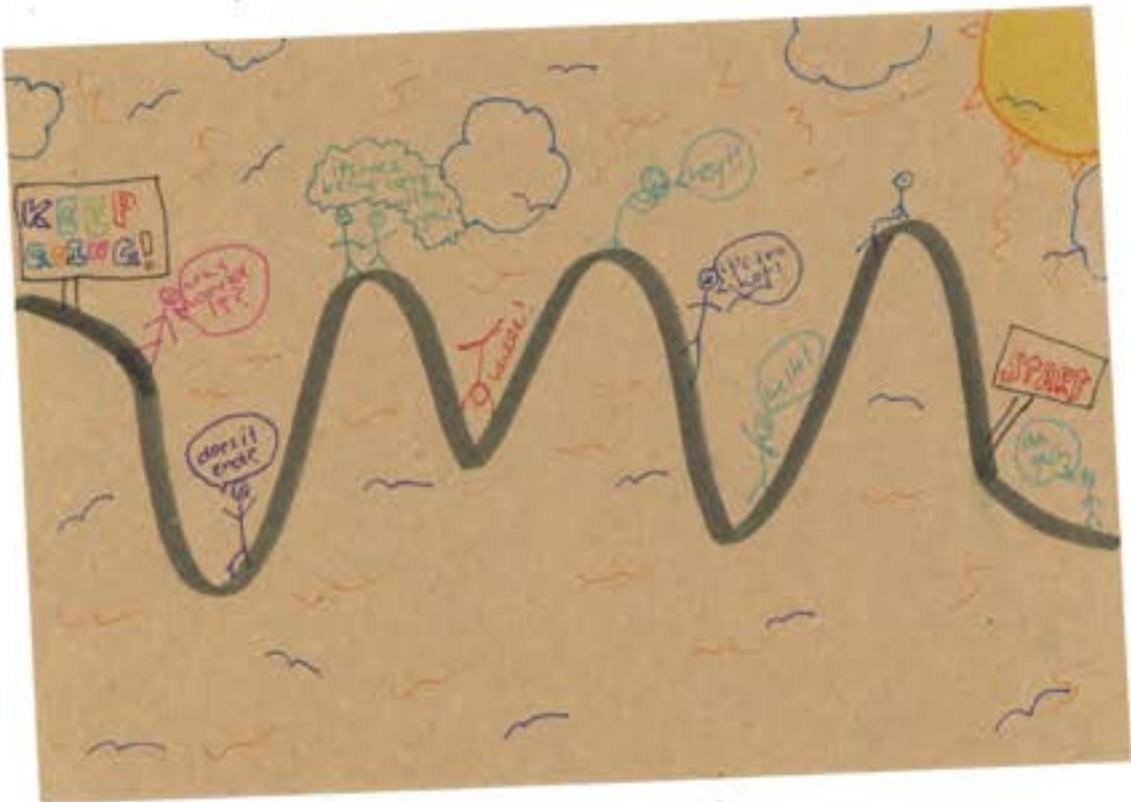
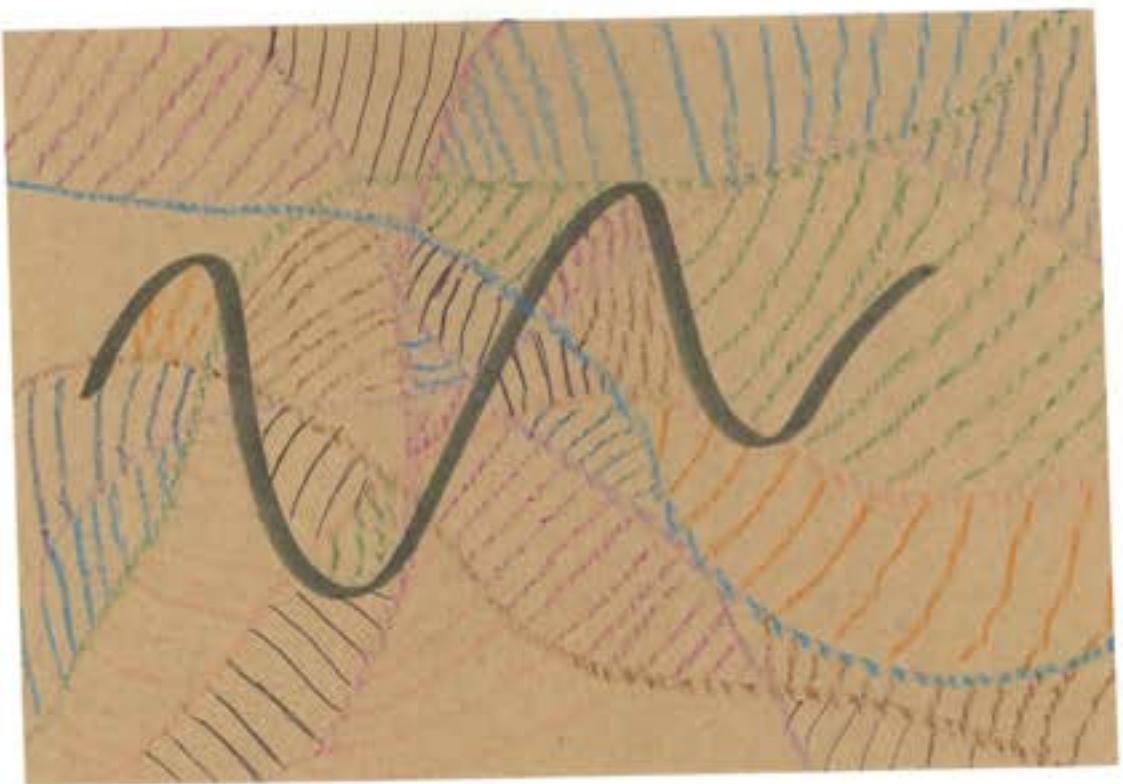
TOLBERT  
- ELLA ↗

Q T M  
Tiger Maday

Tiger

Maday

Thee Shining world  
The world needs your light  
Yafa + P

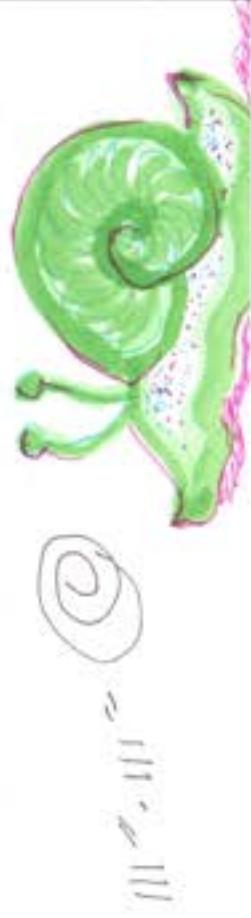


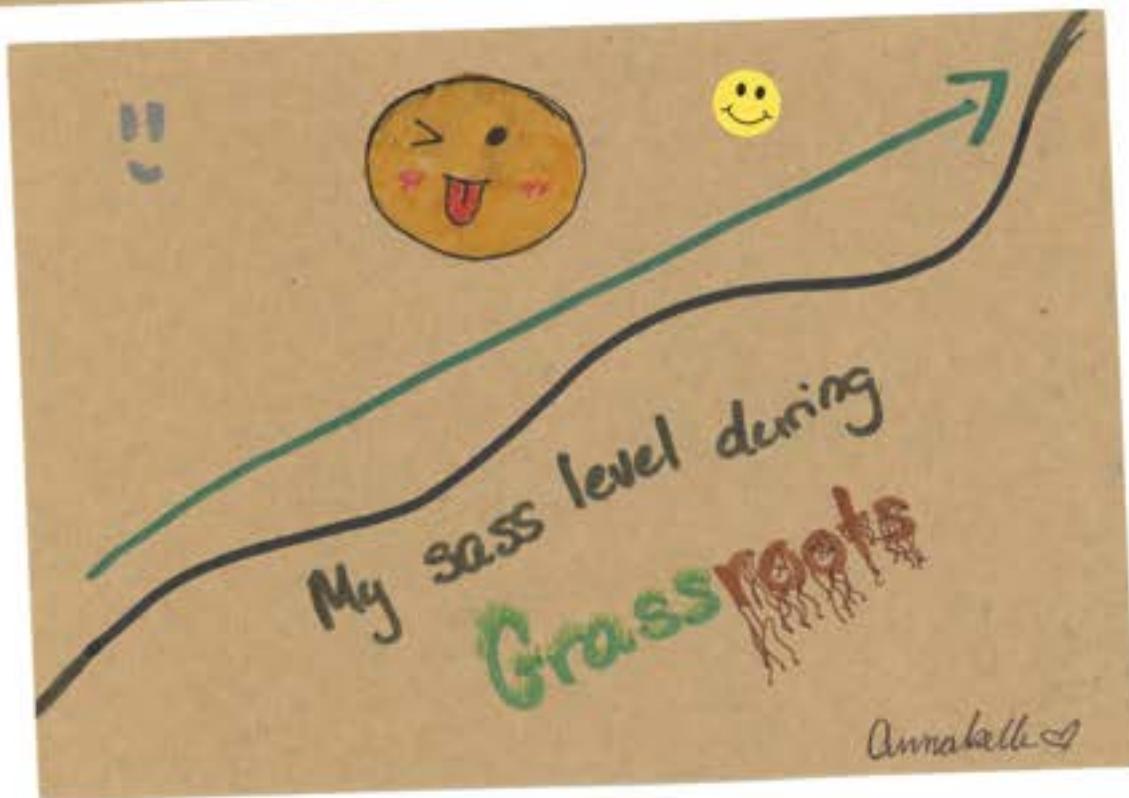
EARTH IS

BEAUTIFUL



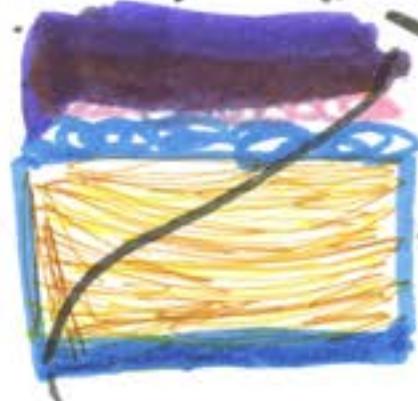
John is  
my son  
-Dad -







SMALL THINGS



Buntec  
pacas  
cake



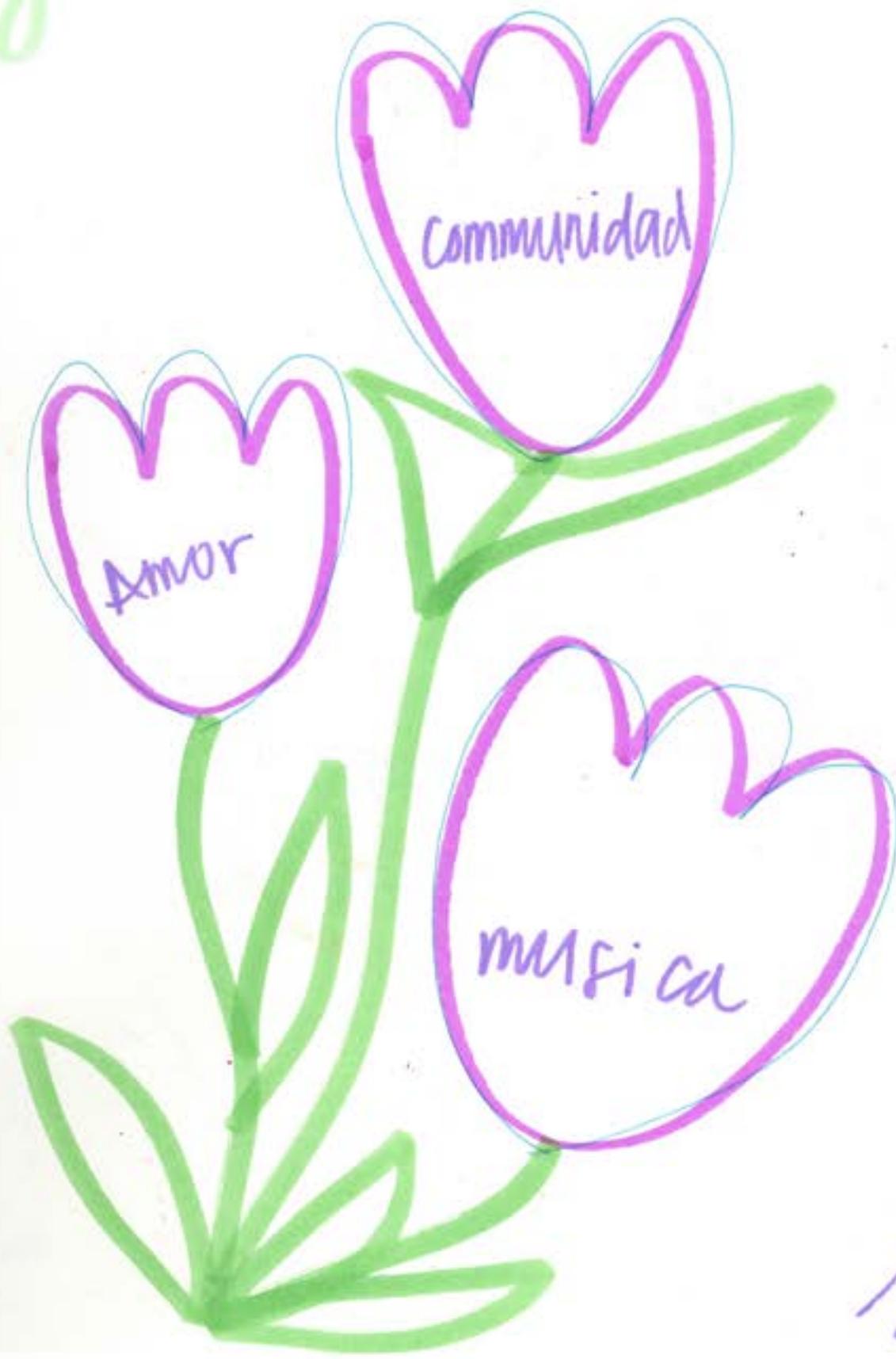
LG: Adele824

I'm a 17 yr old heading to college Aug'23 and art is a hobby!

I wish to expand in the future!



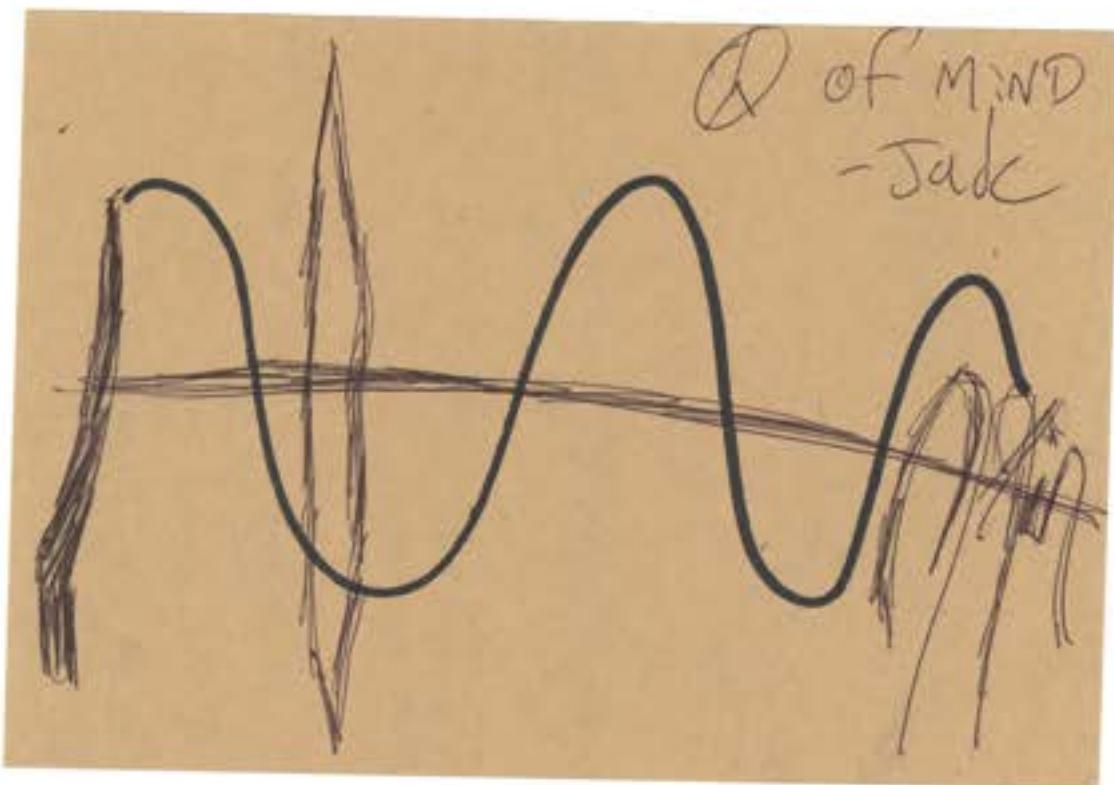
grassroots 2023



SP.

~~ANRAGRAY~~

o





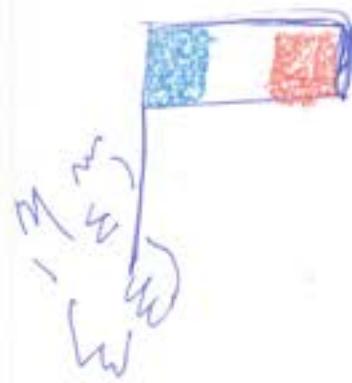
Hi



SD







Some frenchy's are here.

French folks from France. Yes indeed.

We are having a beautiful experience here  
in Grassroot. Thanks for the invitation, this beautiful  
idea of a shared books. Hope you have as much fun  
as we have.

lot's of love from us.  
If you like wine → check up Domaine Sibé from the Rhône Valley

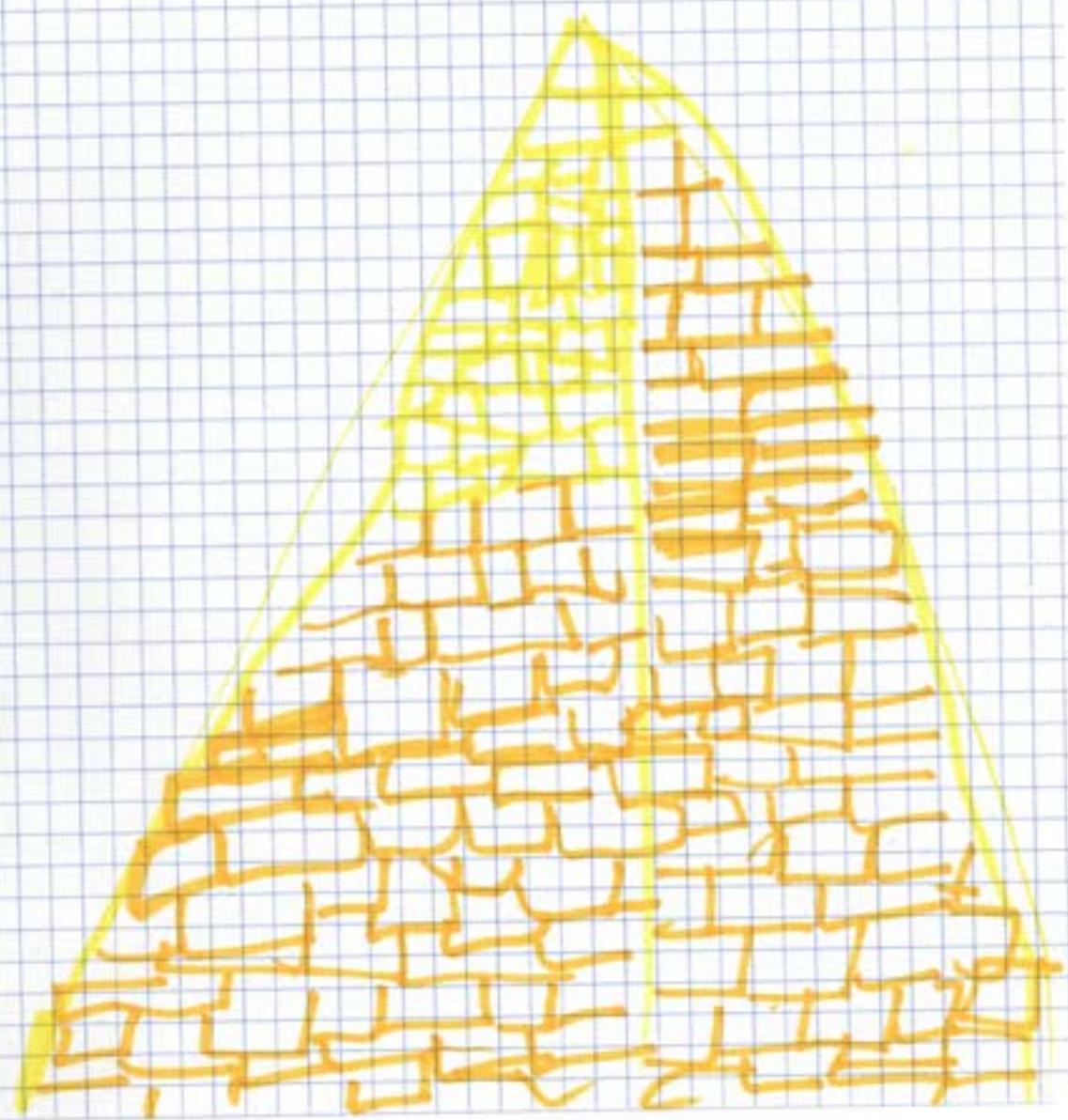
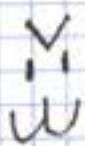


Have a nice  
moment everyone!

feel  
the  
Magic\*

Spread  
the  
LOVE

pyramid





Spread Love

∅ \* Δ \* Serenity  
Jane  
Liz



T.T.  
HAPPY  
grafftoots



Elisabeth  
L. 11

Car

have a wonderful experience



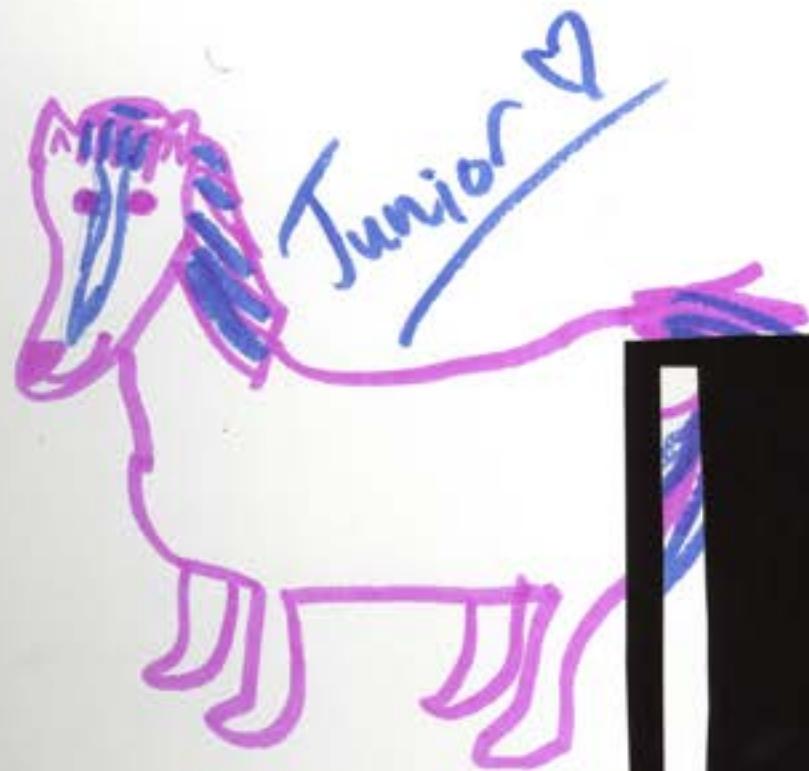


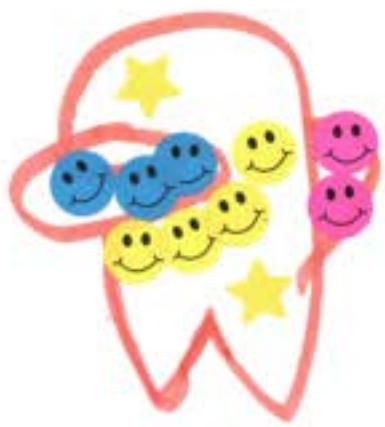
Eliza was  
here!!



On  
BREOUND

⑥ Fazzard







IAZUKU!

GIZUK D.K.

Happy Roots CMR&TSB '23



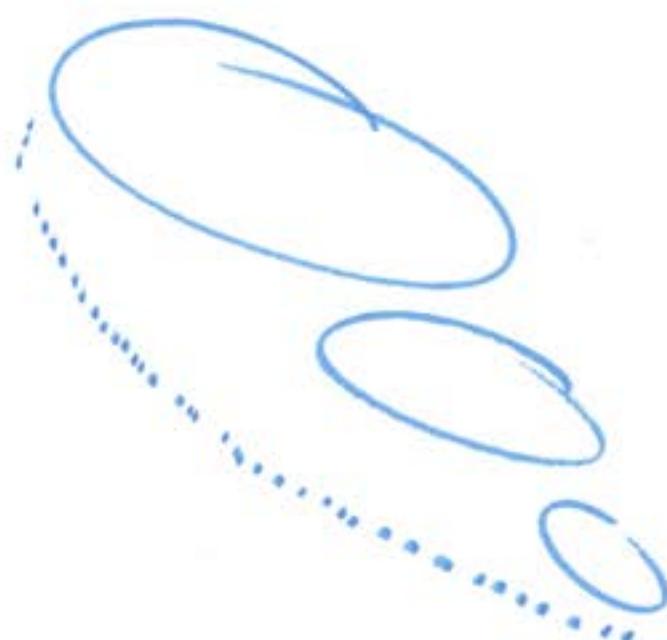


CUTE!

SKYLAR







Deep  
Doodle APP

1st

10/22/

time @  
grassroots!

- Marissa



1/23/23

Watch out

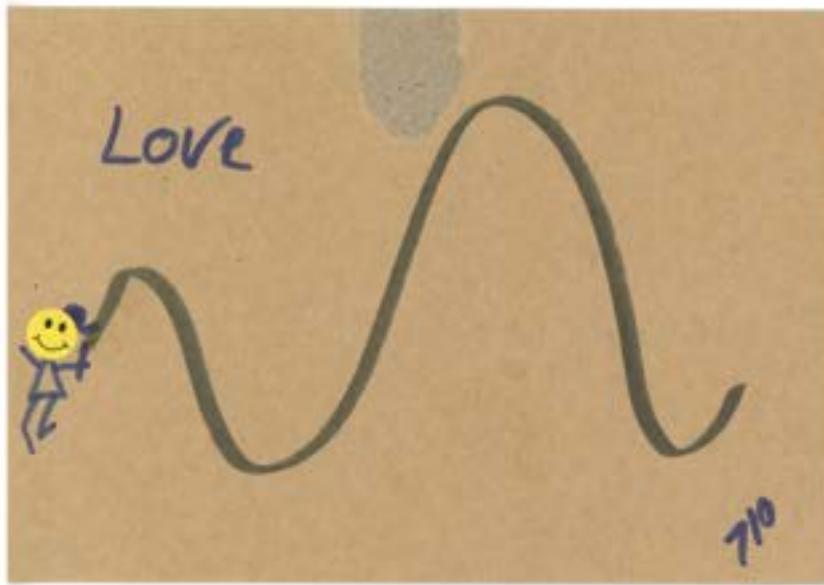
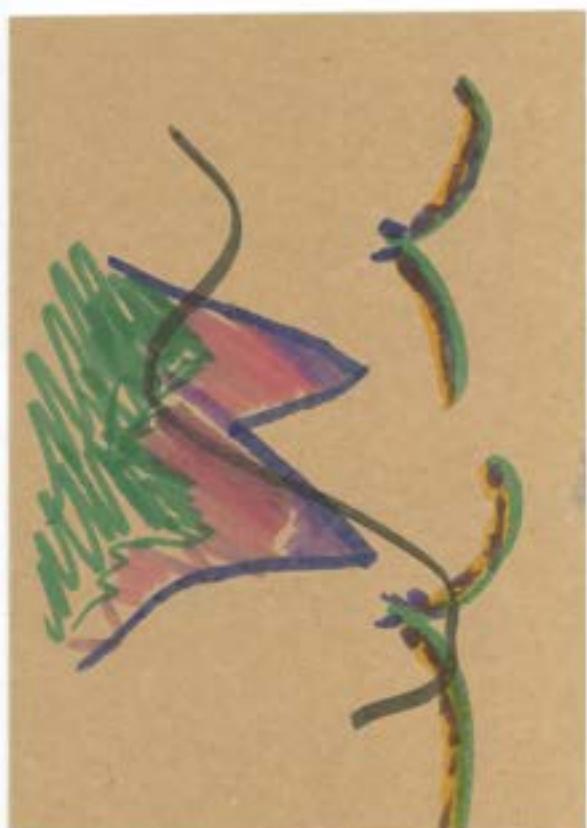
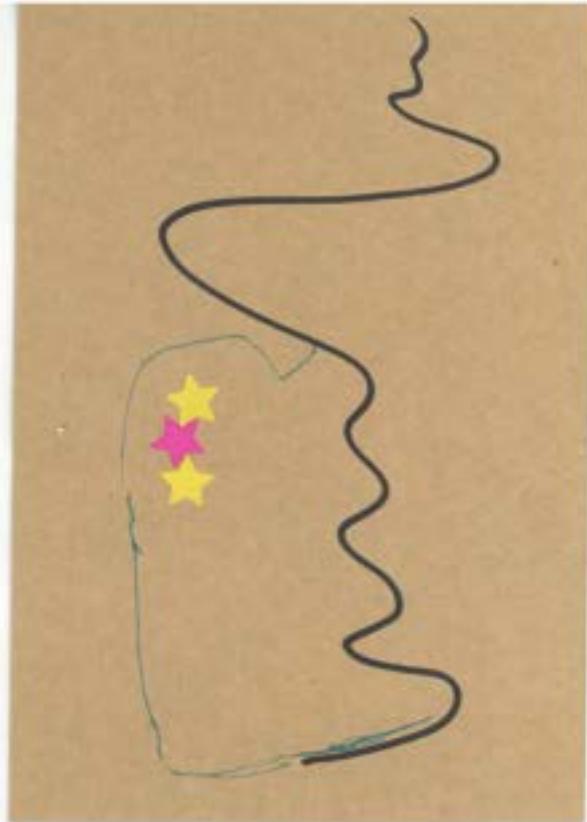
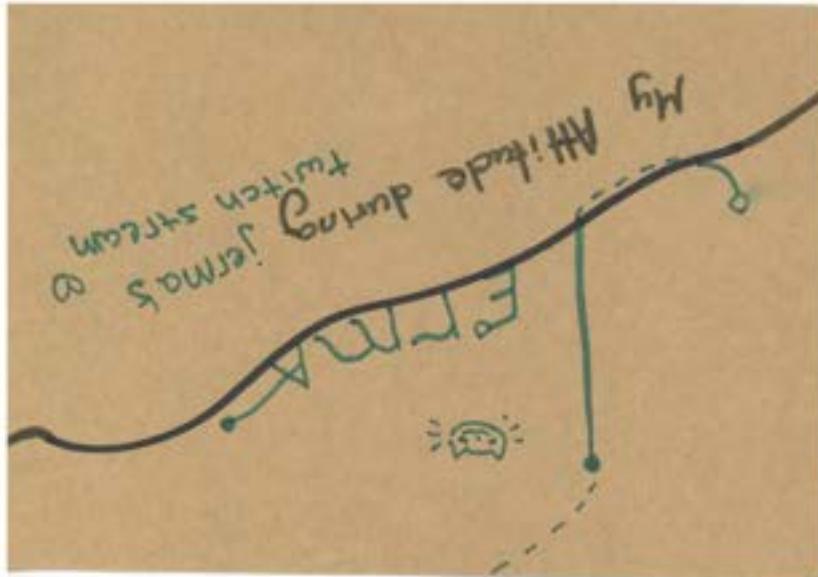
for I

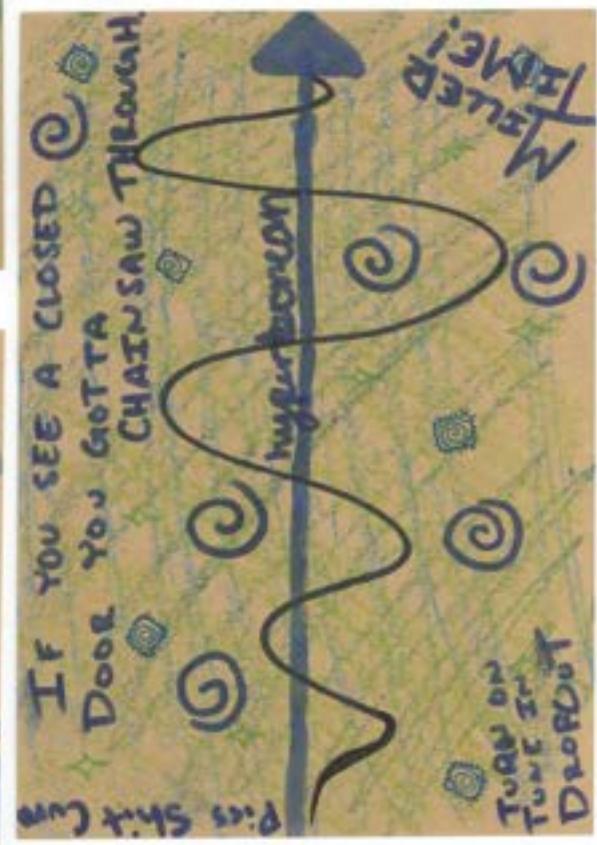
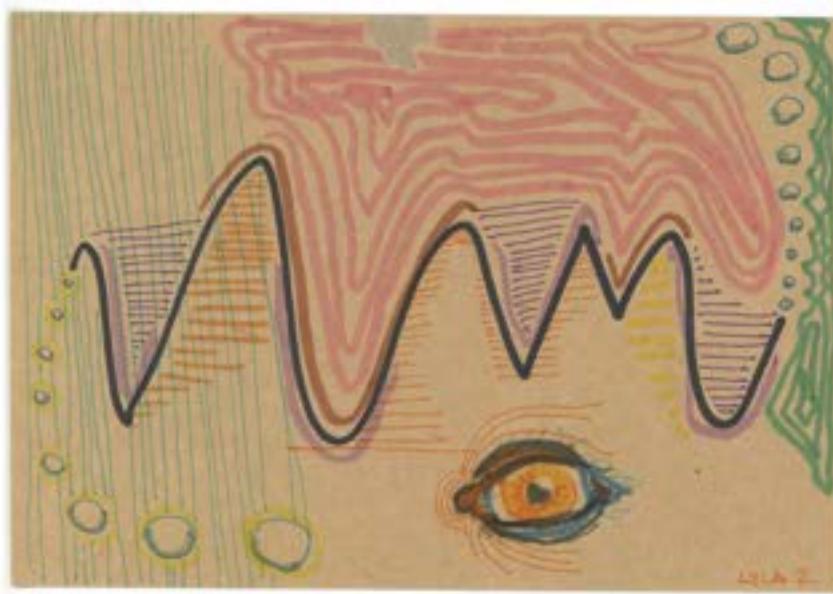
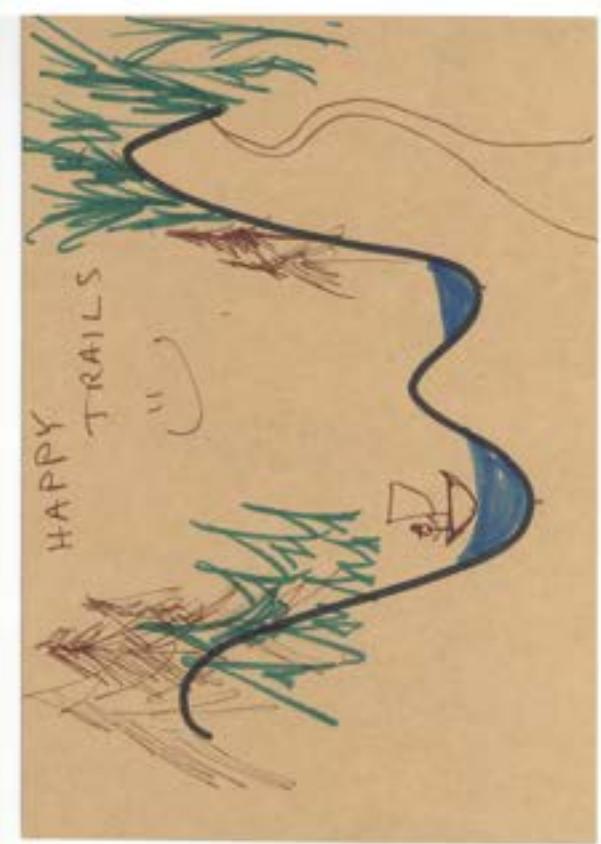
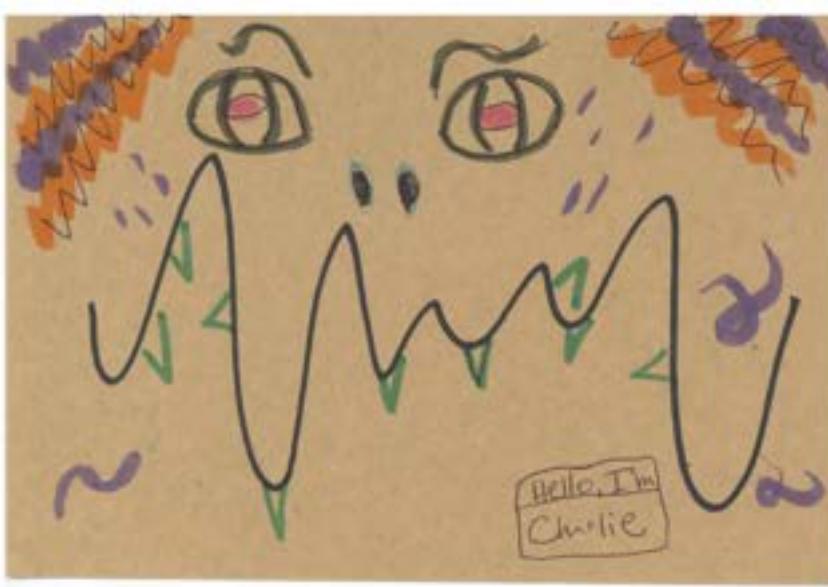
aren't

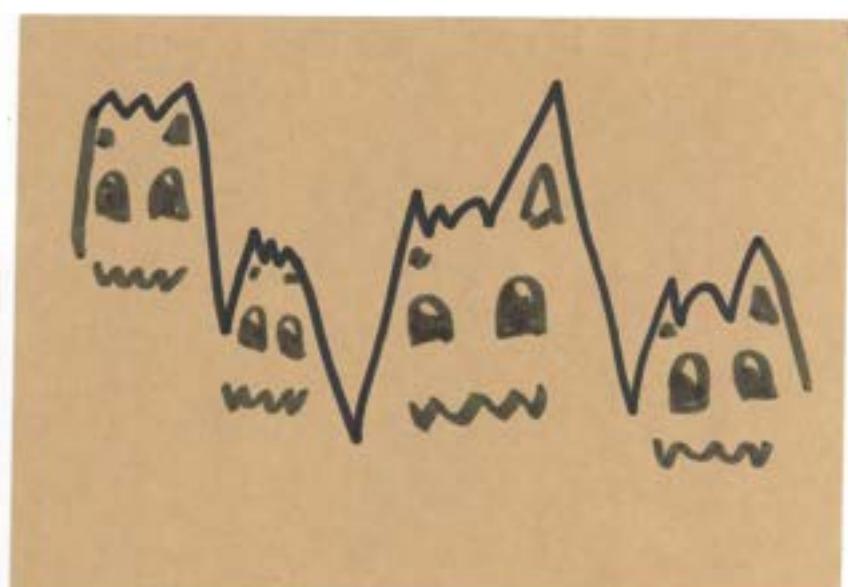
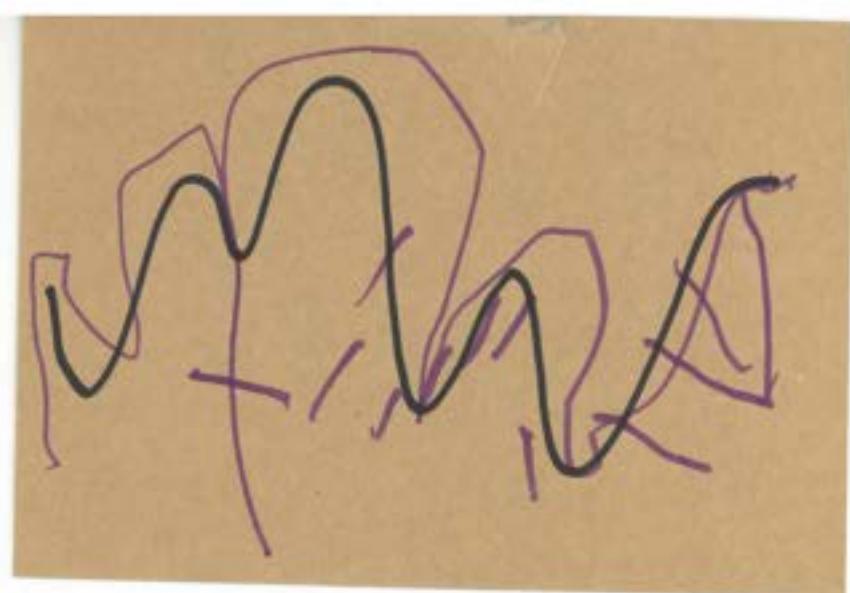
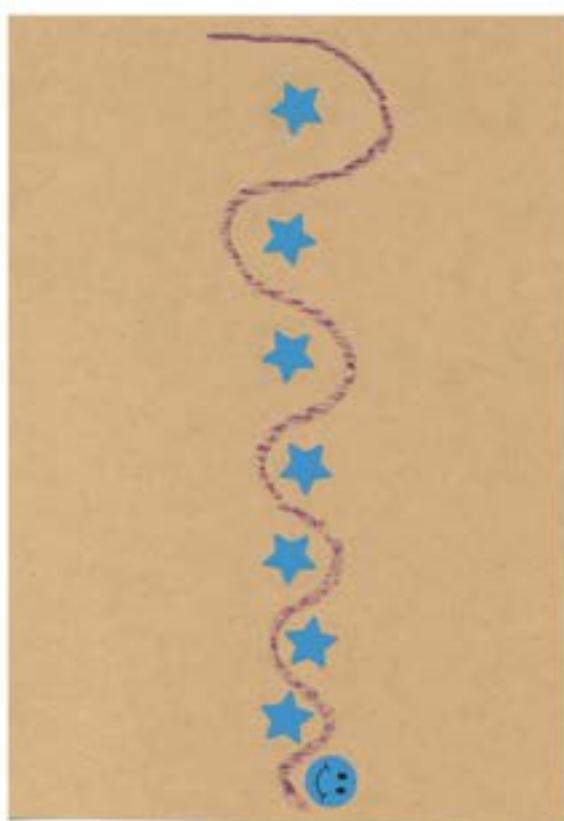
lion!

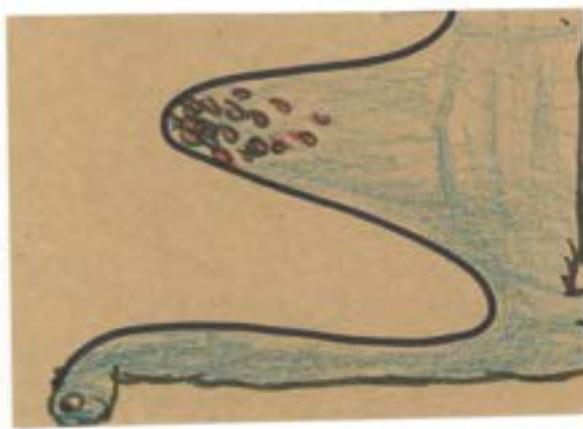
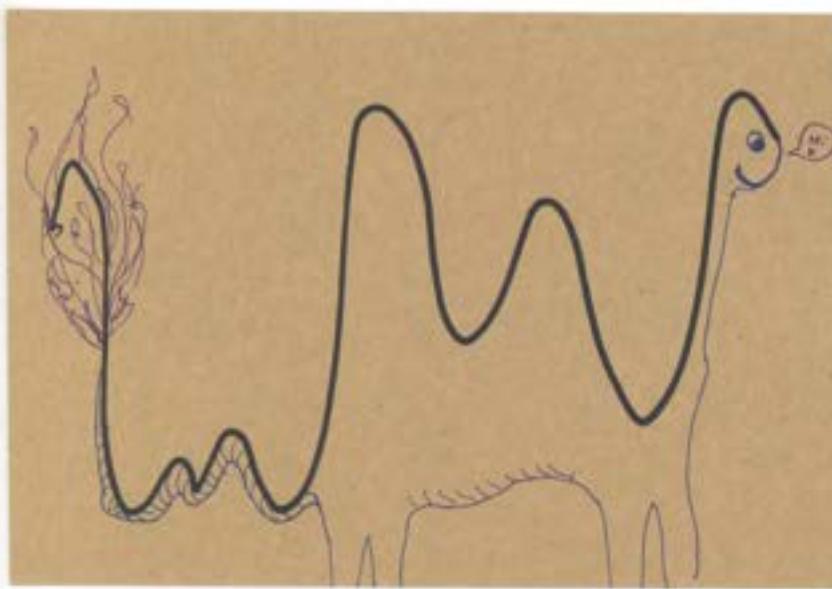
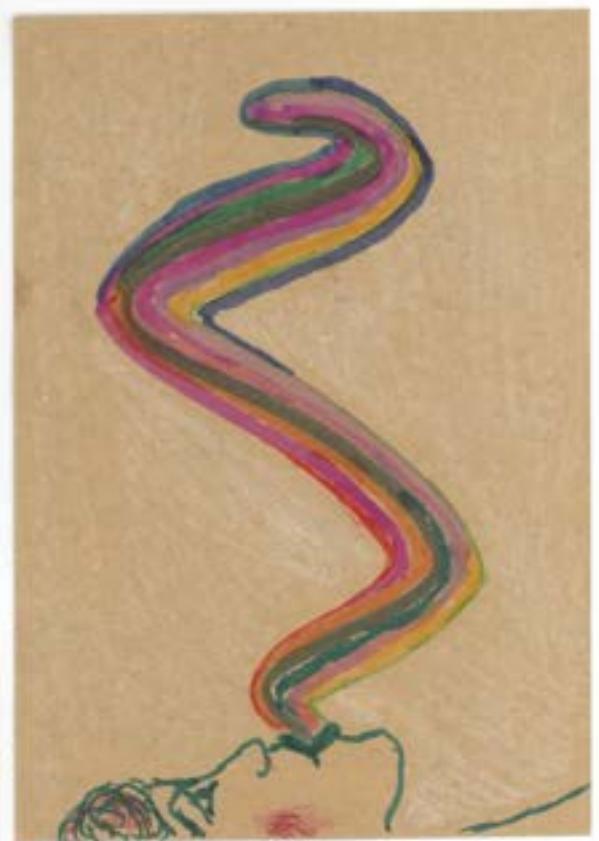
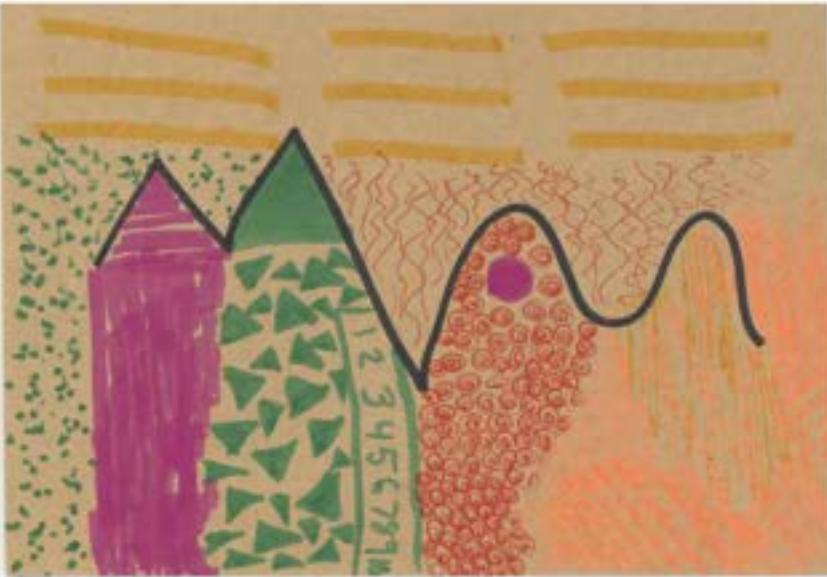


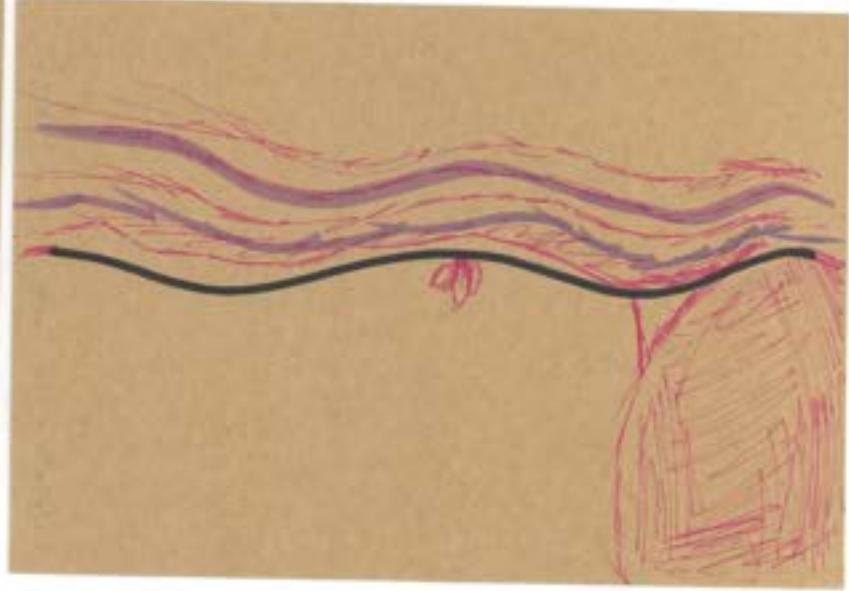
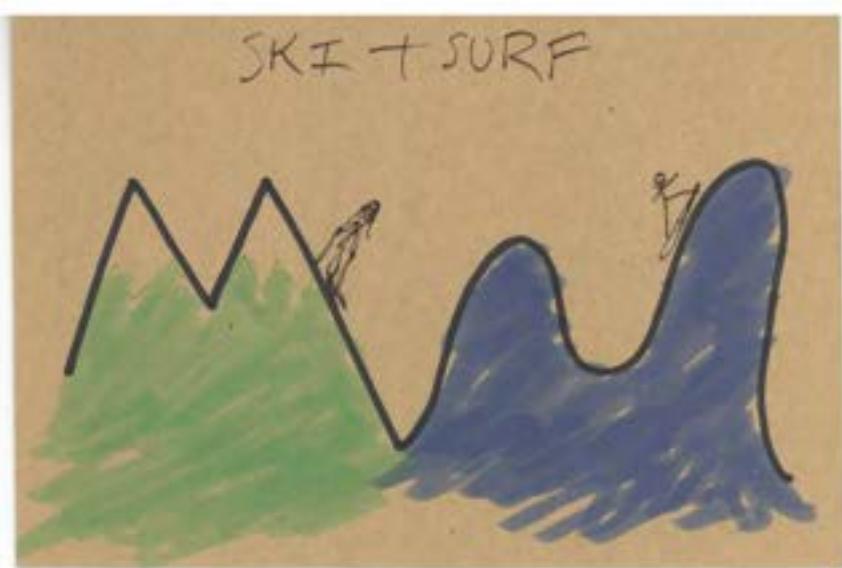
01003202205016

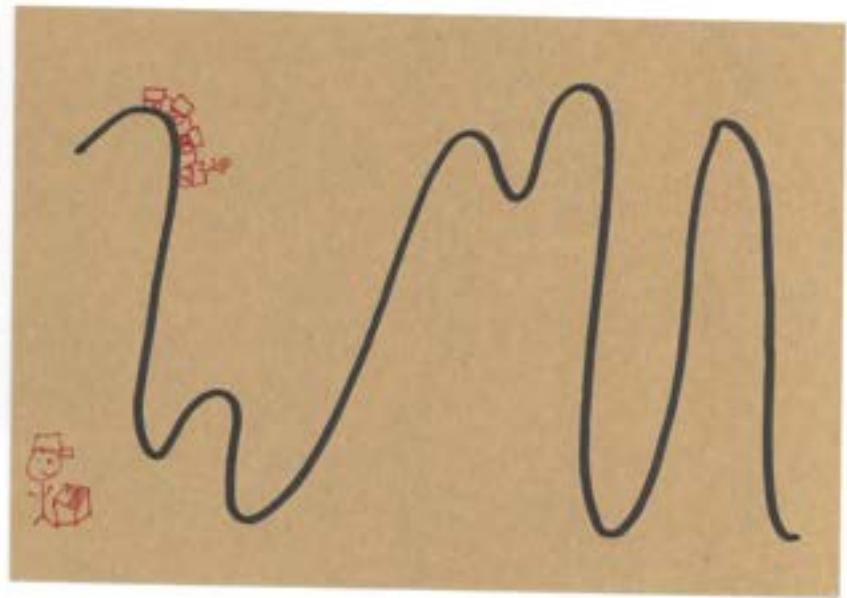
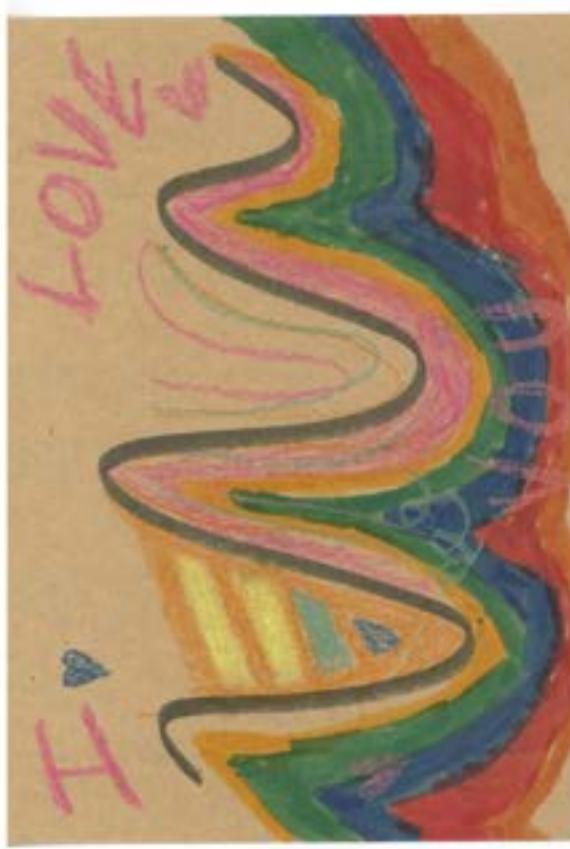
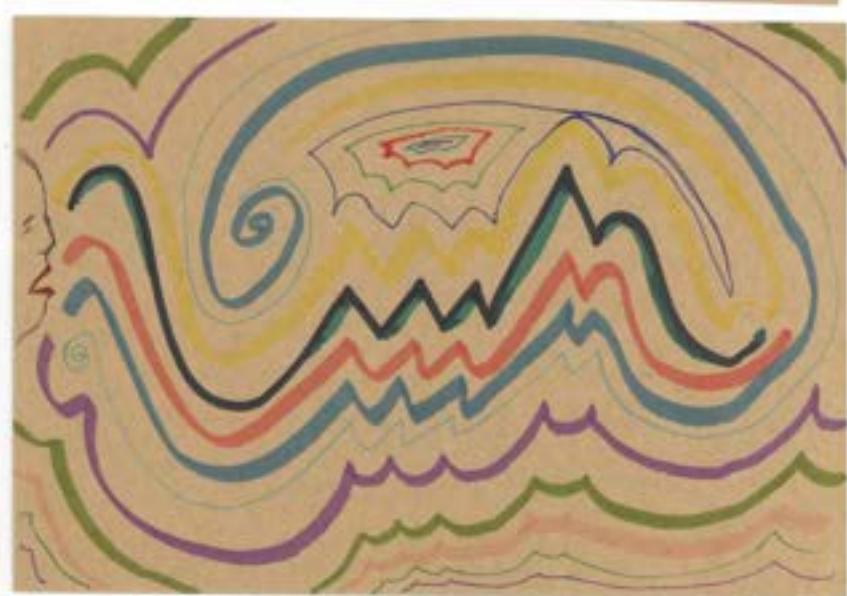
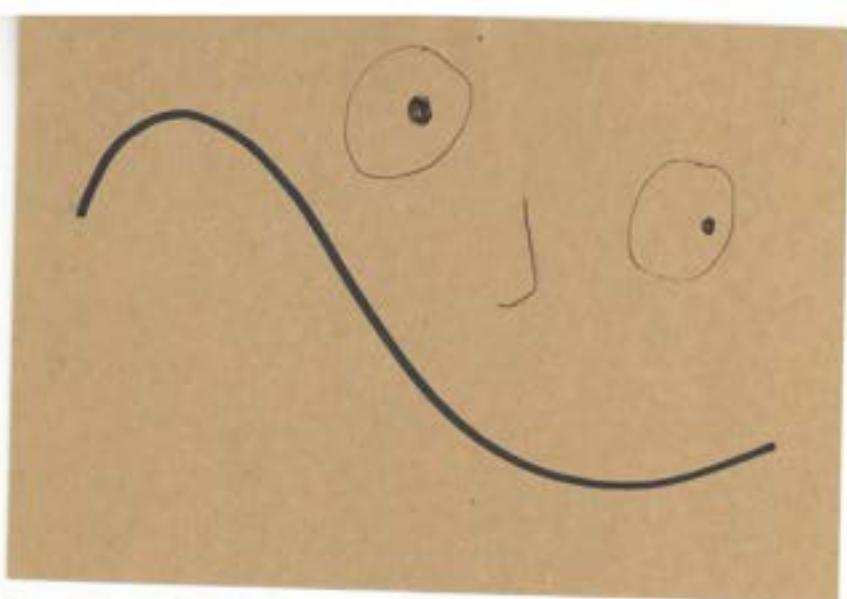
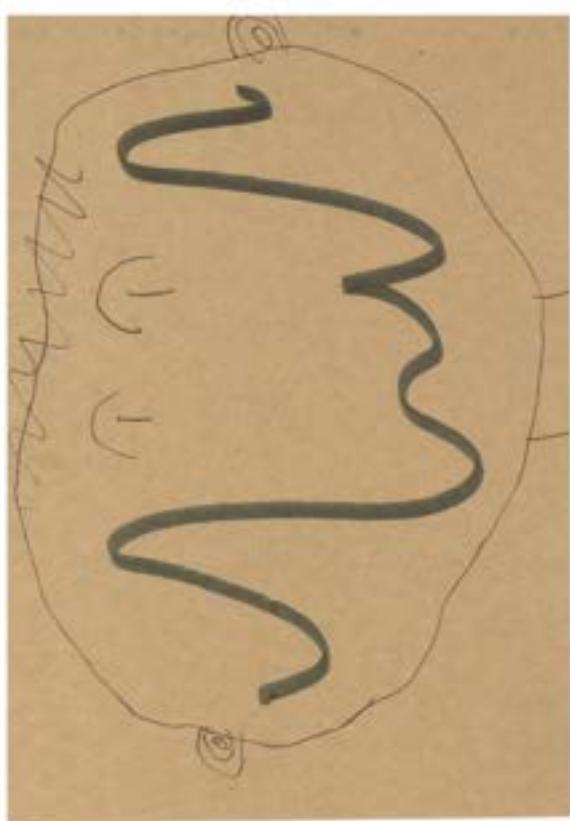


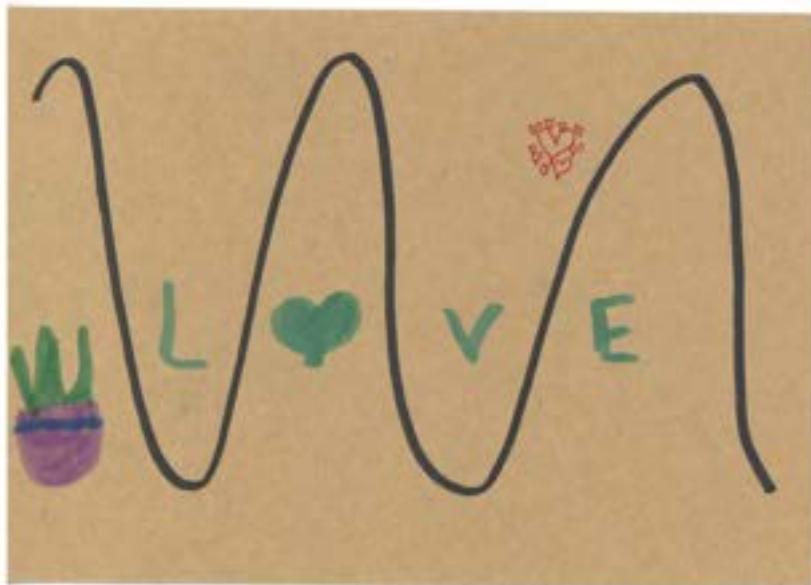
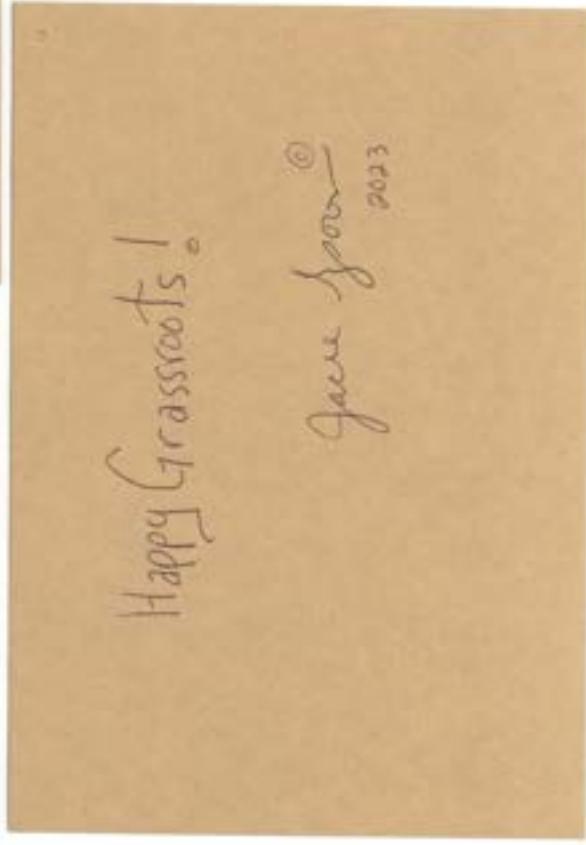
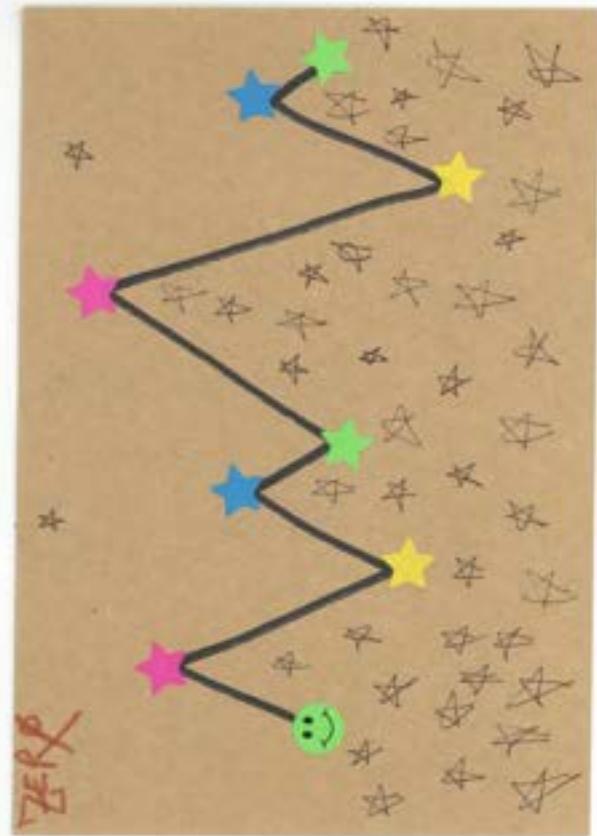


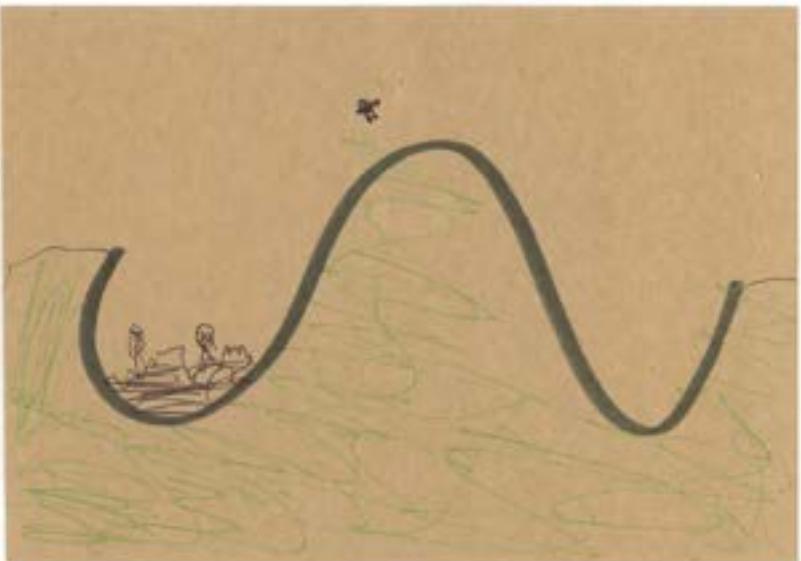
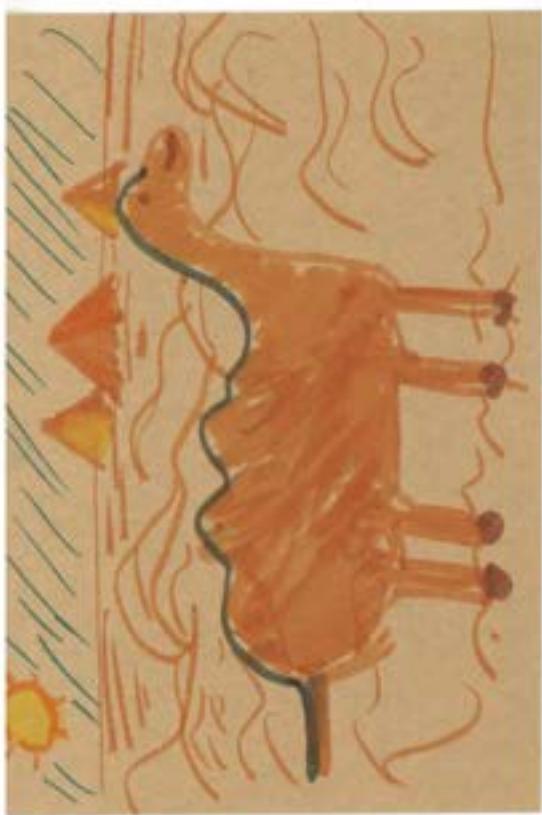
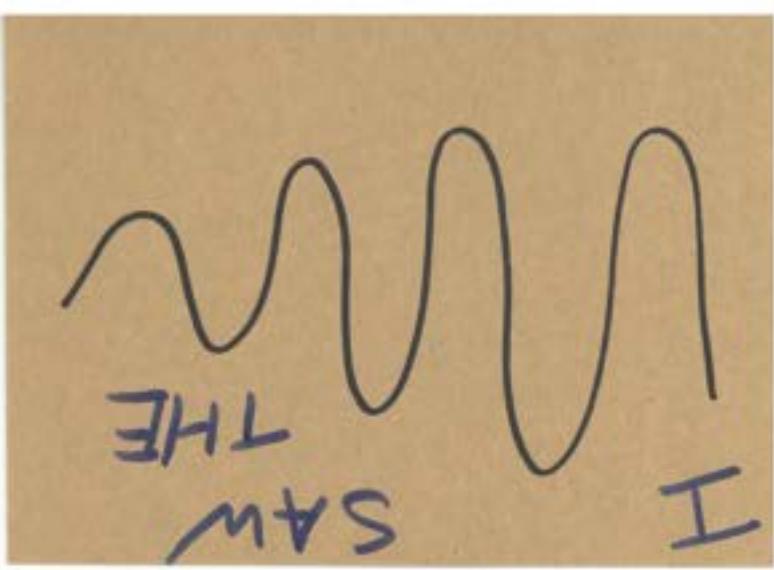


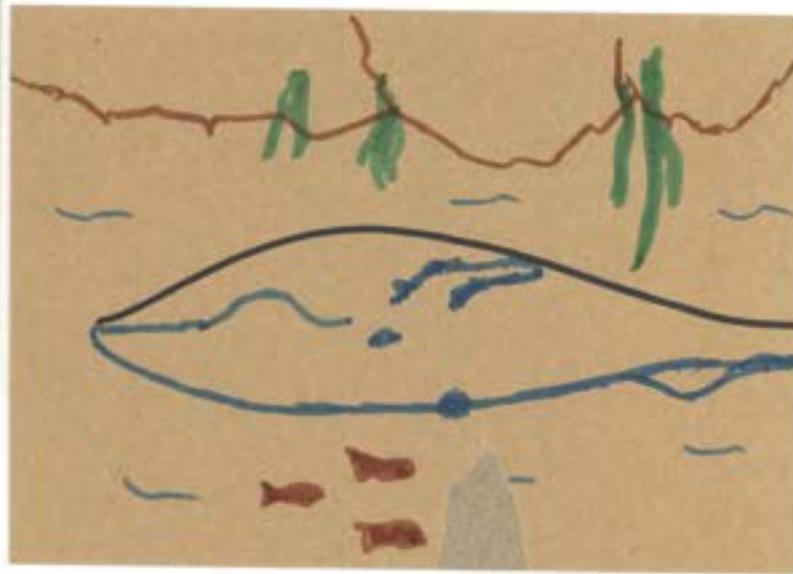
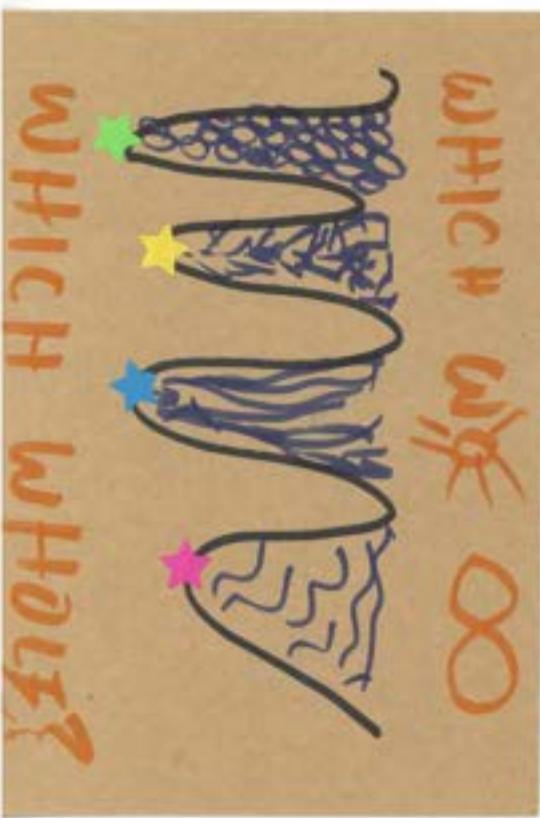
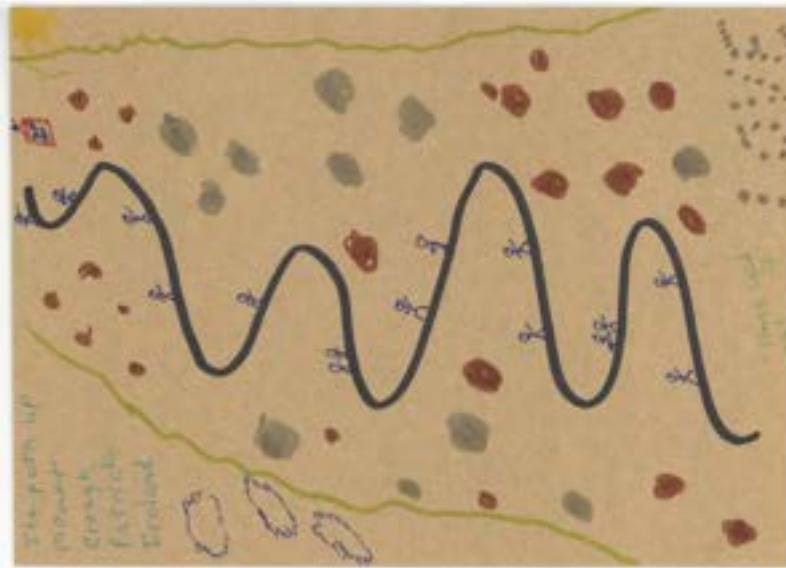
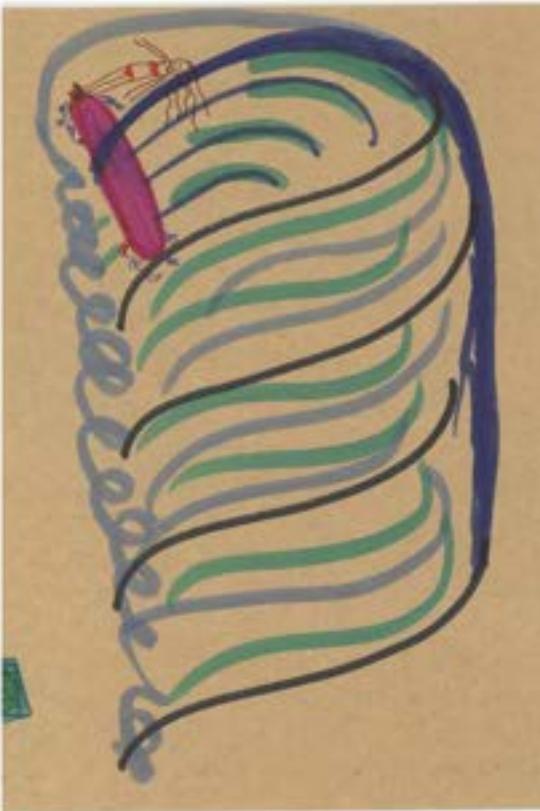


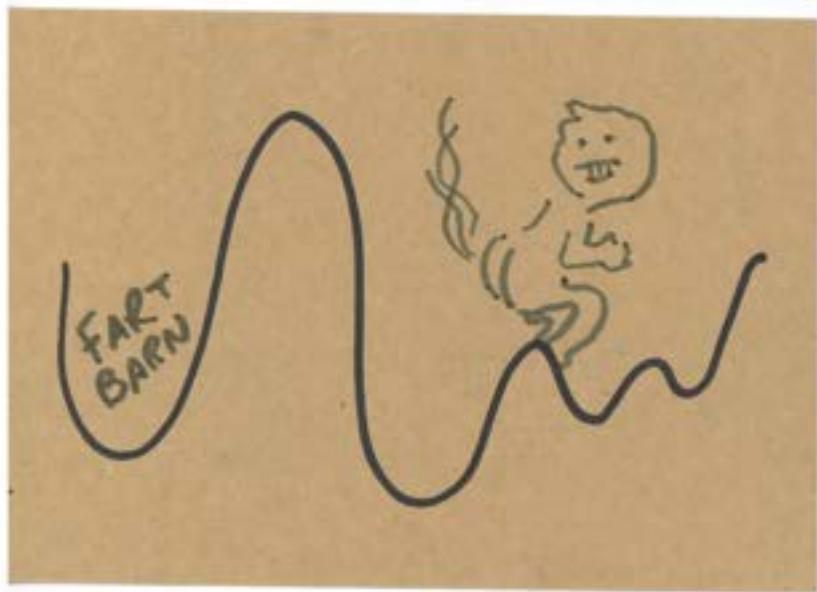
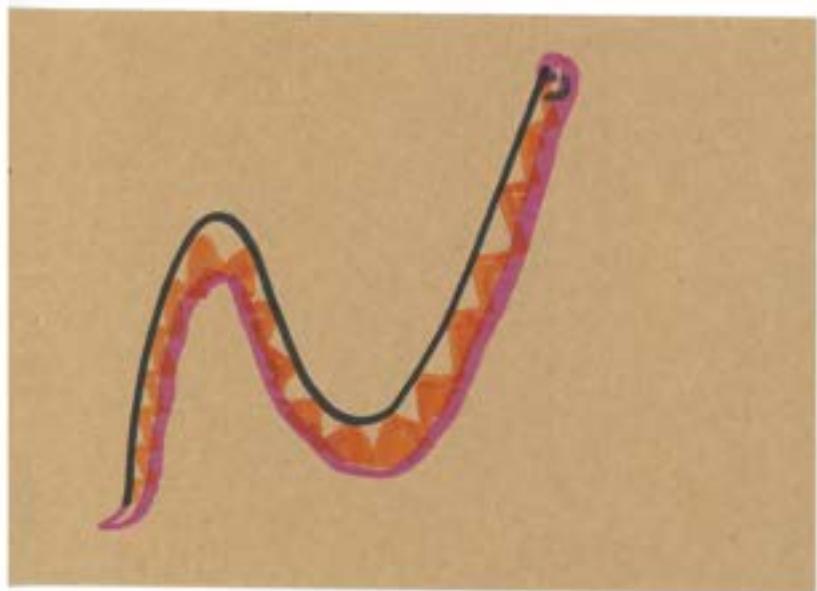
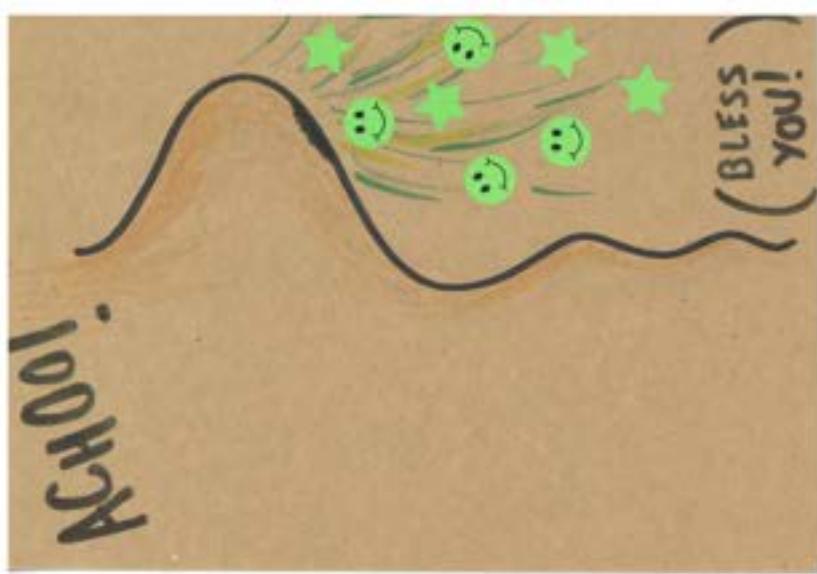


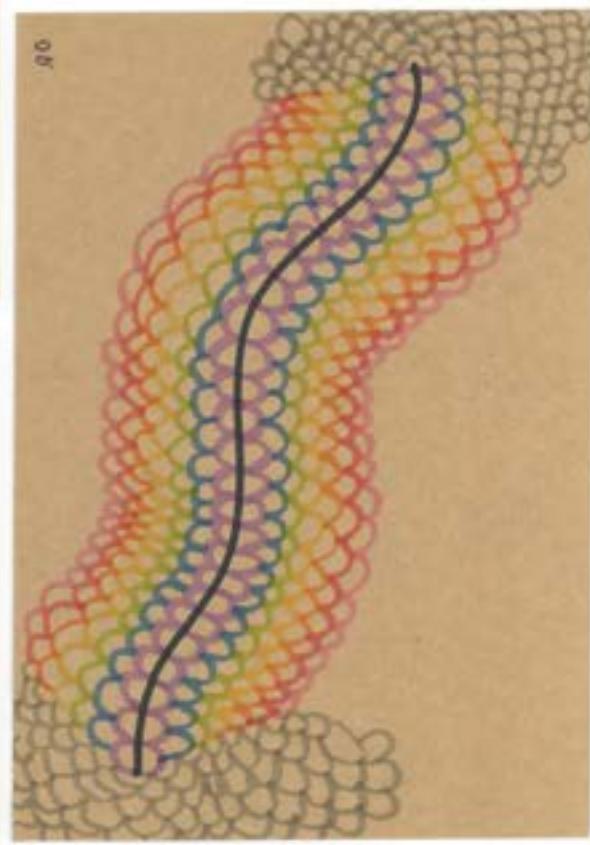
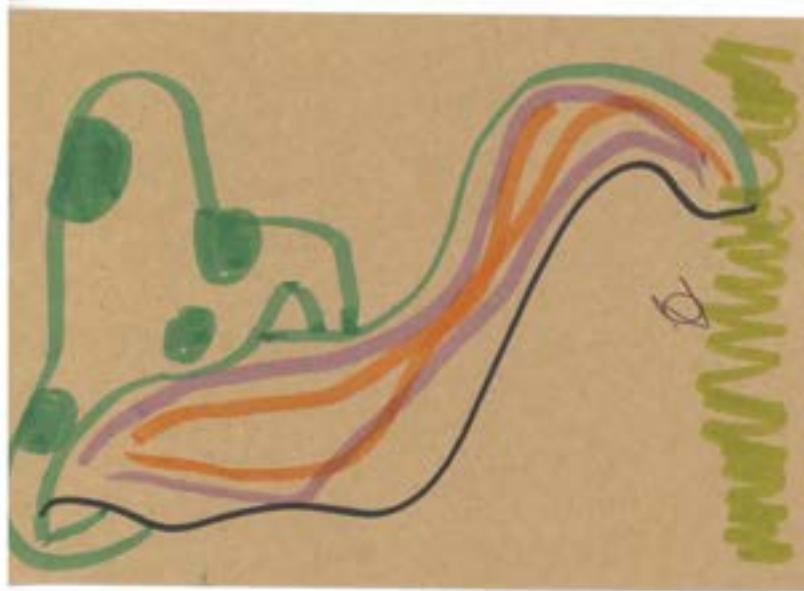
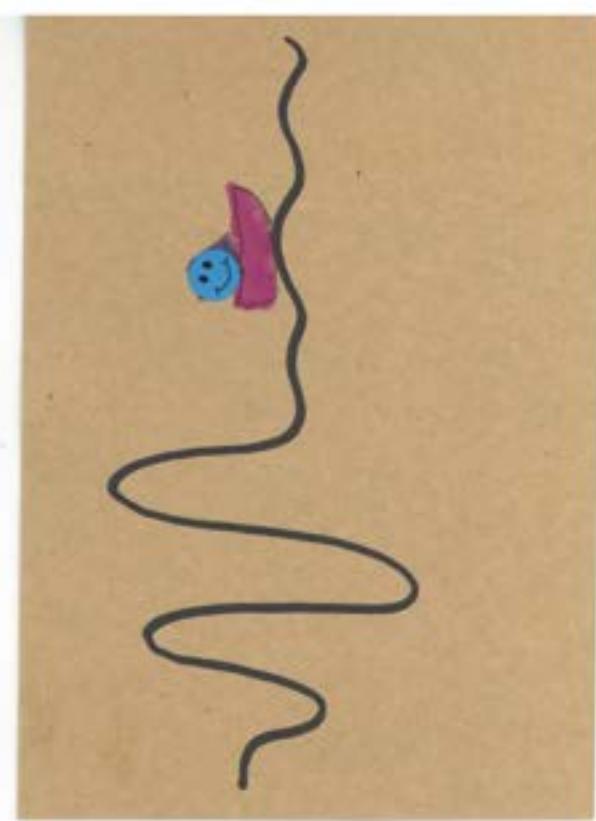
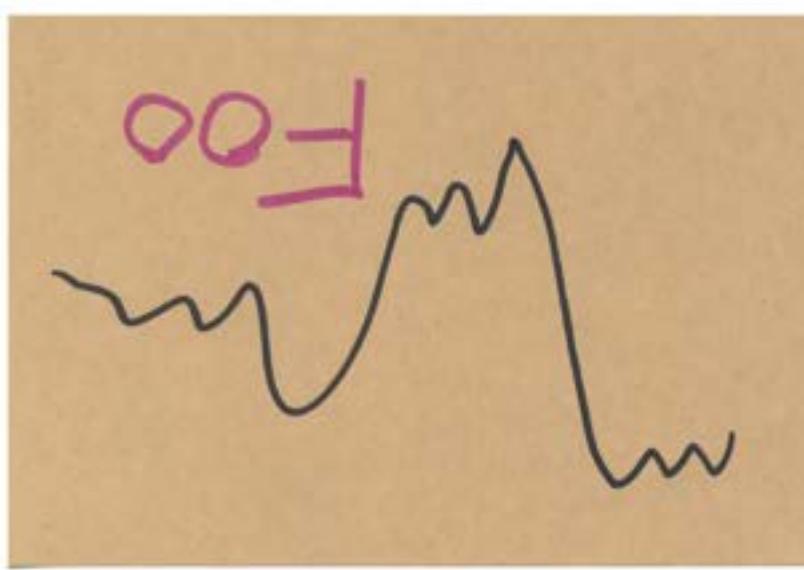


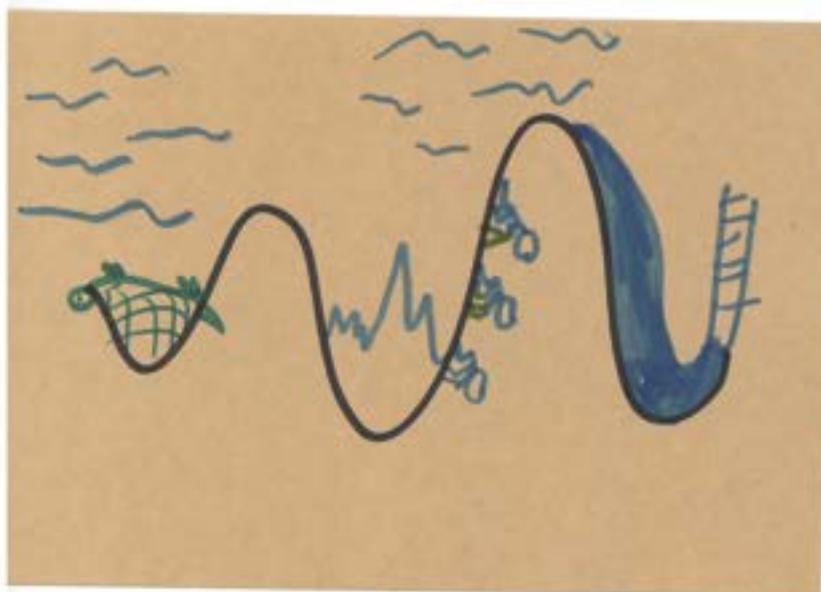
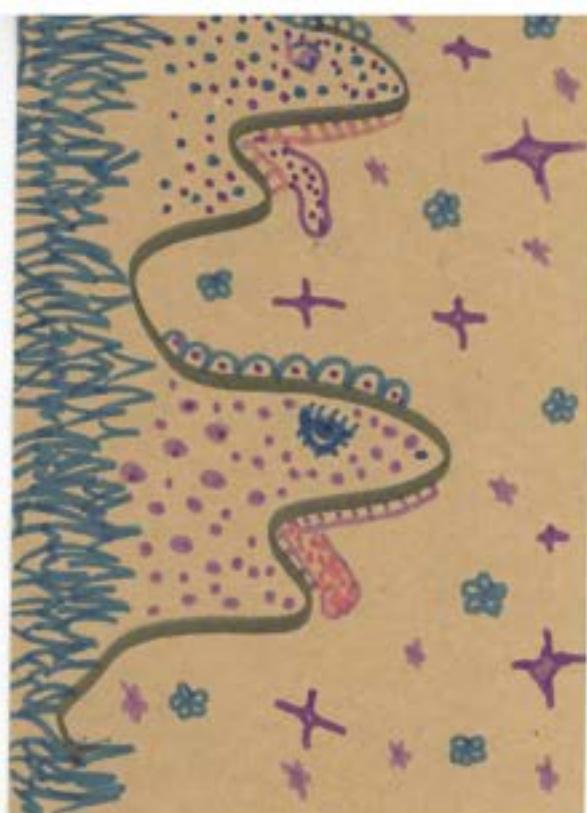
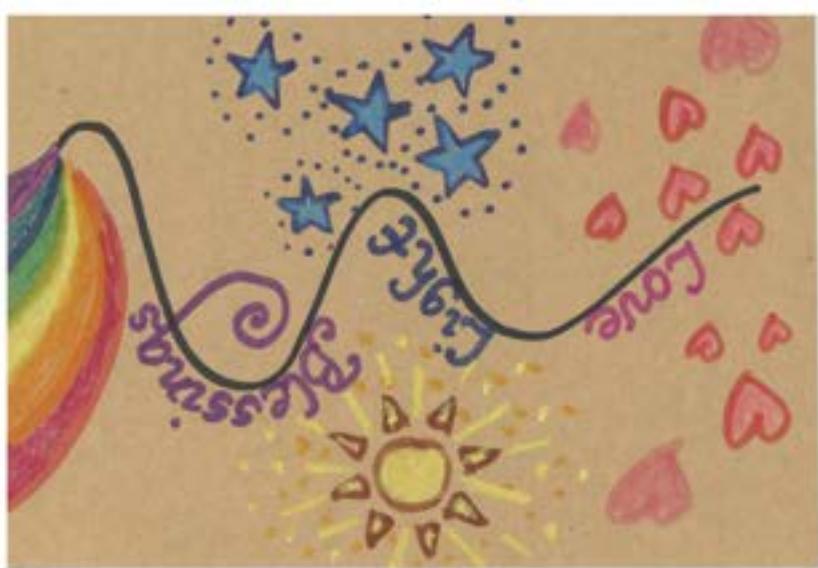


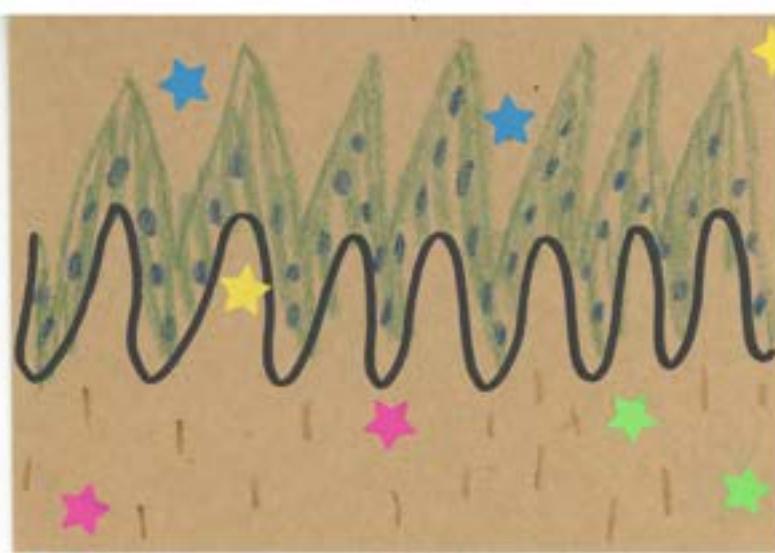
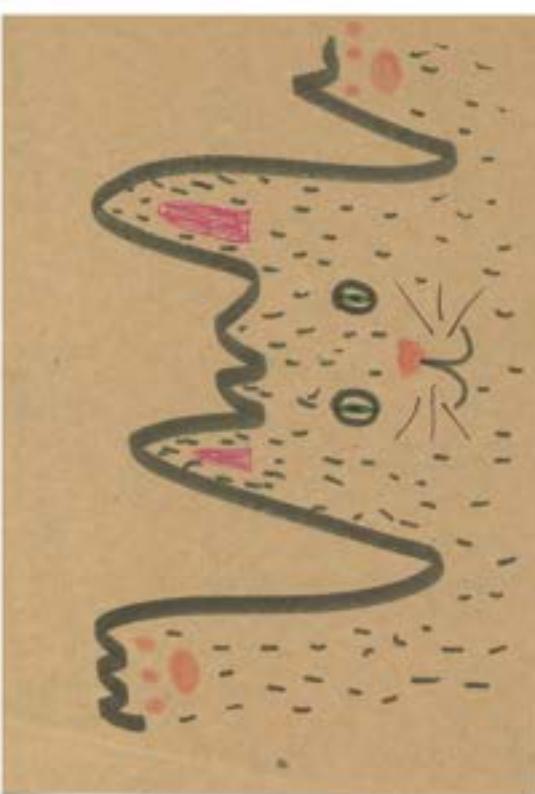


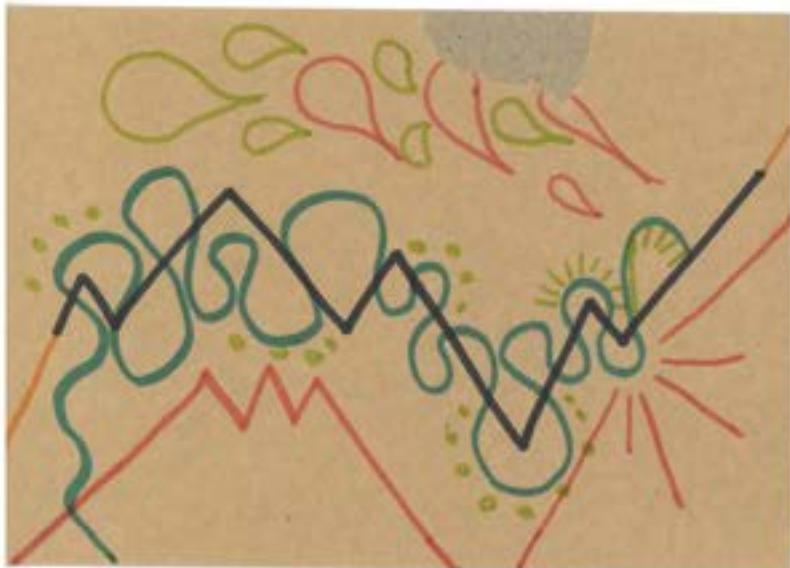
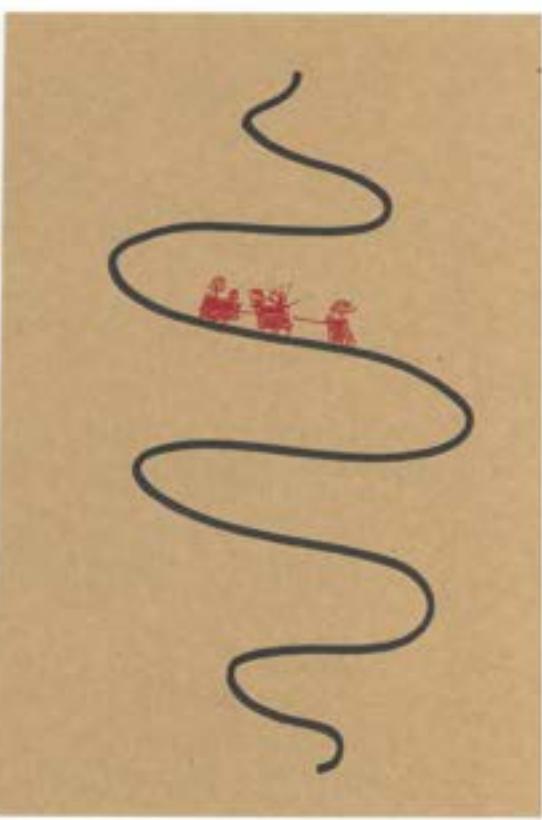
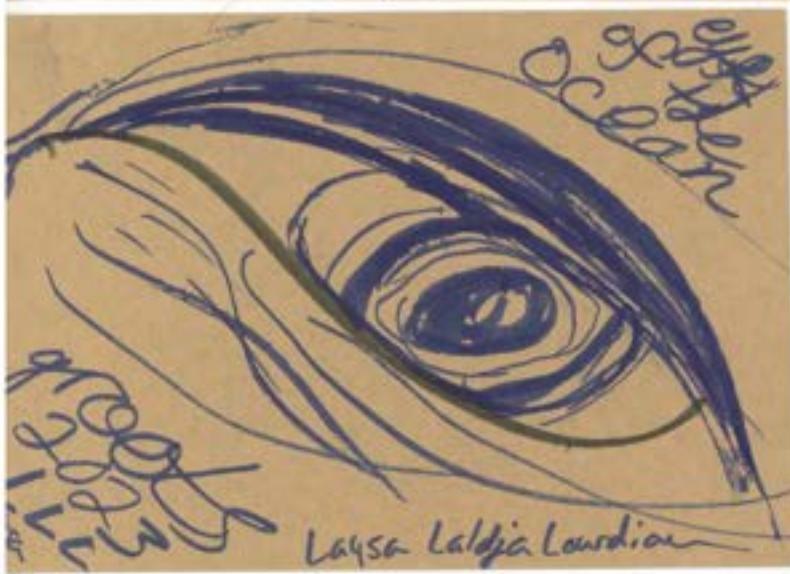


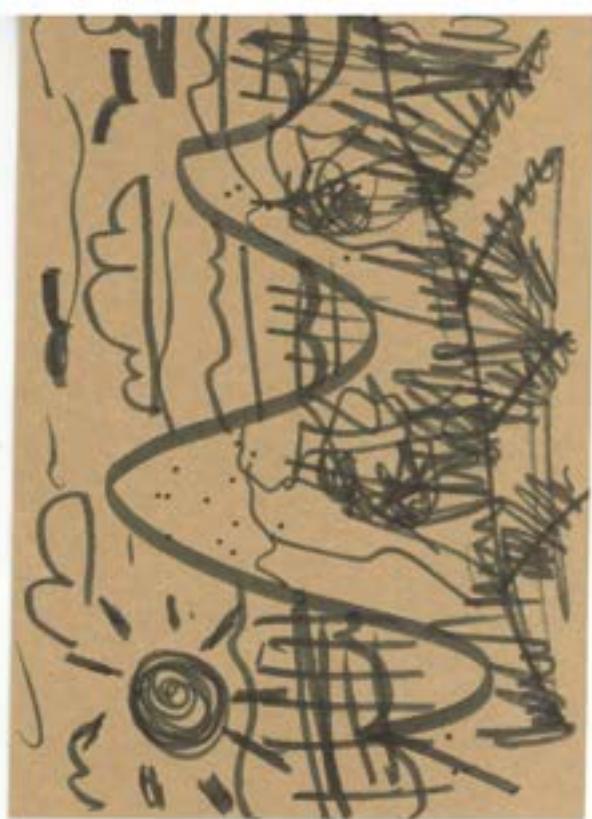
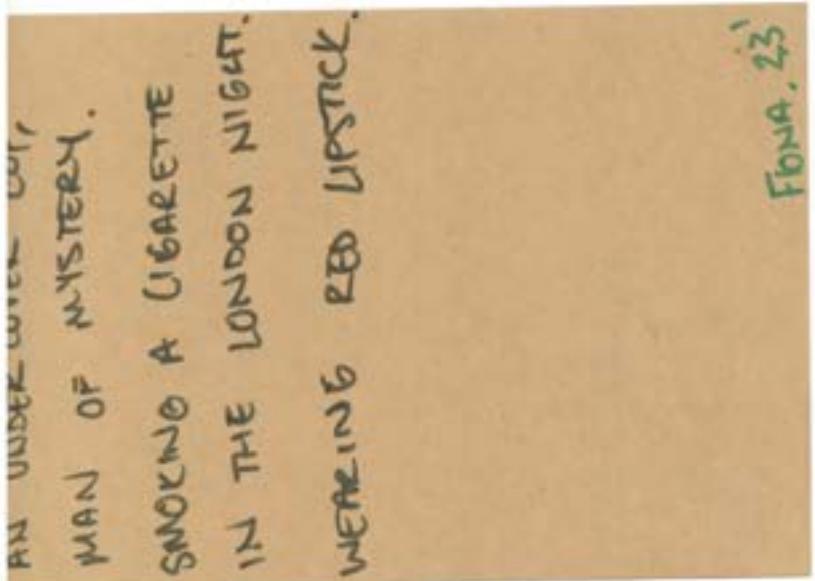
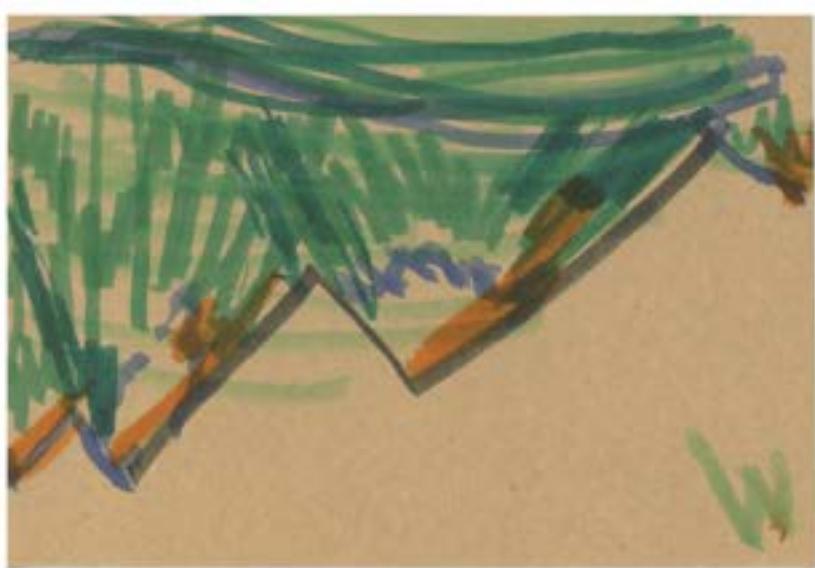














beginning

# CHECK OUT THE beginning BOOKS

for graphs & data about this year's lineup, schedule, music (don't just look, feel free to write & draw, too!)

## MARKERS + PENS

- Use all you need & want
- Don't take any!
- See the pink sign if you need a creativity boost!

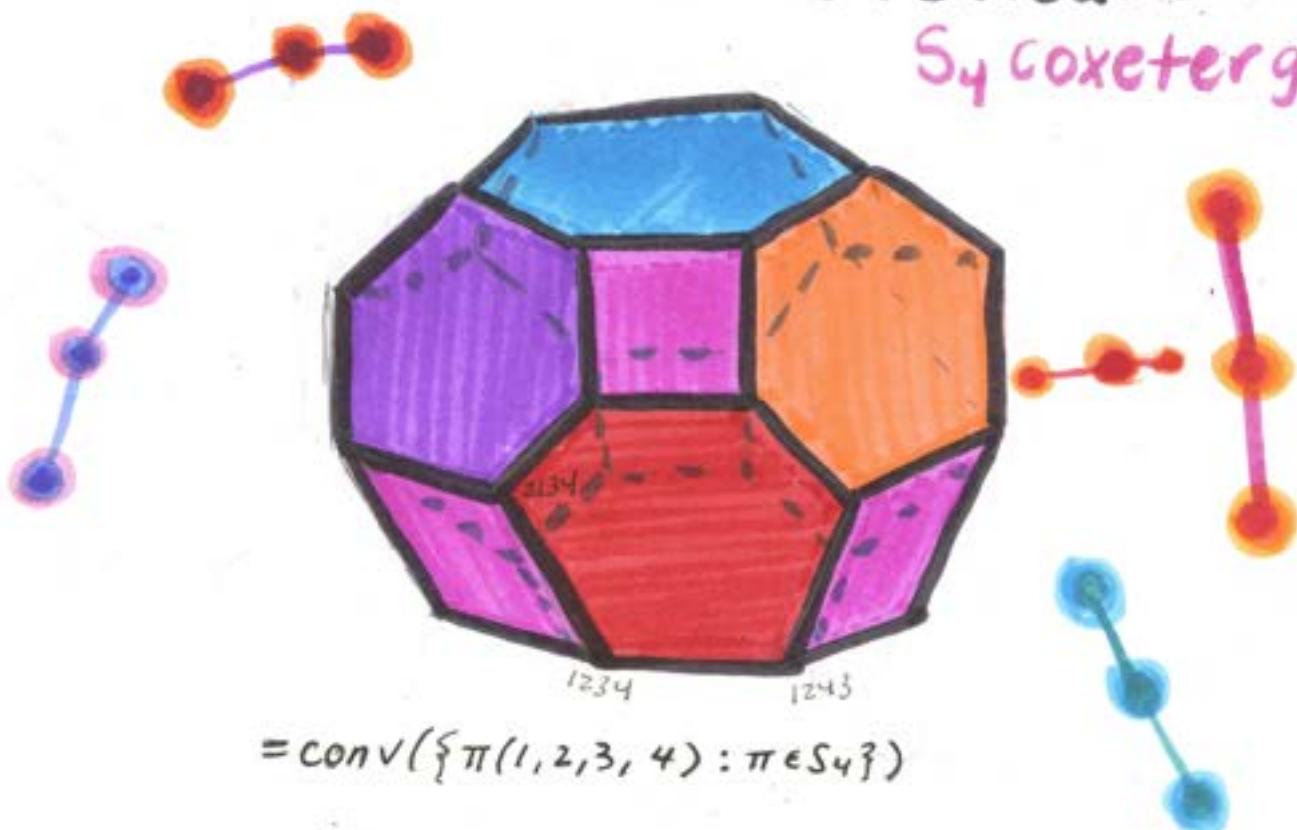
A graph could be...

- a mountain range
- the strings of a guitar
- a snake
- a string of a guitar
- a lock of hair
- a bendy leg or arm
- just a line!
- that can be
- beautiful too!!

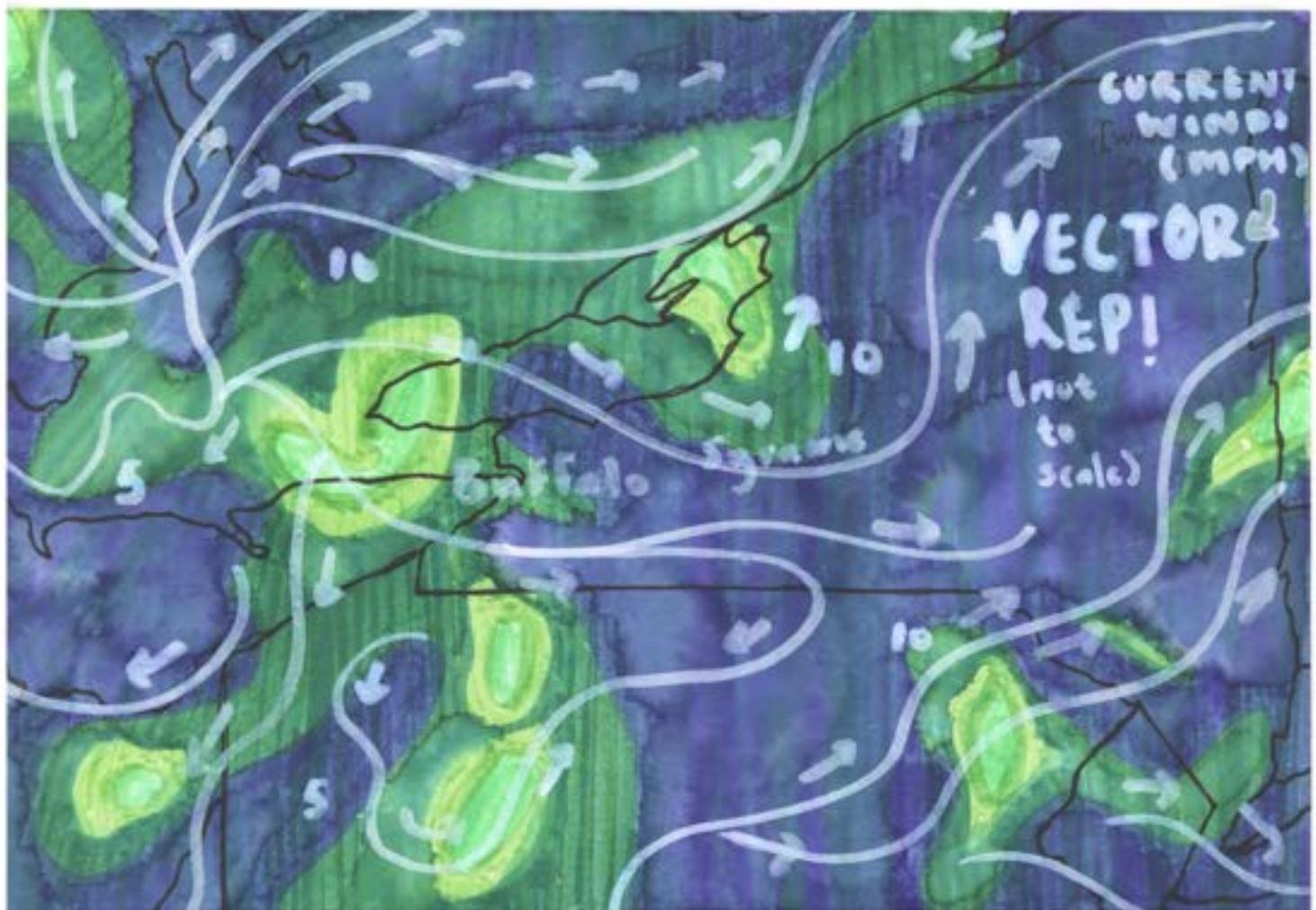
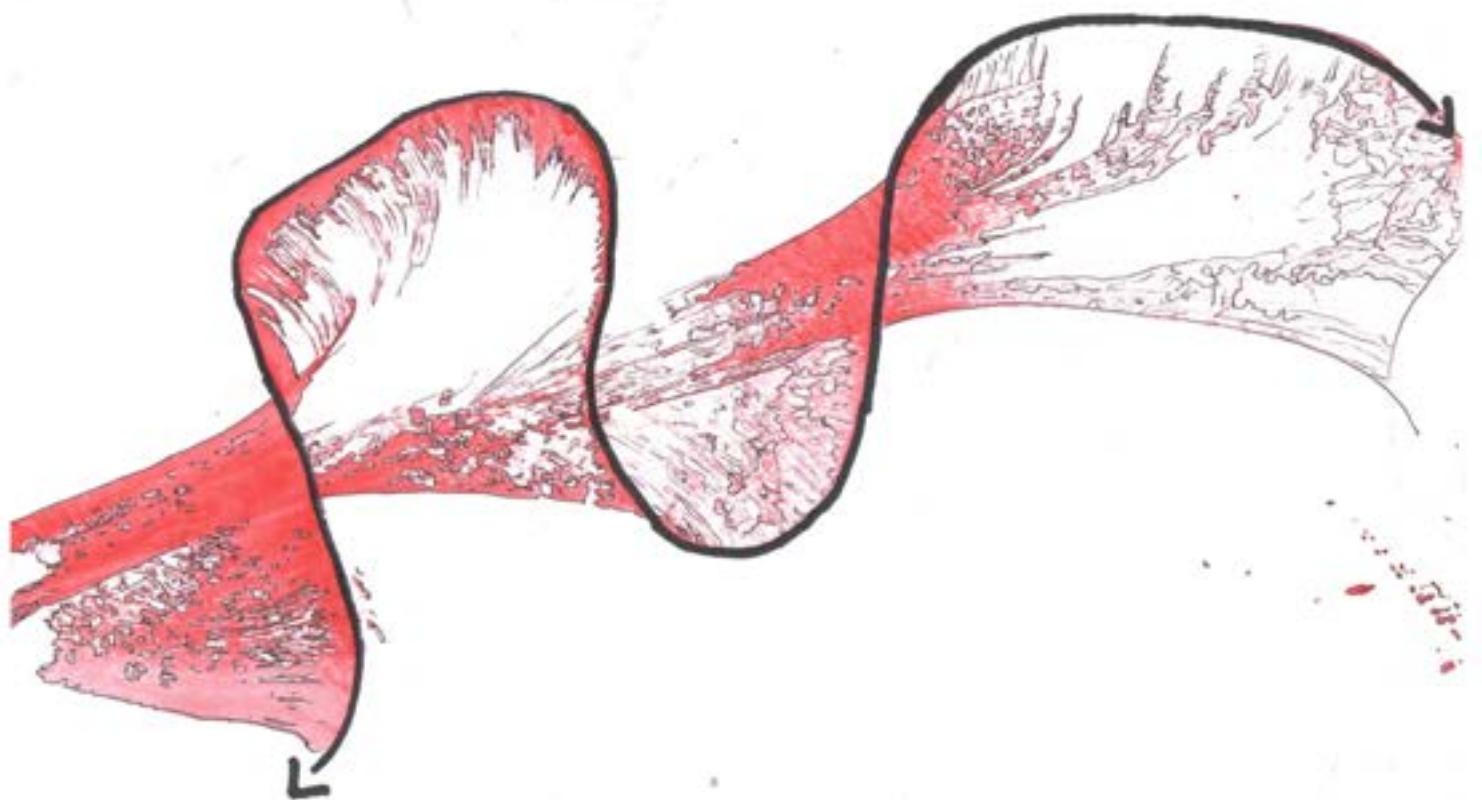
I 3D-printed this!  
It's a sine curve  
 $[y = \sin(x)]$  made  
into a planter →

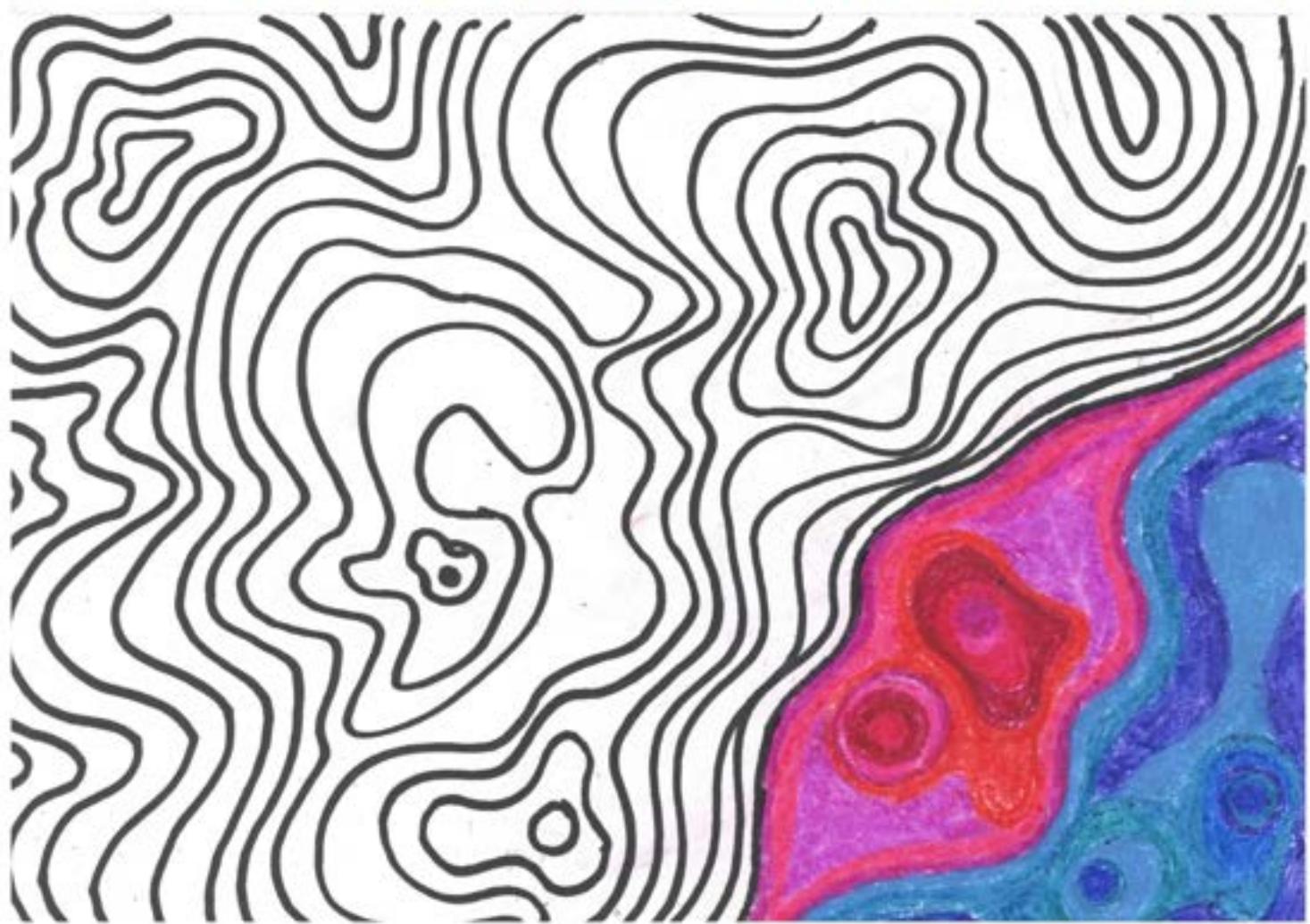
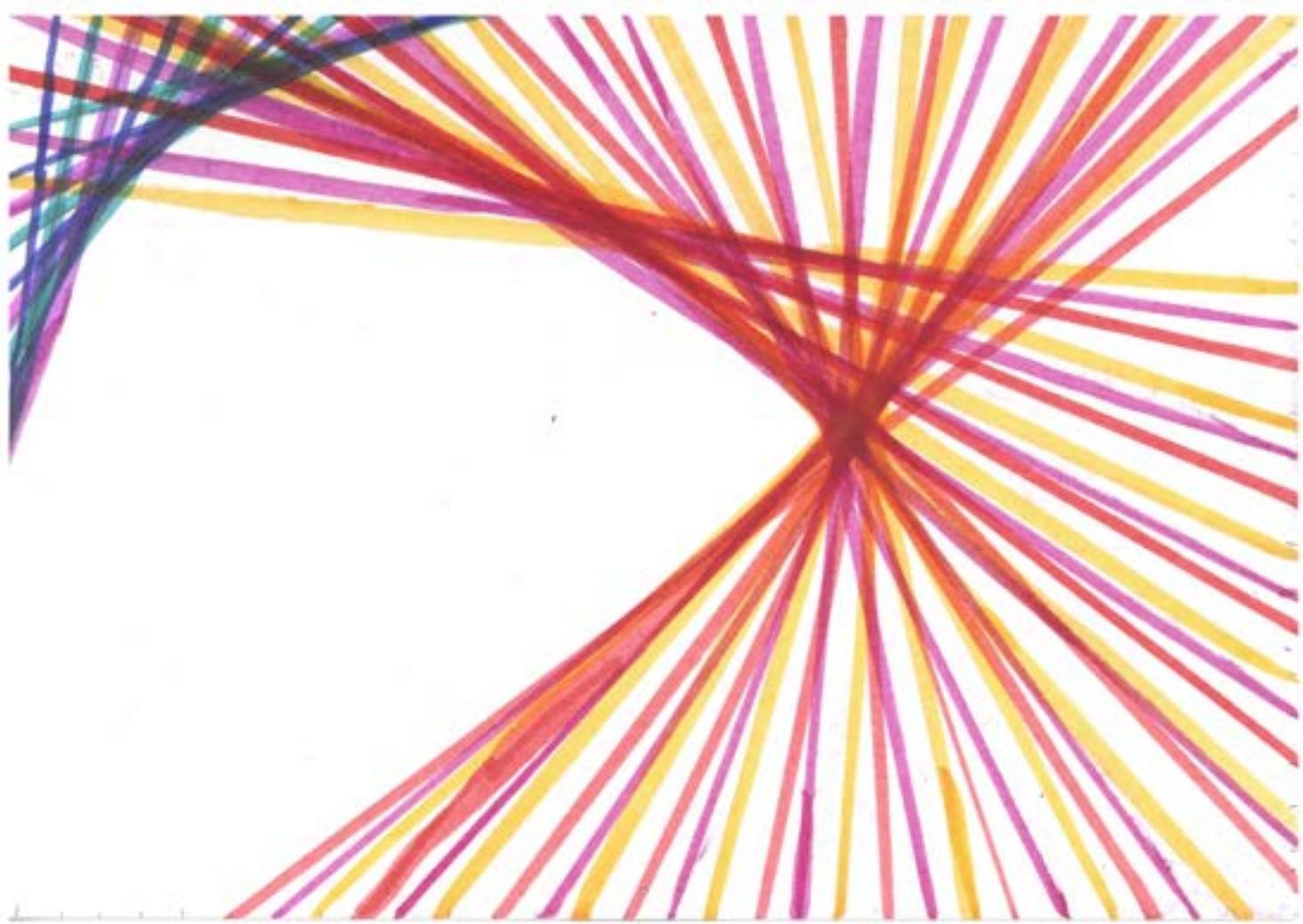


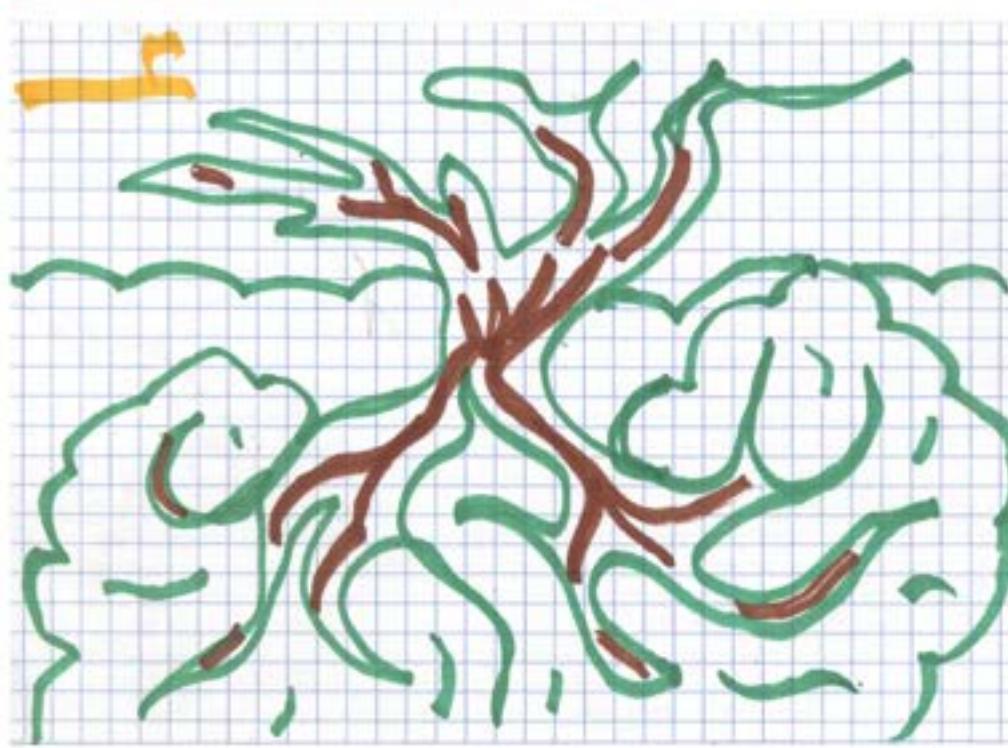
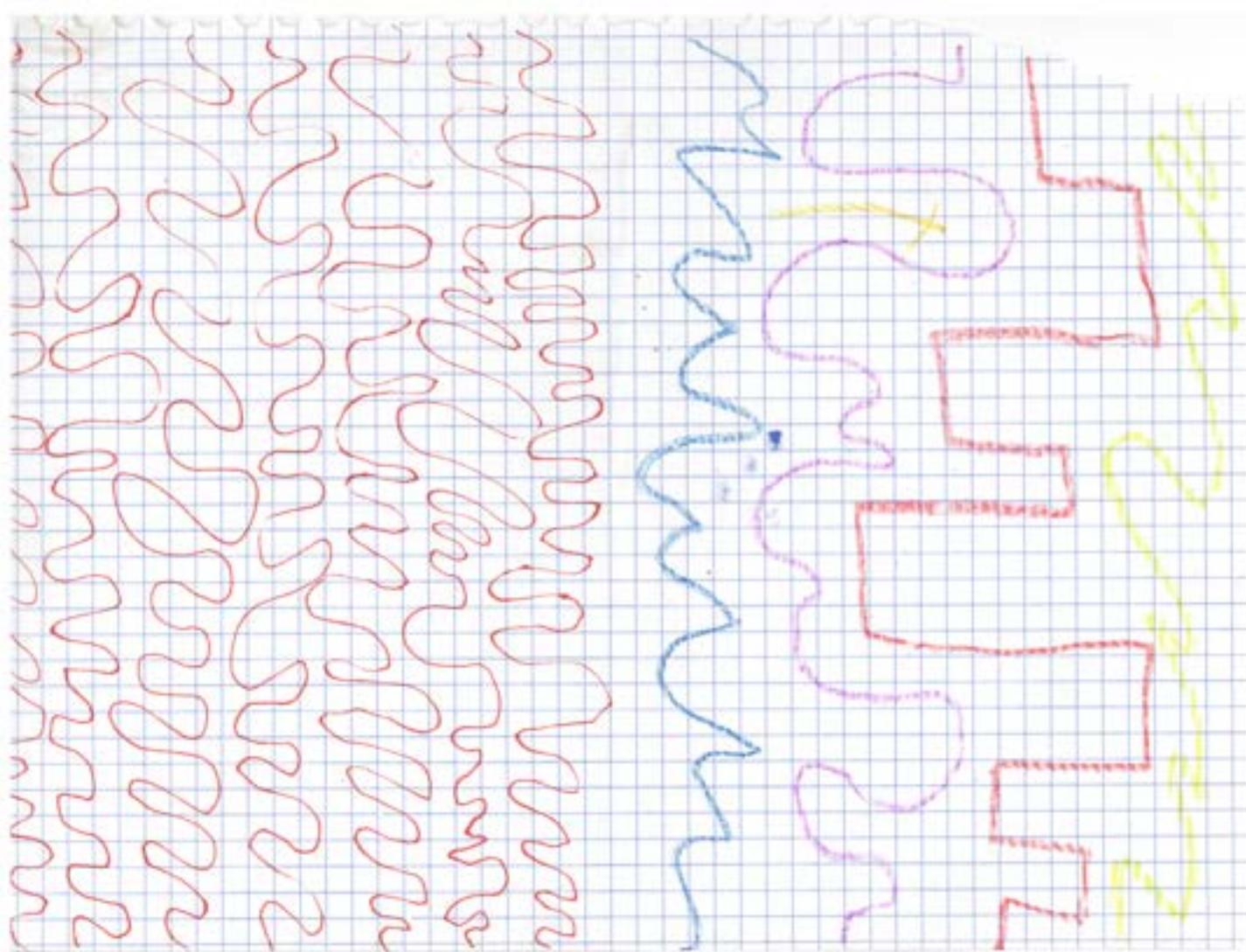
## Permutohedron $\circlearrowleft$ $S_4$ Coxeter graph



$$= \text{conv}(\{\pi(1, 2, 3, 4) : \pi \in S_4\})$$







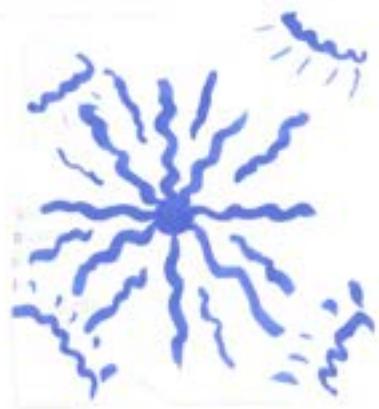


sd \* J2 R+\*



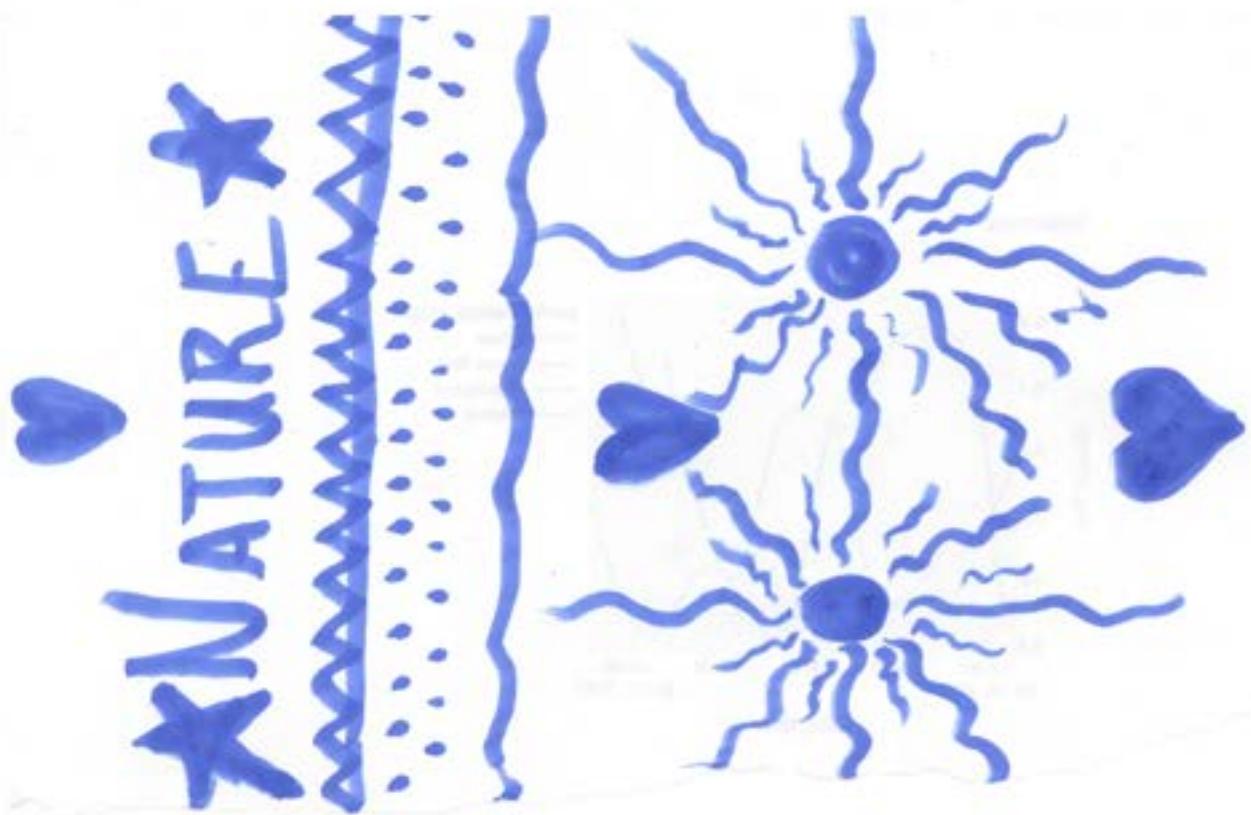
Good morning

lets climb tree trunk









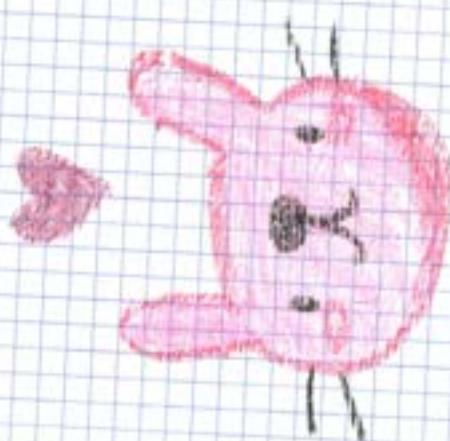


The Lobster  
sh

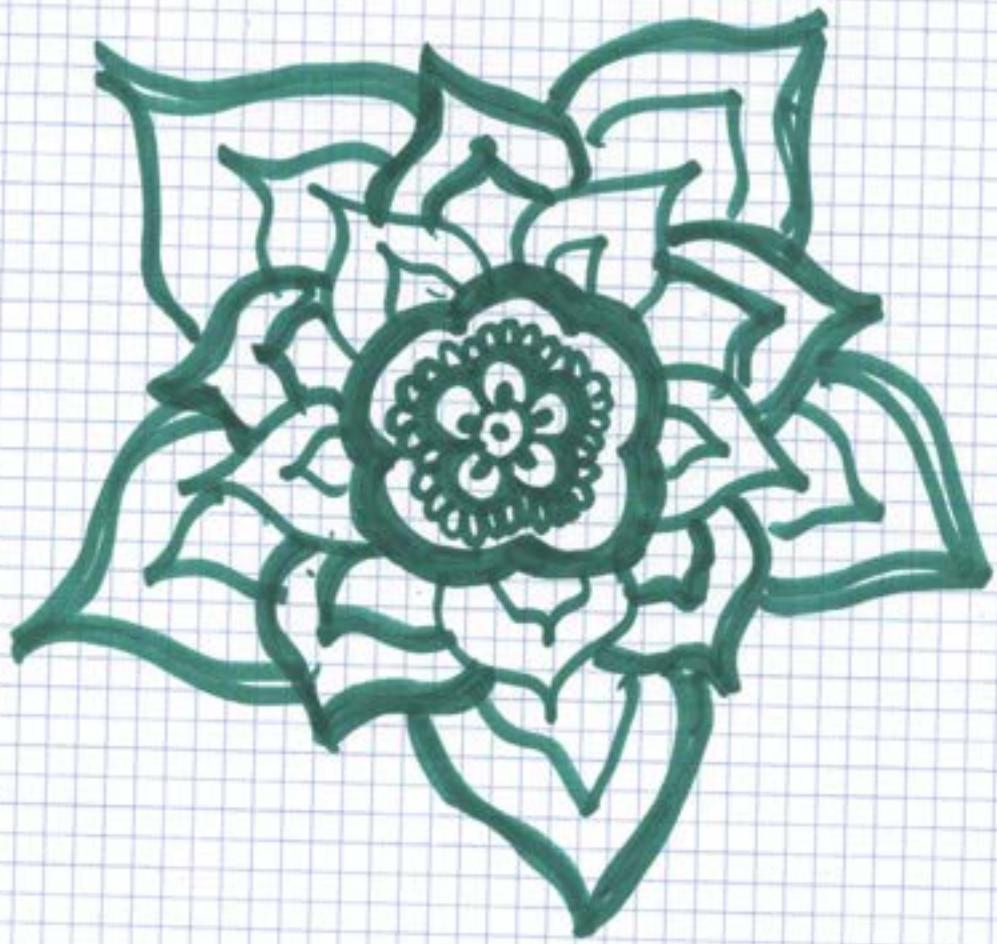




The Lobster  
set







HABE AN

O D E C

M A N D

