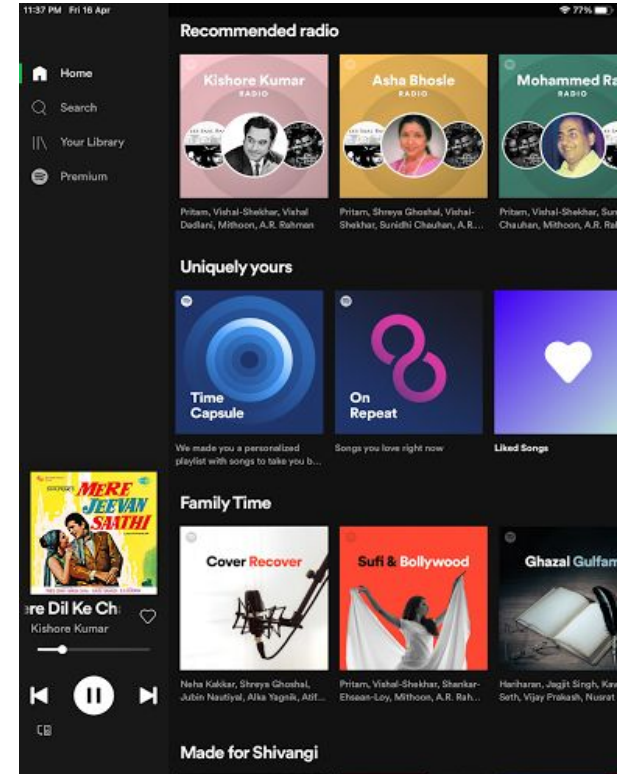
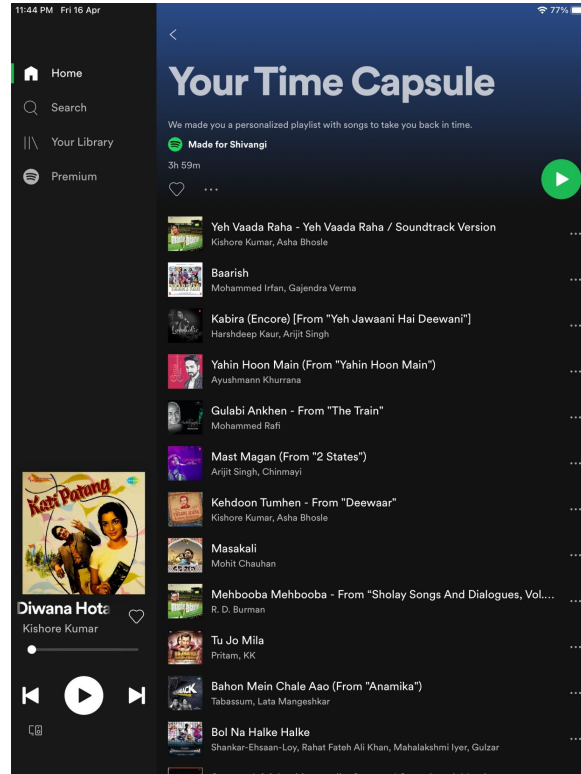
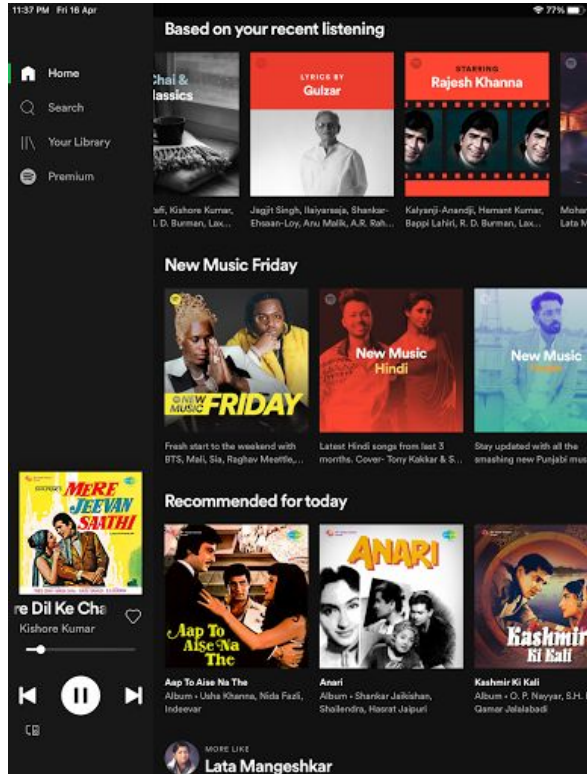

Algorithmic Effects on the Diversity of Consumption on Spotify

Ashton A., Lucas M., Rishabh M., Ian A., Mounia L.
University of Toronto & Spotify

Spotify Recommendations



Research Focus & Contribution

1. Analysis of diversity in user behaviour in recommender systems and online platforms
2. Study of music listening and streaming services
3. Study of trade off between short-term and long-term engagement in online platforms

Some Related Knowledge

1. **Filter Bubble:** A **filter bubble** is a state of intellectual isolation that can result from personalized searches when a website algorithm selectively guesses what information a user would like to see based on information about the user, such as location, past click-behavior and search history.
2. **Diversity:** In this paper, Diversity is referred to as how similar a piece of music is to the type of music the user has historically streamed
 - a. It can facilitate exploration by helping users discover new content or inculcate new tastes.
 - b. It can help the platform spread consumption across artists and facilitate consumption of less popular content.

Data

- 100M distinct premium users data
- Time period of data collection: 28 days of July 2018 + 28 days more for temporal analysis
- Data divided into
 - User-driven data collection
 - Algorithm-driven data collection

Music Embeddings

- Embeddings used to encode latent representations between users and content.
- Bag-of-words Word2vec model
- User generated playlist - documents
- Songs in the playlist-terms
- 850M playlists used with some filtration
- User: average of the song embeddings that they listen
- Vectors - 40 dimensional vectors
- Cosine similarity

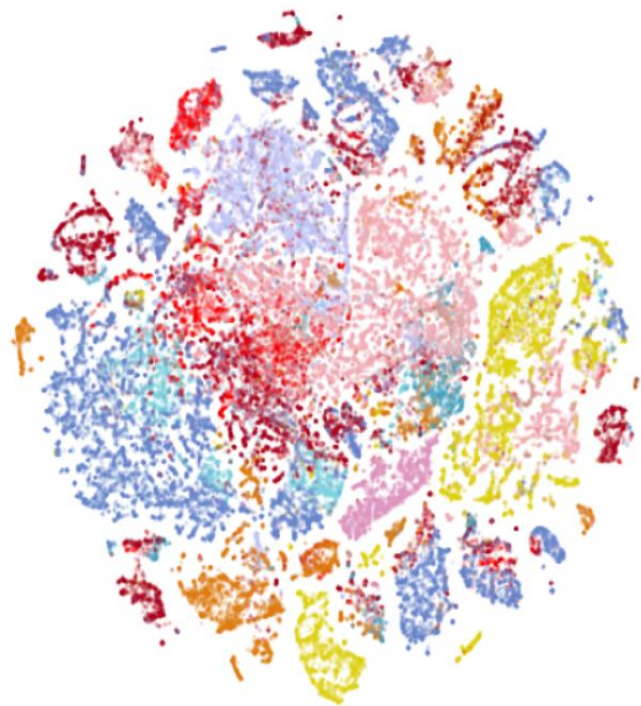


Figure 1: Two-dimensional *t*-SNE projection of 100,000 songs from our song embedding. Songs are represented as points, where two songs are close together if they have high usage overlap in our data. Colors represent genres of music.

Generalist - Specialist Score

- Used to quantify musical diversity of user
- Specialist - if listens to very similar songs
- Generalist - if listens to a diverse set of songs
- GS-score measures the average cosine similarity between a song vector and the average of the user's song vectors.

$$\vec{\mu}_i = \frac{1}{\sum w_j} \cdot \sum_j w_j \vec{s}_j$$

$$GS(u_i) = \frac{1}{\sum w_j} \sum_j w_j \frac{\vec{s}_j \cdot \vec{\mu}_i}{\|\vec{s}_j\| \cdot \|\vec{\mu}_i\|}$$

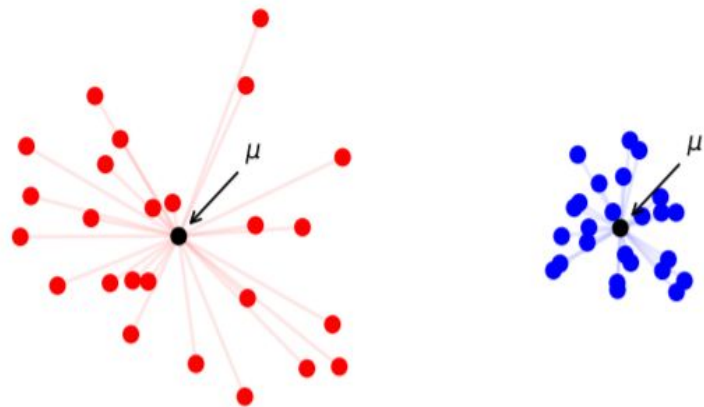


Figure 1: A schematic depicting the vector representations of communities contributed to by a generalist (left) and a specialist (right). The generalist's communities are spread out, and the specialist's communities are clustered together.

Diversity by Activity Level

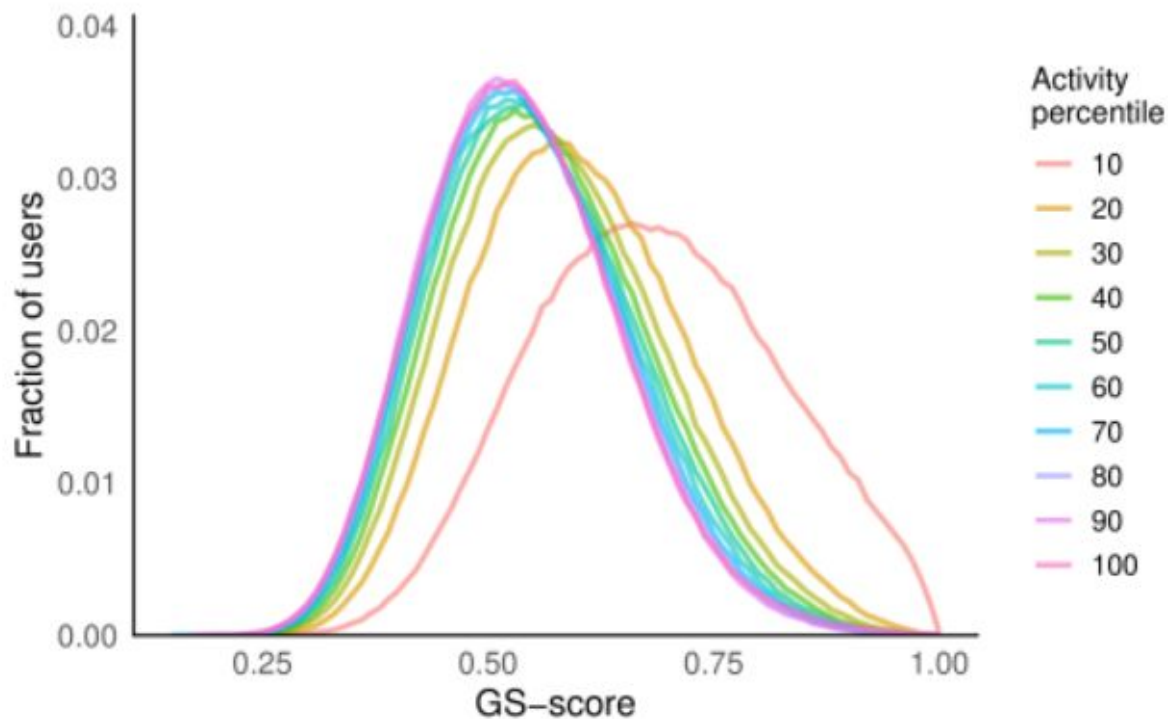
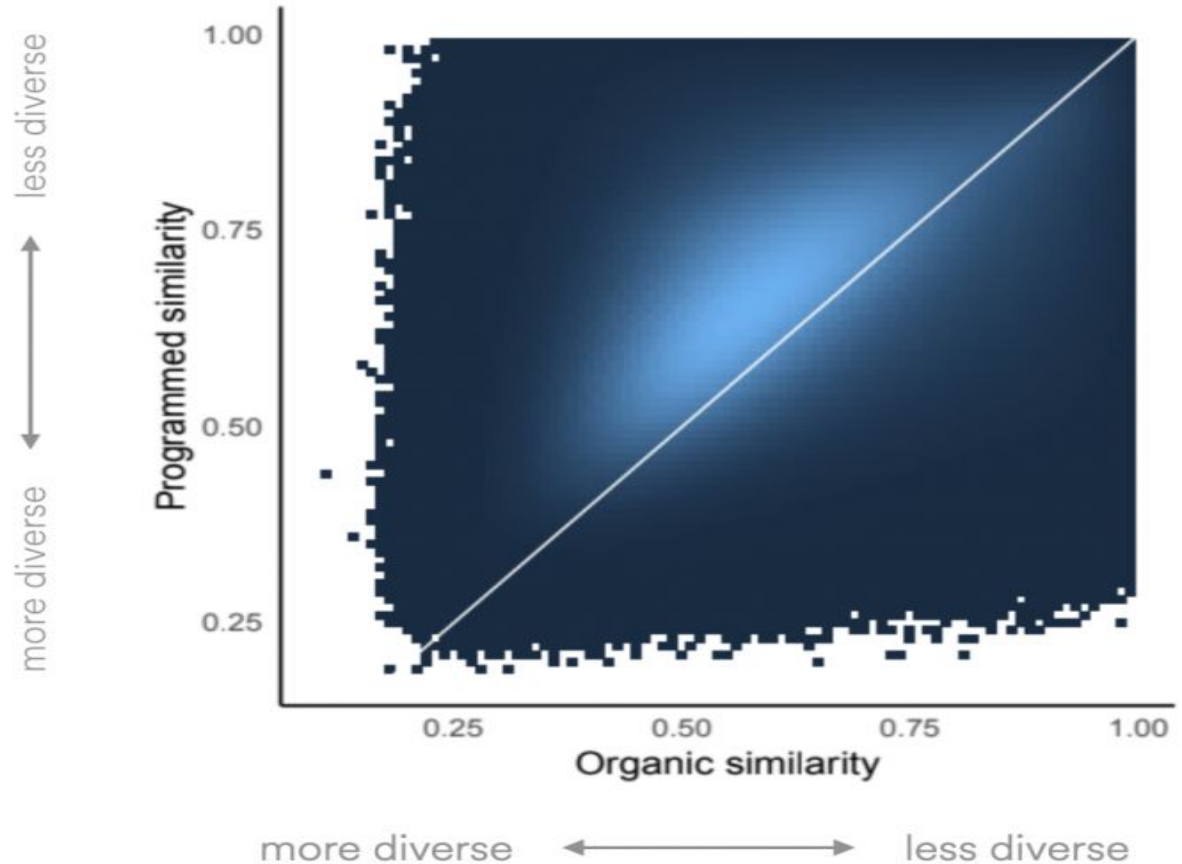


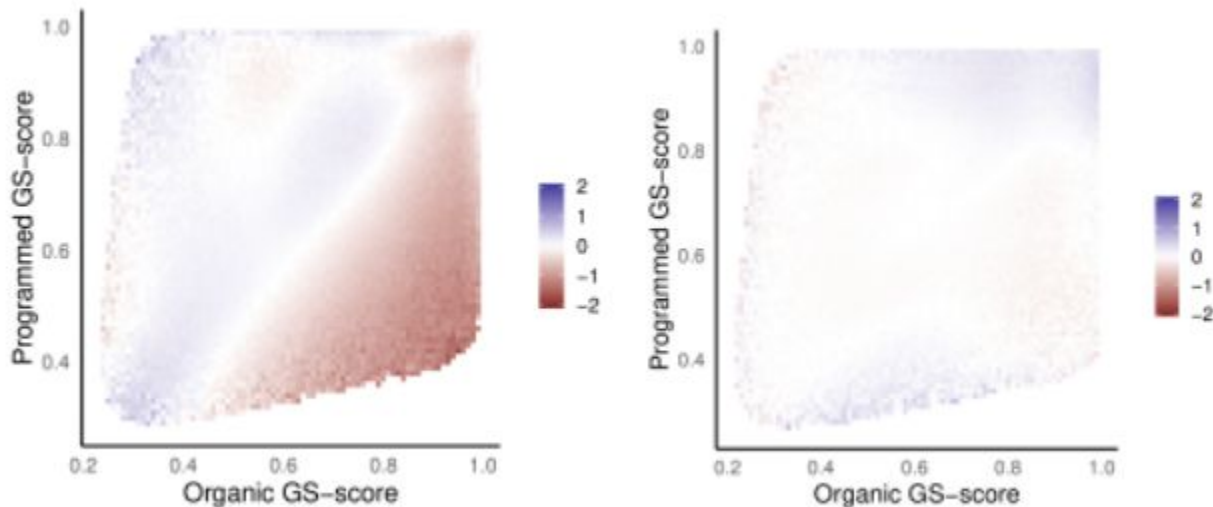
Figure 2: Distributions of diversity controlling for activity.

Organic Vs Programmed Diversity

The $y = x$ line is shown in white. The vast majority of users are above this line, indicating that their programmed listening is less diverse than their organic listening.

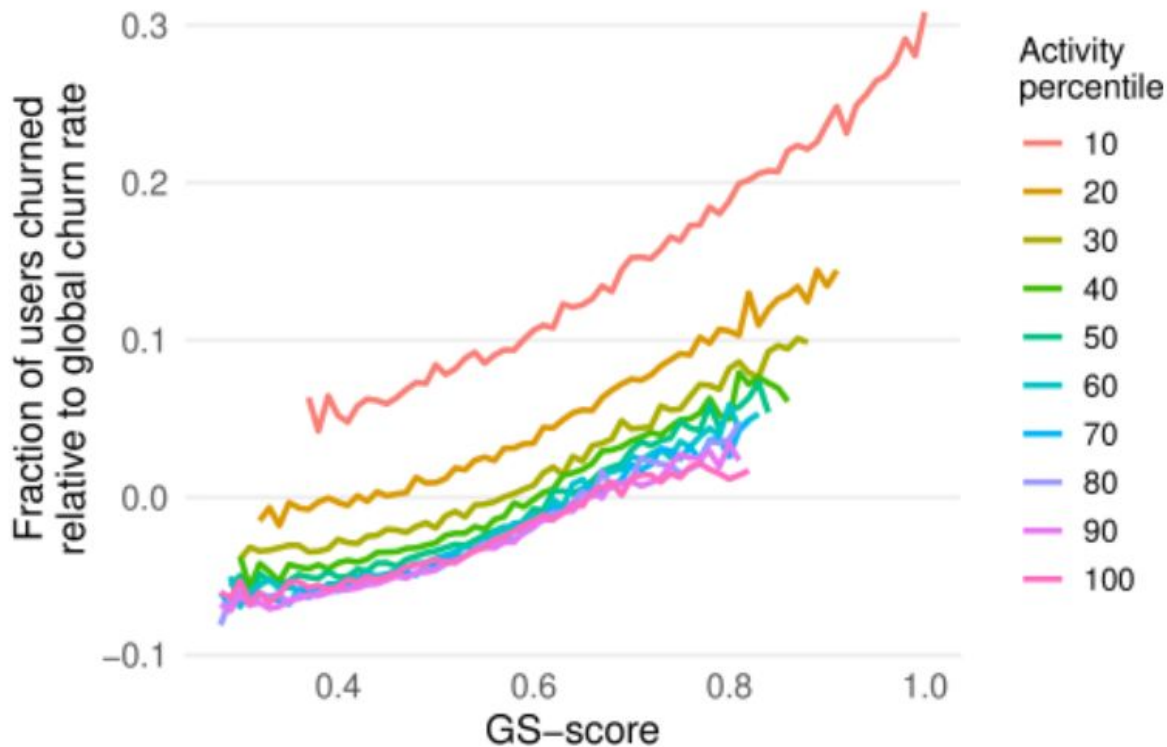


Demographic variation in Musical Diversity

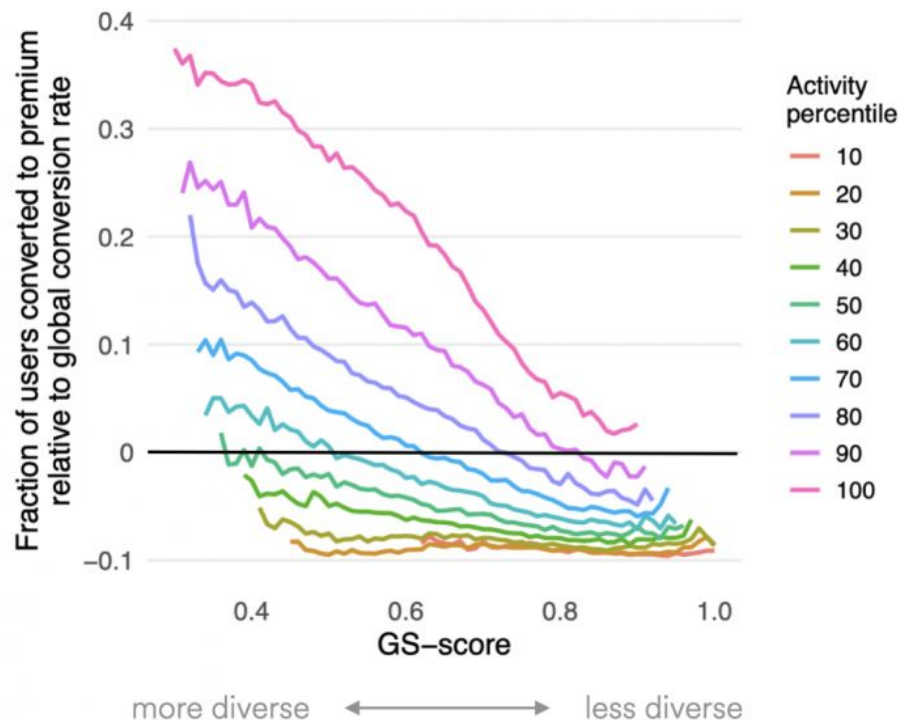


Log odds ratios of diversity distributions for (a) younger and older users and (b) male and female users.

Retention: Are users remaining on the platform?



Conversion: Are generalists or specialists more likely to become premium members?



Conclusion 1

- Conversion and retention are associated with greater content diversity.
- Recommendation Algorithms of spotify, though derives a significant amount of engagement, are associated with lower content diversity.
- Recommendation Algorithm can be effective in short-term while they are counterproductive in long-term.

My Experiment

I created a poll after reading this paper, to know how people in my linkedin connection feel about their Spotify Recommendations

- 39% - Less Diverse
- 3% - More Diverse
- 58% - Mixture of both

Total people voted = 31

Total views on poll = 1059

(PS: Not an influencer yet to get more people see my post and vote)

Music applications like Spotify provide us recommendations based on our listening history, etc. How are your recommendations?

You can see how people vote. [Learn more](#)

Very related content (narrow)	39%
Very diverse content	3%
Somewhere in middle of both	58%

31 votes • Poll closed

4

1 comment • 1,059 views



Like



Comment



Share



Send

Reactions



Comments

Most relevant ↕



Kaushal Kumar Maurya • 1st

CS Ph.D. Research Scholar @IITH | Upcoming...

1 mo

Indeed the personalized recommendation agents like Youtube are good. Though I think they are too person-centric. There should be some reliable exploration and exploitation trade-off.

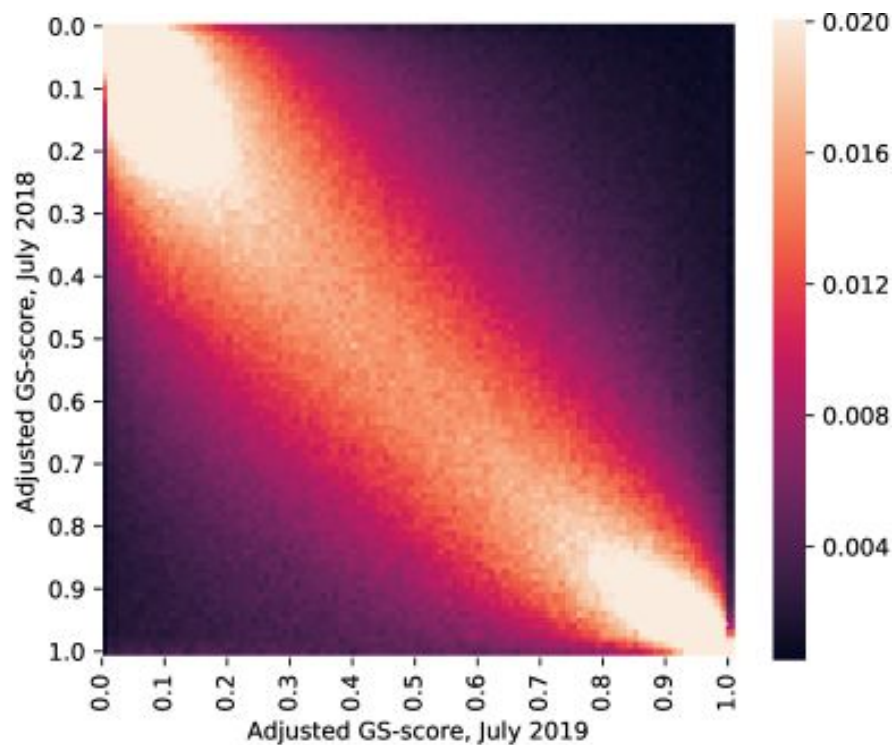
Like • 1 | Reply

Musical Diversity Over Time

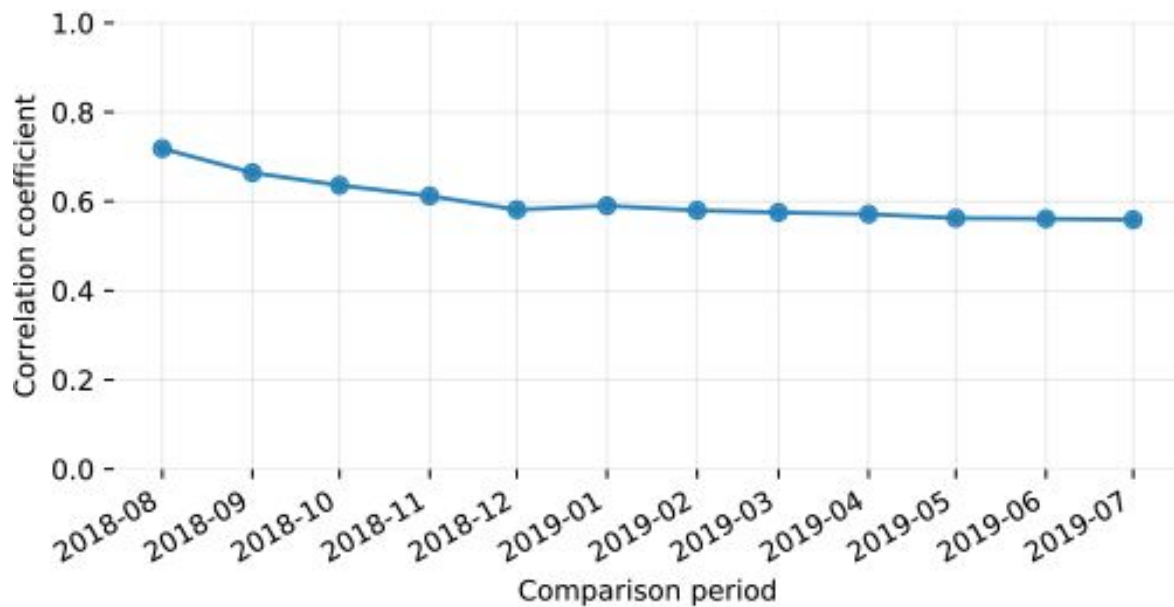
Activity Adjusted GS Score

For a given time period T , a user activity-adjusted GS SCore is the percentile rank of their GS SCore relative to all users in the same activity bucket at time T . This enables comparing GS Scores across time, controlling for any activity biases.

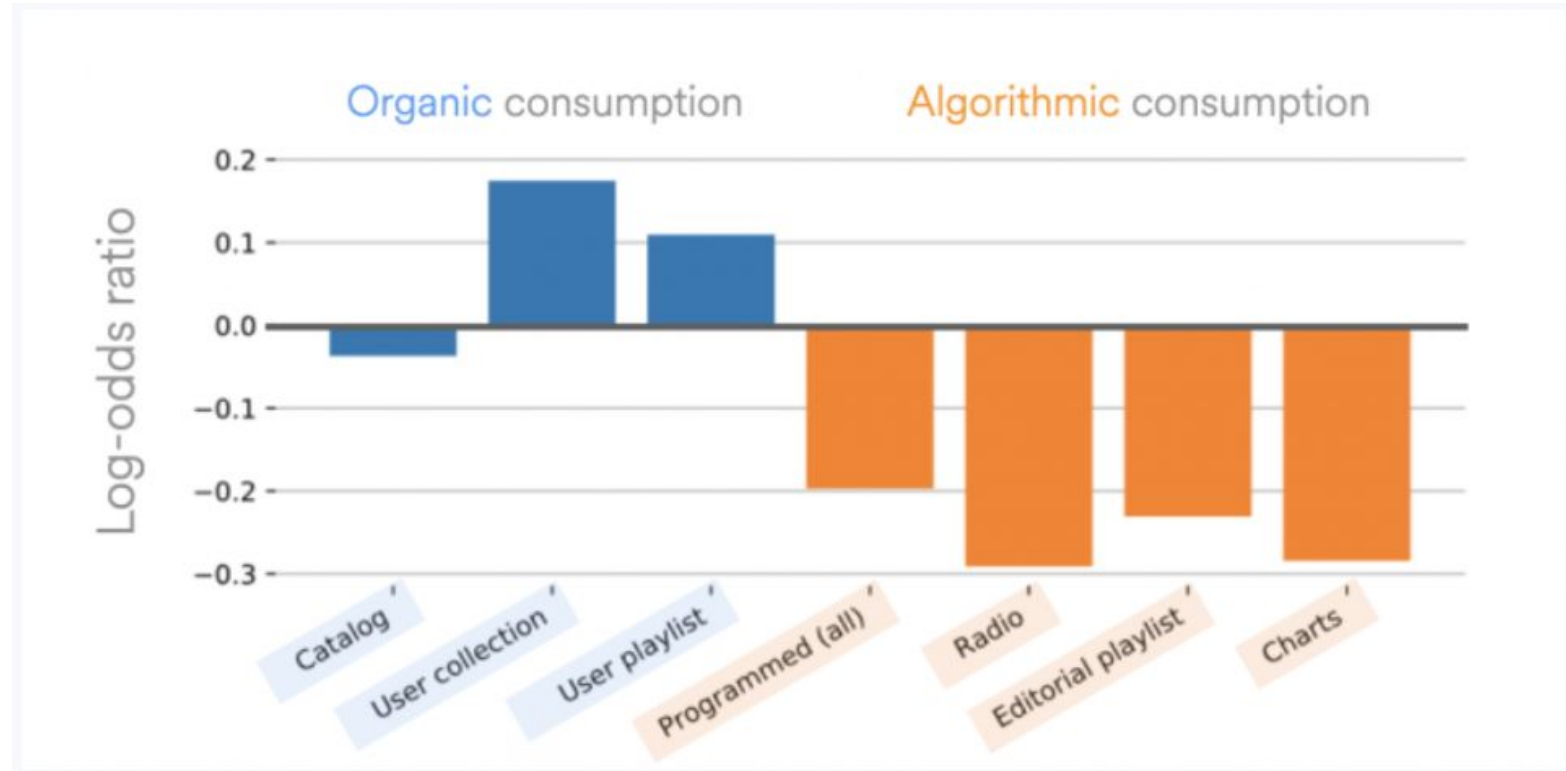
The Stability of Musical Diversity



The Stability of Musical Diversity



Mechanism of Change



Conclusion 2

- The GS-score is quite stable over time, clarifying that it captures an inherent behavioral characteristic of users.
- On explicitly analyzing users who increased their diversity over time, author found that these changes are accompanied by increases in their organic streaming and decreases in their algorithmically-influenced consumption

Impact of Recommendations for Generalist & Specialist

Experimental Setup

- Author Considered 7 popular algorithmic playlists
- Randomly assign a ranking algorithm in these playlists
 - Popularity Ranker - popularity in descending order
 - Relevance Ranker - relevance to user
 - Learned Ranker - based on neural network model with user-level, song-level and interaction level features.
- Online A/B Test on 5,40,000 users using free version of spotify

Relative Performance of Different Ranking Algorithms

Comparison	User Type	Song Streams	Song Skips
Relevance over Popularity	Generalists	+10.03%	+4.71%
	Specialists	+25.66%	+2.89%
Learned over Relevance	Generalists	+1.82%	+0.90%
	Specialists	+1.30%	-9.76%

Conclusion 3

- Consumption diversity is a useful signal in understanding how users will respond to recommendations.
- Classical recommendation models perform much better for specialists than for generalists.
- There is a need of more diversity-aware ranking methods for Generalist users.
- Author hints that there are risks to algorithmic over-specialization in online platforms, and to measuring the effectiveness of recommender systems too narrowly.

Different opinions from people on these recommendations

Tycho Brahe @TychoBrahe · 20/03/21
I look at who **Spotify** thinks I am in these **recommendations** and I feel shame.

Mr.GreyT 「Catboy/VTuber」 @greyt_mr · 2d
Why is this in my **Spotify recommendations**? xD pic.twitter.com/AWpVDImoAw

Zom :3 @FZiome · 1d
Omg my **spotify recommendations** are actually amazing for once how???

Niki Tonsky @nikitonsky · 6d
I got my YouTube to the state where I know exactly why each single video is recommended and I don't want to watch any of them.

Not necessarily a bad thing

Anton Amelekhin @AntonAmelekhin · 6d
Same with **Spotify**. I even get angry when sometimes I hit the like button on some of Johnny Cash's songs and the next day I get all the country and folk albums in my **recommendations**.

1:08 AM Sat 10 Apr

spotify recommendations india

Top Latest People Photos Videos

Krishita Motwani @KrishitaMotwani · 30/04/19
Music recommendations on @spotify in India are super spot on. Thank goodness it's just an app and not a judgmental human, else it would have "labelled" me as either a bar dancer or interstate bus driver 😊

Param Computers @param_india · 06/01/12
Top10's Nifty **Spotify** App Drives 100,000 Song Recommendations In Three Weeks bit.ly/xhSg0M #Tech

SAUMYA SHAH @saumyashah6 · 07/03/19
@spotifyindia thank you for launching in India. You were and always will be a far superior product than @AppleMusic. Your song recommendations never disappoint.

#SpotifyIndia #spotifyplaylist #spotify #AppleMusic

Vaibhav (VB) Srivastav @reach_vb · 04/03/19
@spotifyindia you are the best thing that has happened to me in 2019!

Loving the recommendations and the podcasts, #Spotify premium is so worth it!!

Why didn't you enter India earlier man 😊

Trending

What's happening

News · **LIVE**
Buckingham Palace confirms the Duke of Edinburgh has died
Trending with Prince Philip, Edinburgh

#CricketainmentShuru
VIVO IPL, Big Bull, Hotstar Specials, & much more 🙌
Promoted by Disney+HotstarVIP

Indian Premier L... · **LIVE**
IPL 2021: Royal Challengers Bangalore beat Mumbai Indians in s...
Trending with #RCBvsMI, Kohli

Politics · **Trending**
#ArnabGoswami
6,988 Tweets

Trending in India
Ambani
8,199 Tweets

Show more

Limitations of paper

- Cold-start based recommendations
- Challenges in generating and using the dataset.
- Need to explore more diversity - aware algorithms.
- The importance of diverse recommendations for artists and content creators.

Resources

- [Algorithmic Effects on the Diversity of Consumption on Spotify](#)
- [Generalists and Specialists: Using Community Embeddings to Quantify Activity Diversity in Online Platforms](#)
- [Algorithmic Effects on the Diversity of Consumption on Spotify](#)

THANK YOU :)