Social Media as an Early Data Source for Emerging Substance Use Trends

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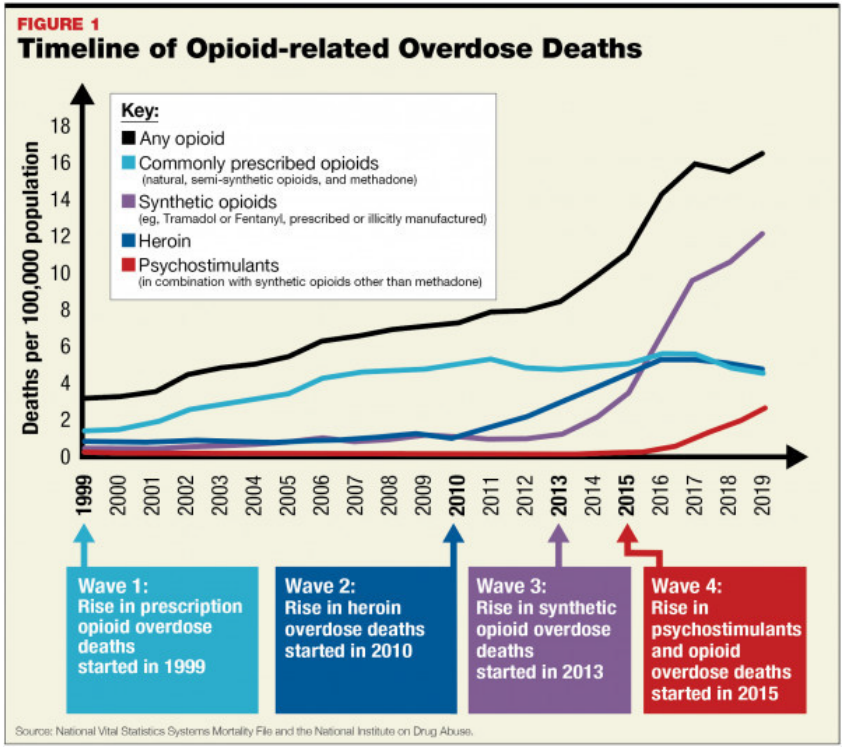
Motivation



- Rapidly changing substances and use practices
- Prevention and treatment efforts need real-time info
- **Can we measure substance use trends in real time?**

Social media can fill gaps in traditional surveillance

Surveys and traditional surveillance

👍Representative

👎Slow

👎Rigid

Social Media

👍Real-time

👍Flexible

👎Convenience sample

Data science can unlock the wealth of info in social media

Free, public APIs provide access to massive quantities of Reddit data.

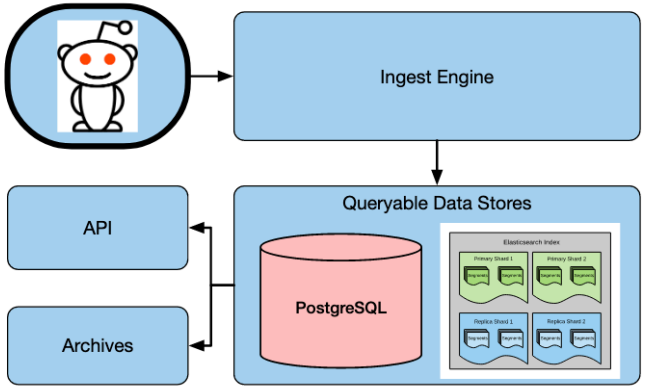
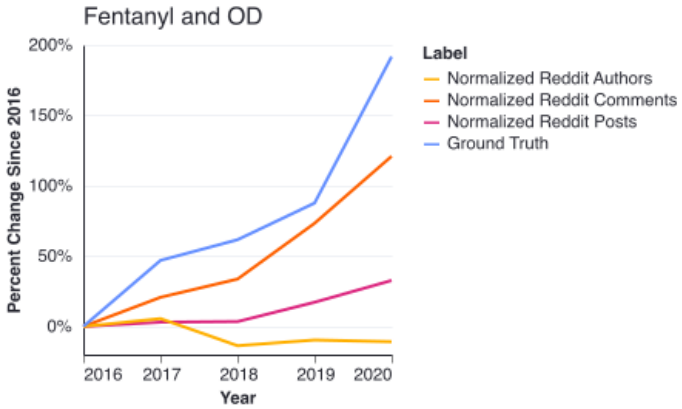


Figure 1: Pushshift's Reddit data collection platform.

Natural language processing (NLP) extracts structured info from large Reddit corpuses.



Baumgartner, J., Zannettou, S., Keegan, B., Squire, M., & Blackburn, J. (2020). *The Pushshift Reddit Dataset* (arXiv:2001.08435). arXiv. https://doi.org/10.48550/arXiv.2001.08435

Agenda

1. **Getting the data**
2. **Structuring the data**
3. **Comparison to “ground truth”**
4. **Next steps**

1. Getting the data

Reddit

75 Opiate Withdrawal Tips that have helped me through kicking over 20 times. (self.opiates)
submitted 2 years ago * by 88Knuckles88

Alright guys, I'm gonna preface this routine I use by telling you straight up, I am not a doctor- taking medical advice from me might be stupid I couldn't tell you- but one thing I certainly am is a hardcore ıg junkie. So when I tell you this provides relief, I'm not some doc telling you this from the sidelines. I have lived this routine too many times, and this is how I have managed to reduce 70-90% of withdrawals each time I have kicked the habit, making it bearable enough to get through by allowing me to eat and get some sleep in that dreaded first week. I dont know if all of the items are necessary or if it would be just as effective without some of them, but each time I've kicked (at least 20 times, sadly) this is the routine I've used. It is expensive- overall around $300-400 for everything- but I'll mention some alternatives to reduce the cost at the bottom. Let's get started with a list of the things you'll need...

- Kratom (preferably an extract, specifically OPMS Gold Liquid Vials or The original UEI Kratom or tincture made from it are the three most effective I have come across for opiate relief)
- Loperamide (Immodium)
- Xanax
- Cannabis
- Restless legs tablets
- Clonidine
- Unisom
- Vitamin C/Ascorbic Acid
  - Mucinex
    - Food that is easy on the stomach (yogurt, apple sauce, peabut butter, bread, fruit)

[–] [deleted] 8 points 2 years ago

Thanks for this! I'm sure a lot of people will find it helpful, I've honestly wanted to try Kratom quite abit but I never know of a place to get any. What is Kratom concentrate like? How does one ingest it?

There's a headshop here that sells just straight up Kratom, but I've heard that the headshop quality stuff isn't usually that good. I've always really wanted to try it but I'm quite skeptical on whether or not it'll actually work. I'm your experience, does it provide analgesia? Anything close to what say, Morphine might do ? Curious - look forward to hearing back. Thank you .

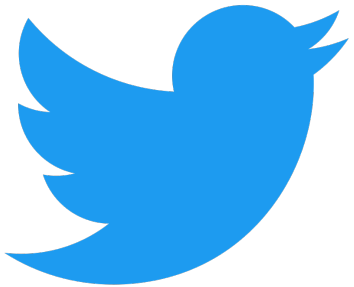
permalink embed save

Full Data:

- Comments & Posts
- *r/opiates & r/OpiatesRecovery*
- 2015-2020

Why Reddit?

- Topic-specific subreddits
- Long texts
- ***Easy access***



Pushshift

pushshift.io

Learn about Big Data and Social Media Ingest and Analysis

Home | Donations | Elasticsearch Quick Reference | Schedule | API Documentation | What is pushshift.io | Social Media

API Documentation

List of Endpoints

There are three main endpoints for the API to get information on comments, submissions and subreddits. The main endpoints are:

- /reddit/comment/search
- /reddit/submission/search
- /reddit/subreddit/search

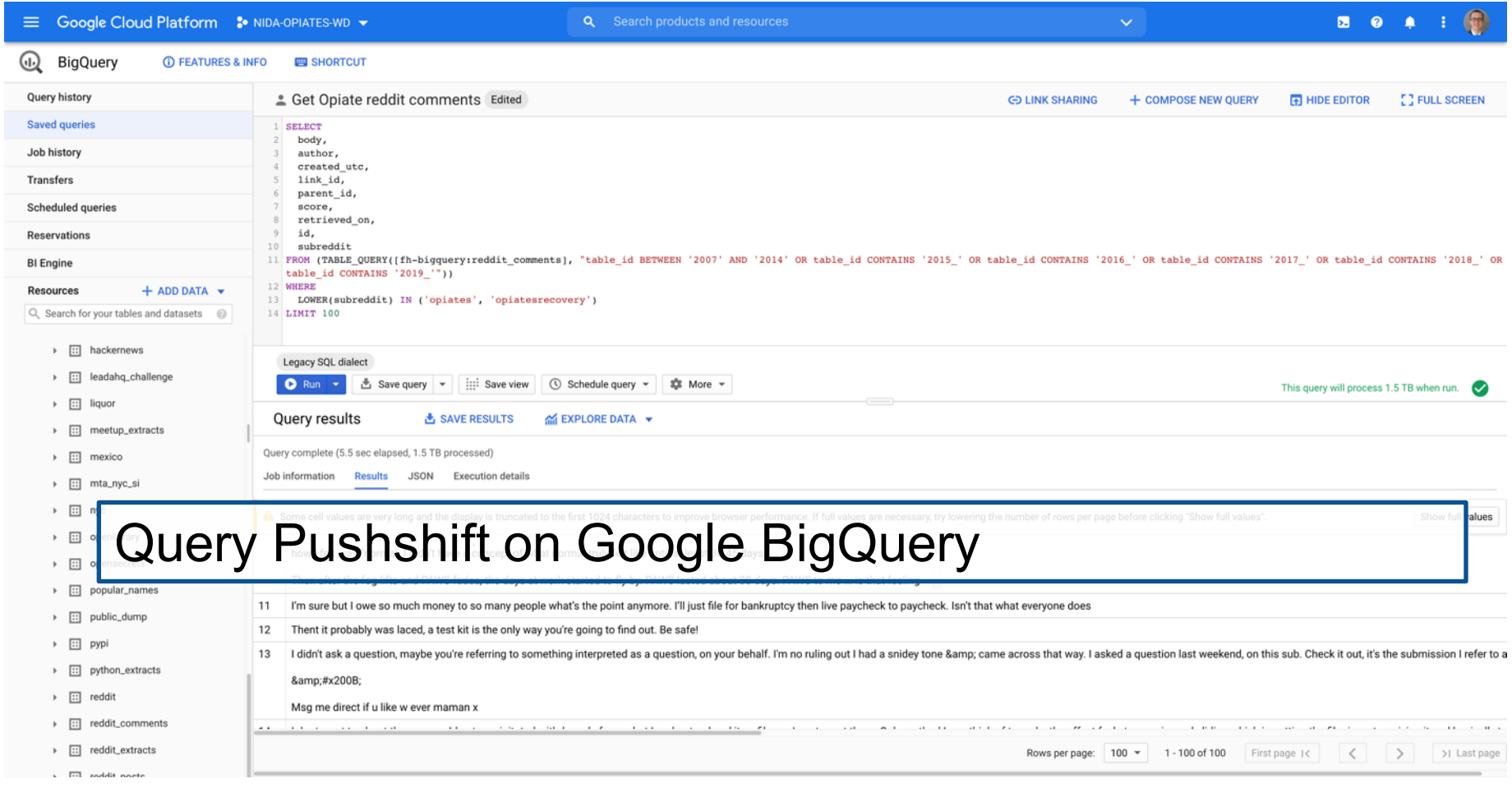
Full List of Pushshift Reddit Specific Parameters

Show 100 entries

Search:

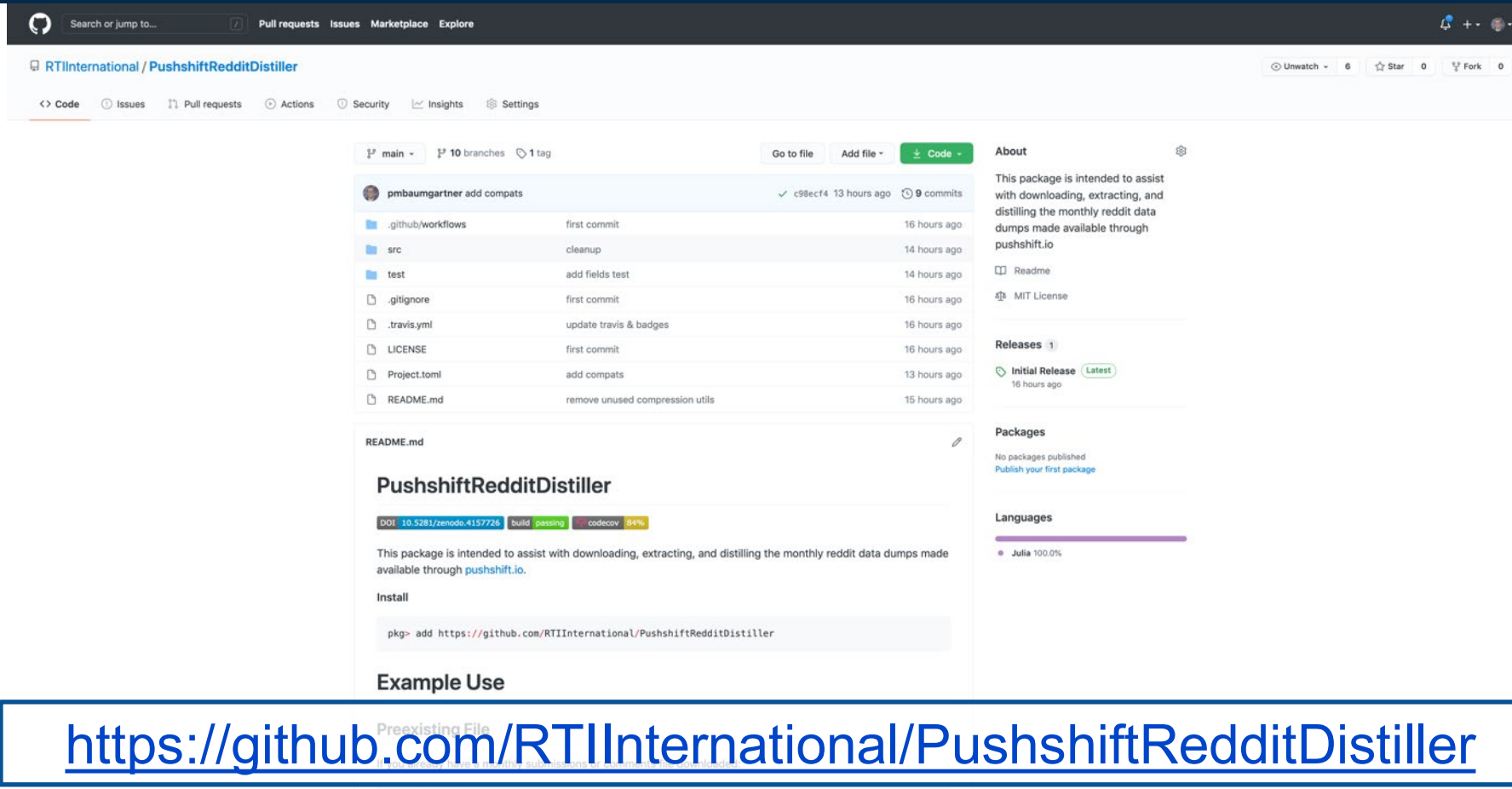
Parameter	Type	Endpoint	Description
sort	Filter	All Endpoints	Sort direction of results ("asc" or "desc")
sort_type	Filter	All Endpoints	Parameter used for sort
after	Integer	All Endpoints	Restrict results to those made after this epoch time

Data Acquisition



Query Pushshift on Google BigQuery

Data Acquisition 2



https://github.com/RTIInternational/PushshiftRedditDistiller

Data Acquisition 3

README.md

PMAW: Pushshift Multithread API Wrapper

circleci passing | codecov 87% | pypi v2.1.3 | python 3.5 | 3.6 | 3.7 | 3.8 | 3.9 | License MIT

Description

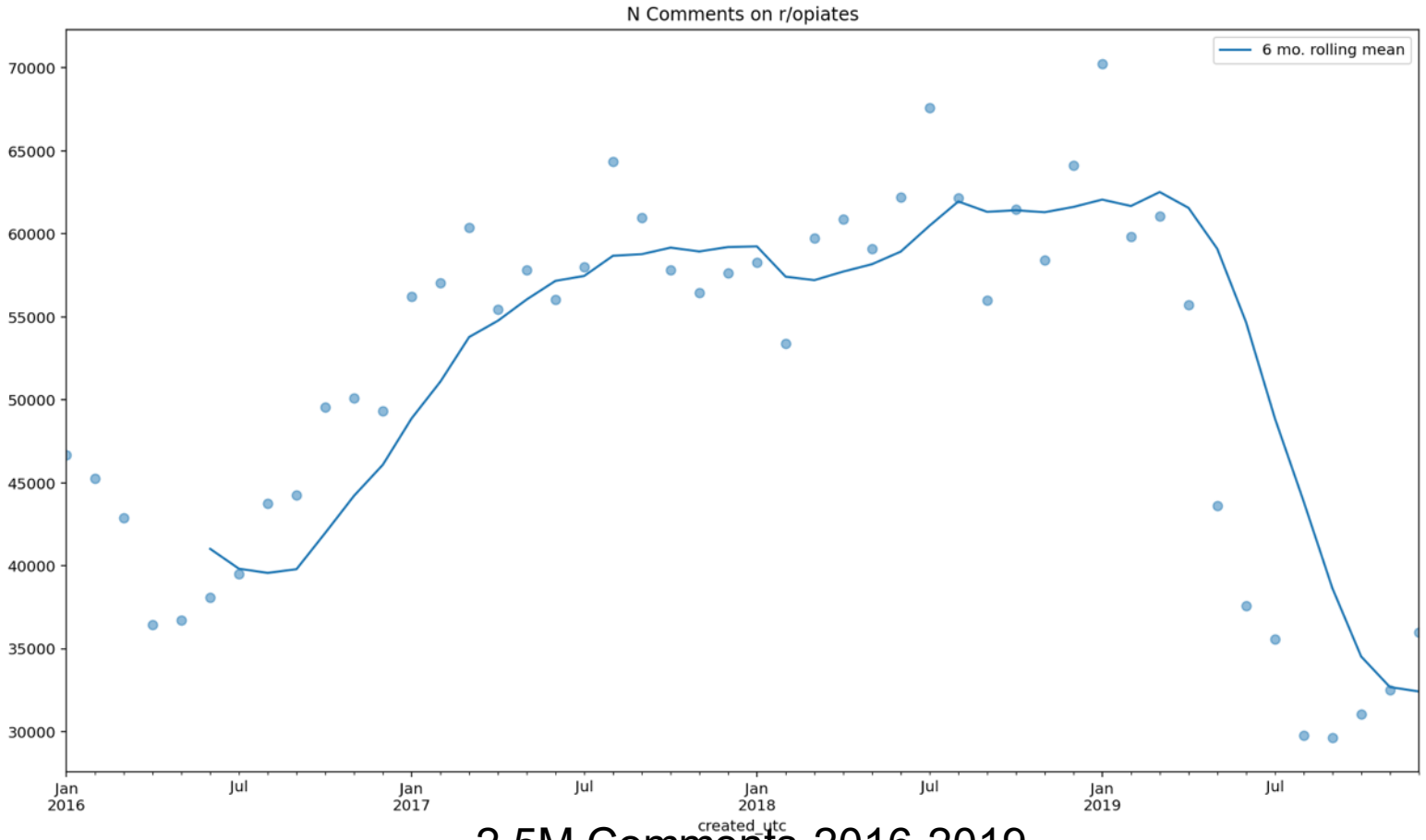
PMAW is a wrapper for the Pushshift API which uses multithreading to retrieve Reddit comments and submissions. General usage is through the `PushshiftAPI` class which provides methods for interacting with different `Pushshift` endpoints, please view the Pushshift Docs for more details on the endpoints and accepted parameters. Parameters are provided through keyword arguments when calling the method, some methods will have required parameters. When using a method **PMAW** will complete all the required API calls to complete the query before returning a `Response` generator object.

The following three methods are currently supported:

- Searching Comments: `search_comments`
  - Details
- Search Submissions: `search_submissions`
  - Details
- Search Submission Comment IDs: `search_submission_comment_ids`
  - Details

https://github.com/mattpodolak/pmaw

How much data?



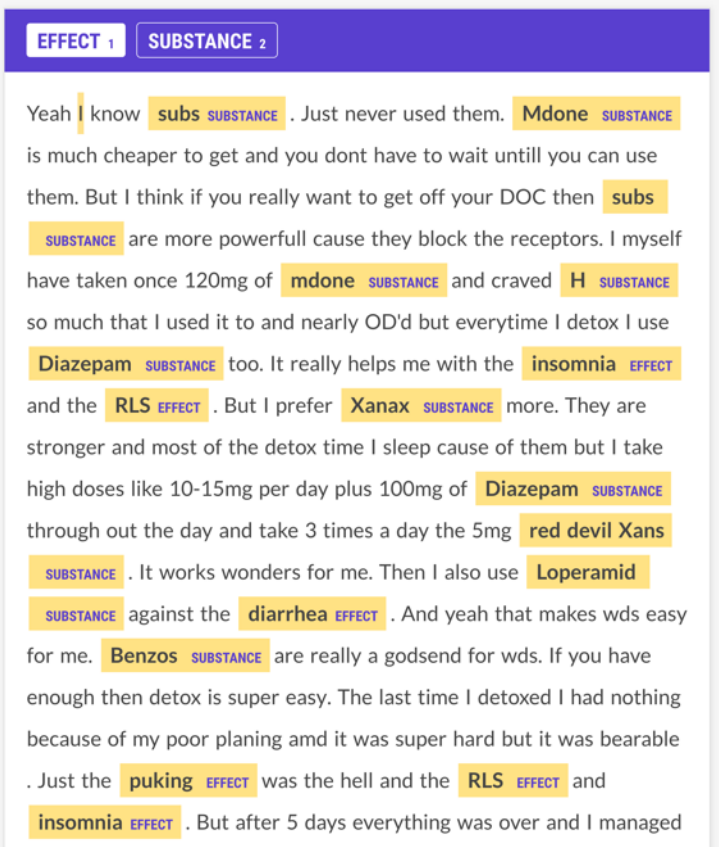
~2.5M Comments 2016-2019

2. Structuring the data

Named Entity Recognition

Effect: a therapeutic or adverse effect mentioned as a result or rationale for consuming a substance.

Substance: a drug, remedy, supplement, or other consumable item used to treat an effect or induce a desired effect.

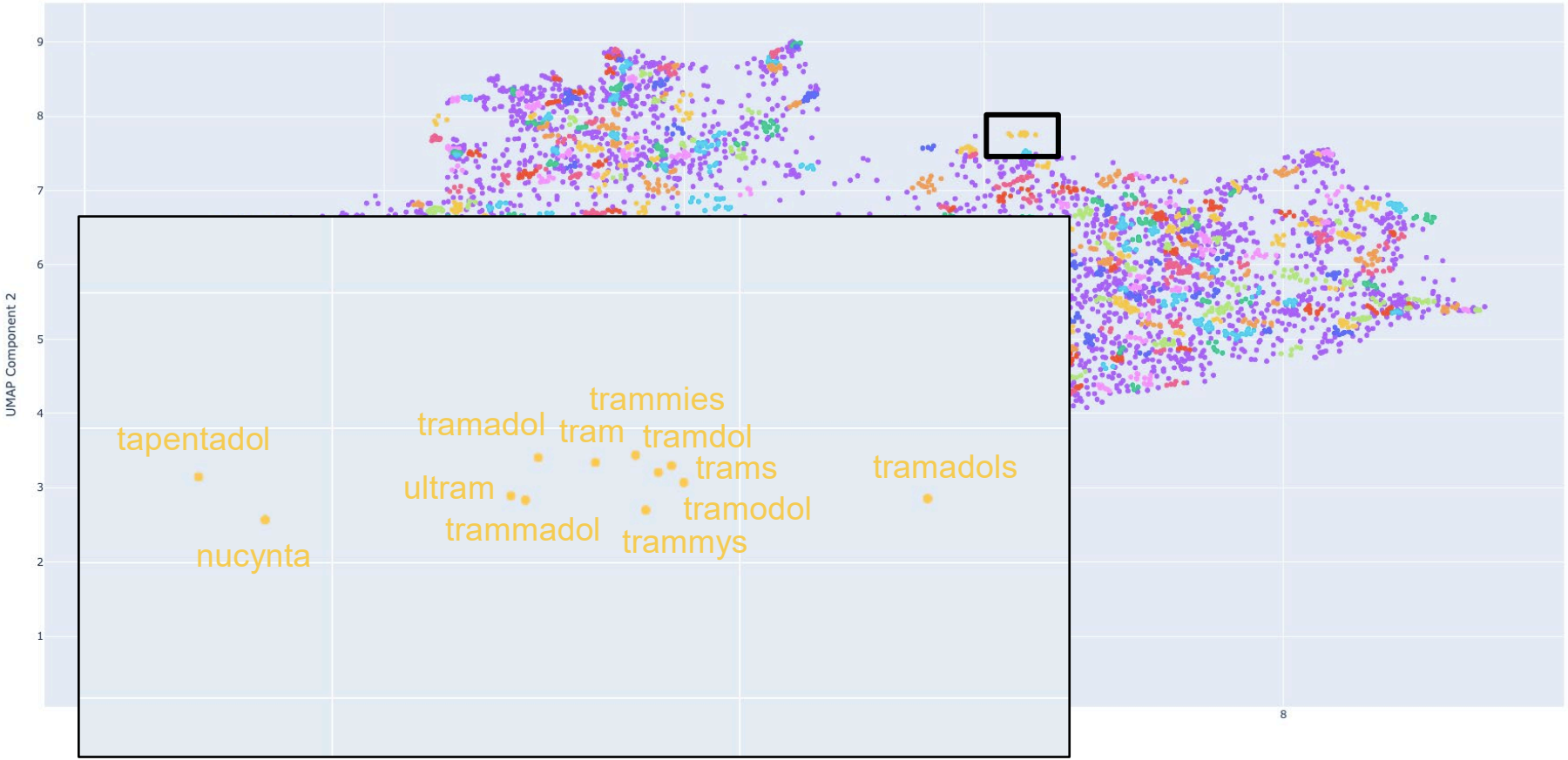


Problem

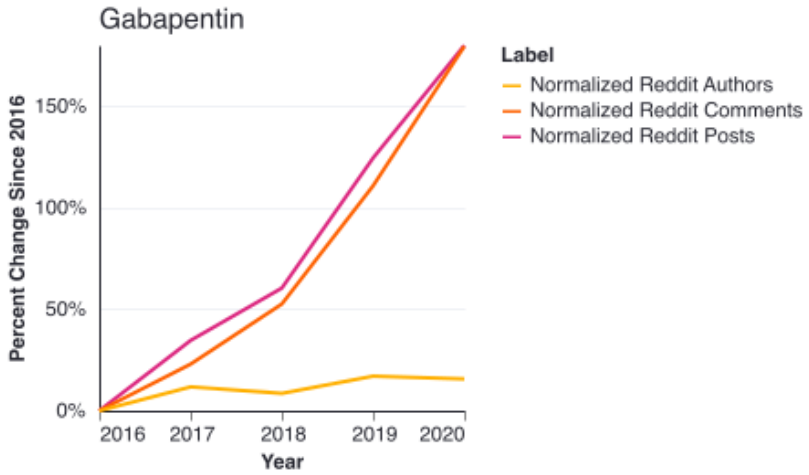
Entity	Count
lope	16853
lope imodium	2
lope lope	3
lopeamide	2
lopedium	6
lopeermide	2
lopemide	13
loperadime	3
loperaide	2
loperamade	2
loperamaide	4
loperamid	37
loperamide	7424
loperamide hci	2
loperamide hcl	49
loperamide hydrochloride	18

Entity	Count
immmodium	2
immodium	3598
imodiom	3
imodium	3093

Clustering deduplication



Measure trends in entity mentions over time



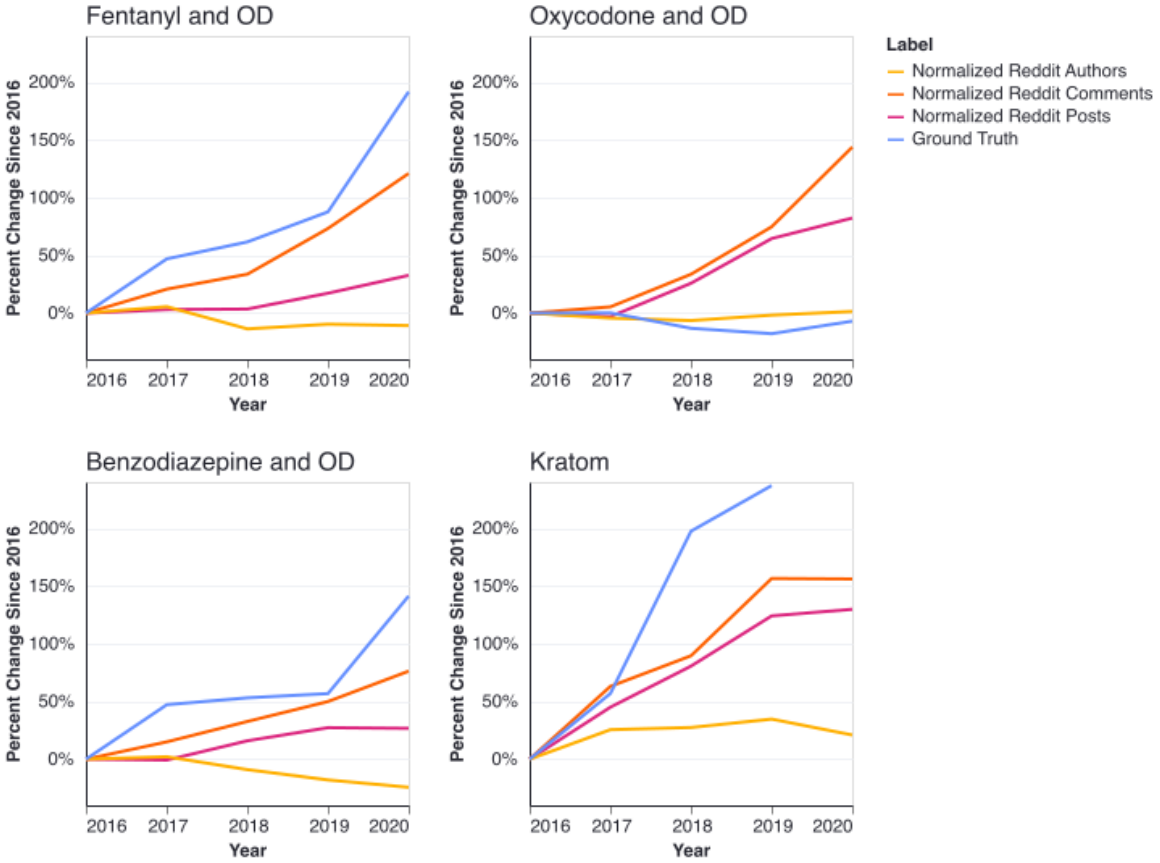
- Posts, comments, and unique authors
- Normalized as proportion of all posts which mention topic

3. Comparison to “ground truth”

Comparison Methods

- Select topics where a “ground truth” comparison is possible (e.g., fentanyl overdose)
- Extract Reddit discussion trends and comparison data over same time frame
- Visualize and estimate correlation

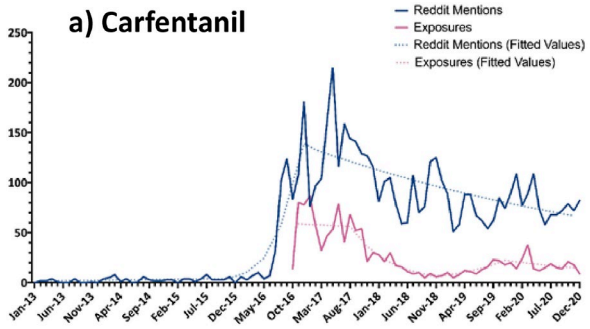
Comparison Results



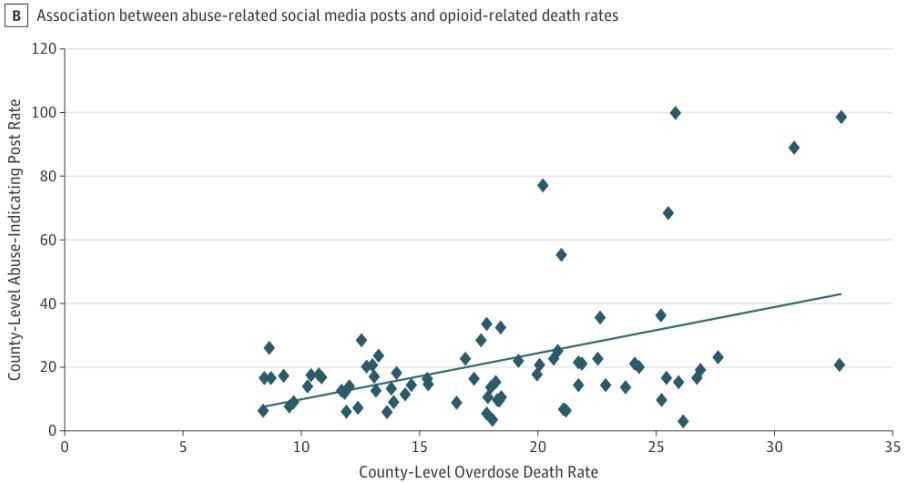
4. Next steps

Many proofs of this concept

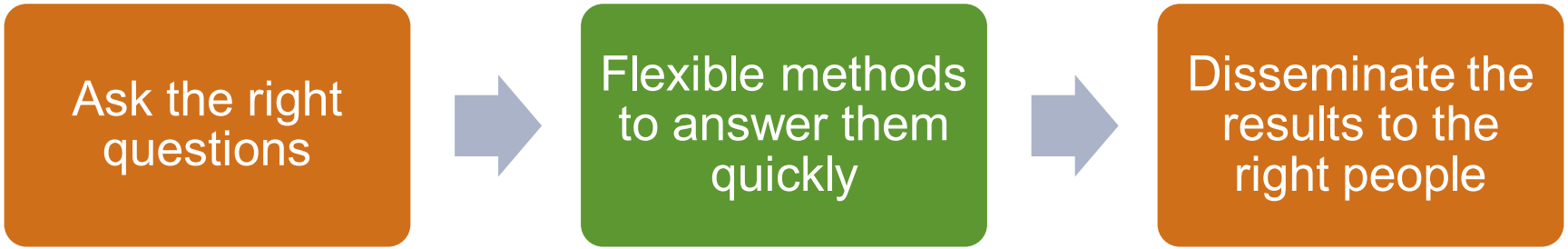
Barenholtz, E., et al. (2021). Online surveillance of novel psychoactive substances (NPS): Monitoring Reddit discussions as a predictor of increased NPS-related exposures. *International Journal of Drug Policy*, *98*, 103393. https://doi.org/10.1016/j.drugpo.2021.103393



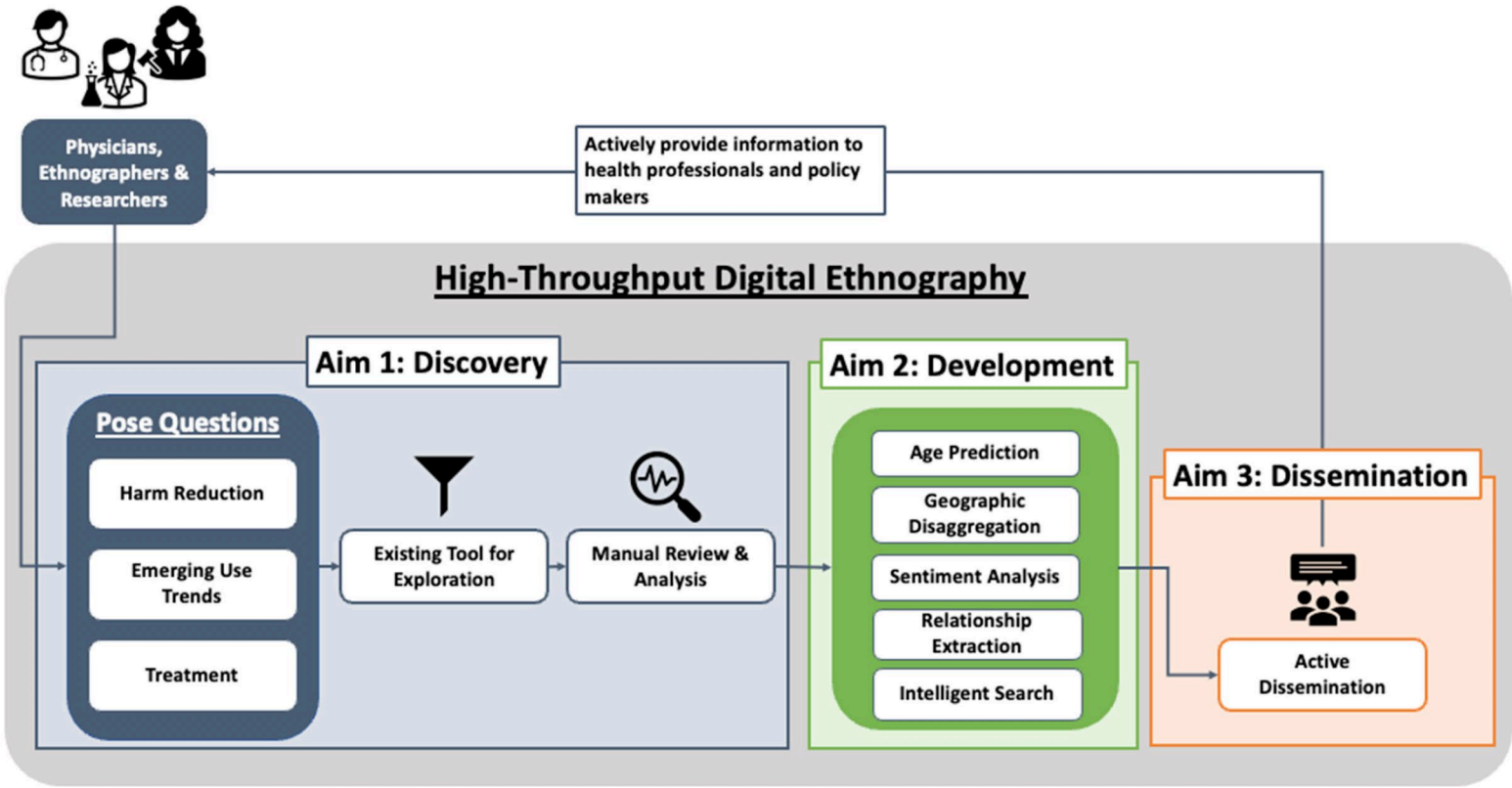
Sarker, A., Gonzalez-Hernandez, G., Ruan, Y., & Perrone, J. (2019). Machine Learning and Natural Language Processing for Geolocation-Centric Monitoring and Characterization of Opioid-Related Social Media Chatter. *JAMA Network Open*, *2*(11), e1914672. https://doi.org/10.1001/jamanetworkopen.2019.14672



On-the-ground implementation remains a goal



NIDA R01: High Throughput Digital Ethnography for Substance Use



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Appendix

Dealing With Large Data in Natural Language Processing

1. **Solve a smaller & simpler problem**
   a. **Identify** relevant documents with a keyword list derived from word vectors
   b. **Build** labeled data as fast as possible with binary decision-making on token-based entities
2. **Iterate with the data**
   a. **Train** *disposable* models as soon as feasible (n < 250)
   b. **Apply** the disposable model to remaining data, aggregate results, do error analysis on results, identify documents with errors for training

Where to start?

1. Bootstrap identifying relevant documents with a terminology list derived from word vectors
    1. Start with obvious ones: “opiates”, “oxycontin”, “tiredness”, “yawning”, etc.
2. Start generating labels as fast as possible with binary decision-making on token-based entities
3. Make corrections on simple binary annotations rather than start from the blank page of no annotations

In sum: identify likely relevant comments and solve simpler problems first

How to improve the model

1. Train a model with limited training data (n<1000) and run it on the full dataset.
2. Aggregate predicted entity occurrences.
3. Perform error analysis on aggregated entity counts.
    1. i.e. “lack of” as an effect, “wal-mart” or “adhd” as a substance
4. Identify documents not in training dataset with erroneous entities, create a new batch of training data with those documents
5. Annotate again on identified erroneous examples.
6. Repeat from top until you have an acceptable error rate within the *top n* most common entities.

In sum: Iterate on your data

Results: Most Common Entities

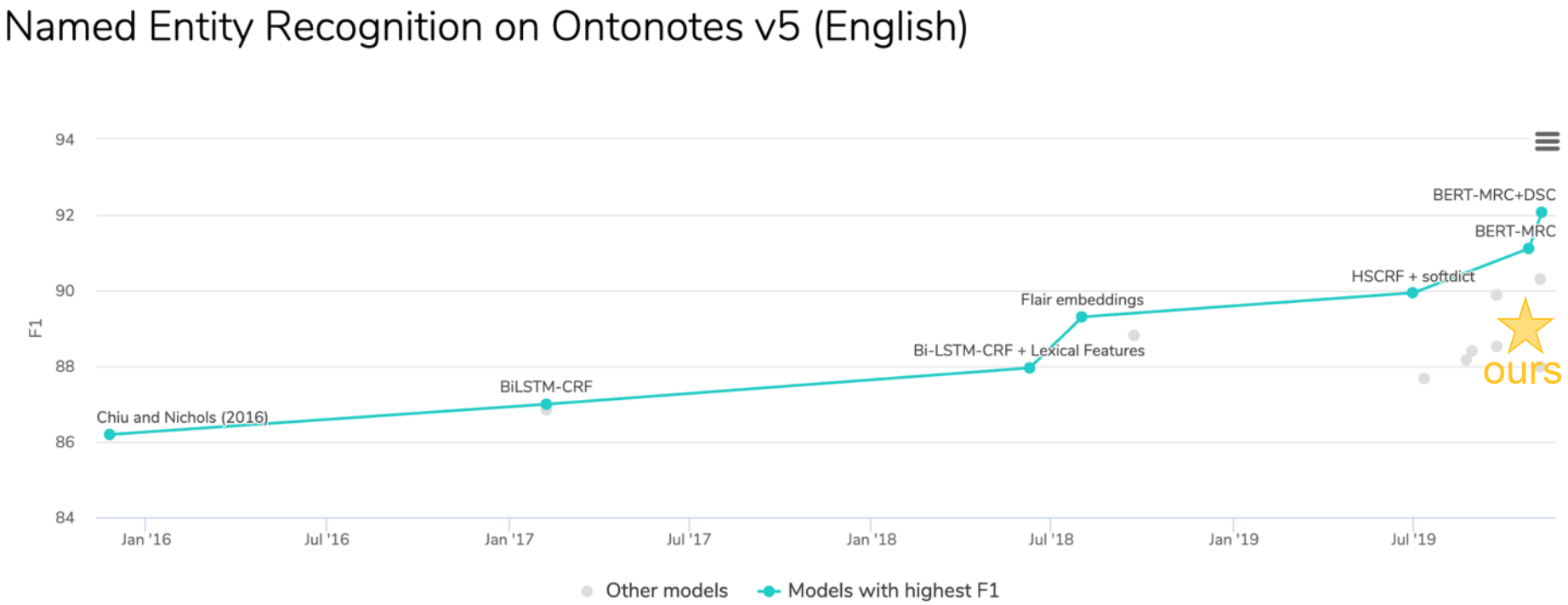
	Substance		Effect	
Rank	**Entity**	**Count**	**Entity**	**Count**
1	dope	184420	pain	70171
2	opiates	162949	anxiety	31013
3	heroin	152477	depression	23567
4	oxy	91823	sleep	22294
5	subs	83456	cravings	19991
6	sub	80744	depressed	11141
7	opiate	79997	rls	8794
8	methadone	73054	nausea	7454
9	kratom	65298	craving	6355
10	fent	64020	insomnia	5594
11	suboxone	62785	puke	5484
12	h	51548	mood	5366
13	weed	49659	seizures	5251
14	morphine	45814	anxious	5190
15	benzos	36115	puking	5063

Performance: Results

Entity → / Measure ↓	EFFECT	SUBSTANCE	OVERALL
Precision	80.90	90.48	88.23
Recall	79.56	91.45	88.63
F1	80.20	90.96	88.42

5-fold cross validation
Scoring: exact overlap

Performance: Is this good?



https://paperswithcode.com/sota/named-entity-recognition-ner-on-ontonotes-v5

Orthography and Semantics (Spelling and Meaning)

Fuzzy string matching

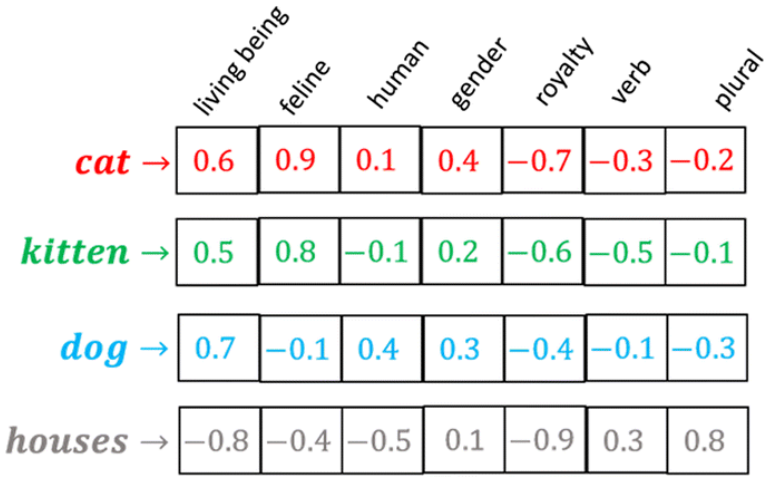
Loperamide

Immodium

Word Embeddings

Word Embeddings:

Vector representations of word meaning



Word Embeddings leverage Distributional Semantics:

”A word is characterized by the company it keeps.” – J.R. Firth

Swatimeena: https://swatimeena989.medium.com/training-word2vec-using-gensim-14433890e8e4

FastText

Amit Chaudhary: https://amitness.com/2020/06/fasttext-embeddings/

FastText Output

Entity	0	1	…	*N*
lope	0.1	-0.3	0.8	0.5
loperamide	0.2	-0.2	0.8	0.6
immodium	0.2	-0.3	0.5	0.8
imodium	0.1	-0.4	0.5	0.7
heroin	-0.6	0.9	0.1	-0.1

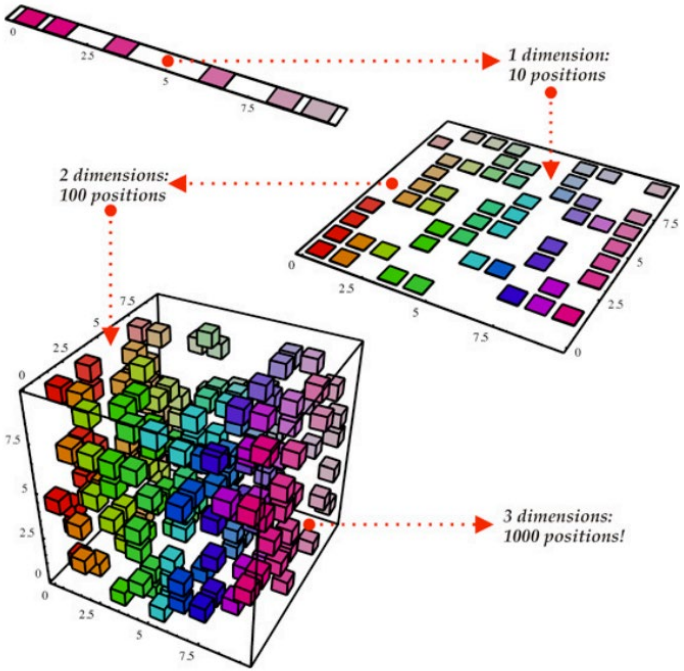
Next Step:

Cluster like with like!

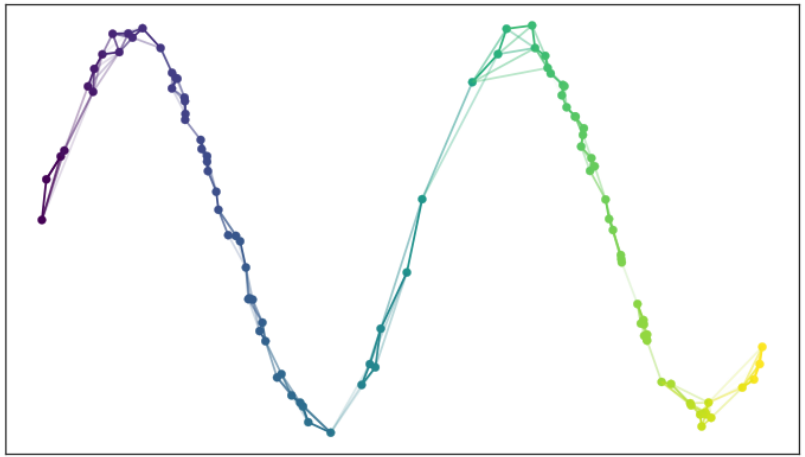
But first…

Dimension Reduction: UMAP

The curse of dimensionality



UMAP:
Uniform Manifold Approximation



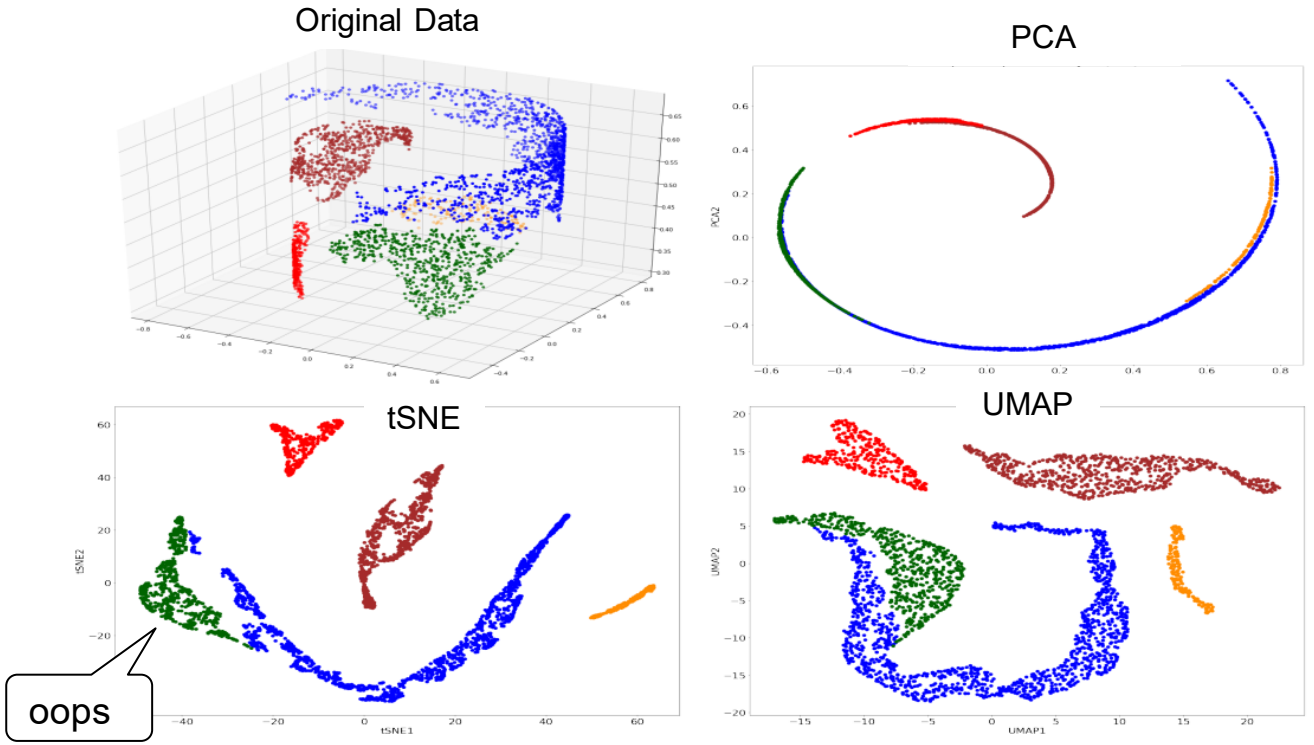
Why FastText?

- Generates embeddings for character n-grams as well as whole words
- Character n-grams capture infrequent misspellings
- Whole word embeddings capture synonyms (e.g. brand name & generic drug)
- Works on words not in training data

Amit Chaudhary: https://amitness.com/2020/06/fasttext-embeddings/

Why UMAP?

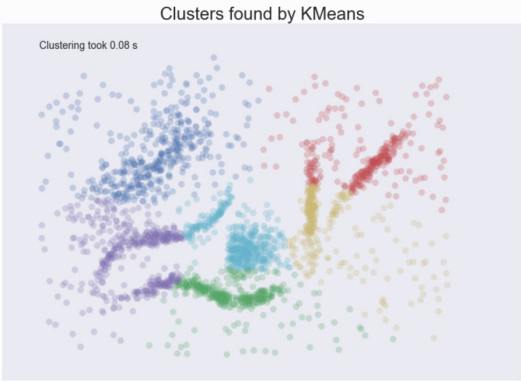
- Retains heterogeneity (groups neighboring points)
- Preserves global structure
- Relatively fast

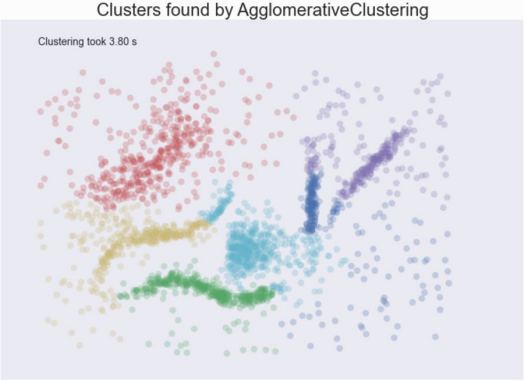


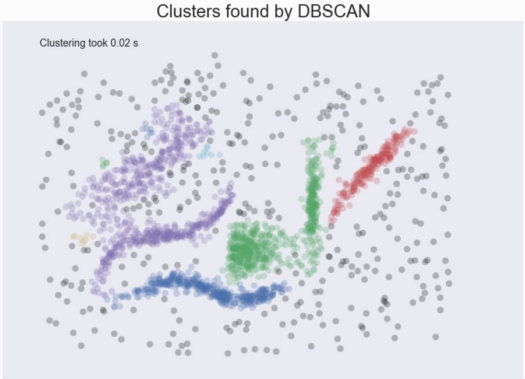
Nikolay Oskolkov: https://towardsdatascience.com/tsne-vs-umap-global-structure-4d8045acba17

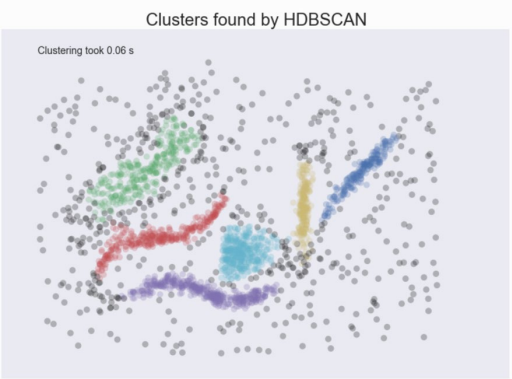
Why HDBSCAN?

- Dense clusters with sparse background noise
- Flexible cluster shapes
- Intuitive parameter tuning (vs DBSCAN)
- Fast









https://hdbscan.readthedocs.io/en/latest/comparing_clustering_algorithms.html

Clustering Output

Cluster ID	Most Common Entity	Number of Entities	Other Entities
120	lope	17	immodium, imodium, lope, lopemide, loperamid, loperamide, loperamide hcl, loperamideimmodium, loperamine, loperimide, lopermade, lopermaide, lopermide, lopermine, loperomide, lopes, nimmodium
221	fentanyl	8	fentanyl, fentanyl 30s, fentanyl 80s, fentanyl blues, fentanyl heroin, fentanyl ods, fentanyl oxy, fentanyl xanax
271	tylenol	14	aceatominophen, aceta, acetametaphine, acetaminophen, acetaminophen 10325, acetaminophen 5325, aceteminophen, acetimophen, acetomenaphin, acetominophen, apap, aspirin acetaminophen, paracetamol, tylenol