

Style in the Long Tail

Discovering Unique Interests with Latent Variable Models in Large Scale Social E-commerce

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Rob Hall, **Etsy**

Josh Attenberg, **Etsy**

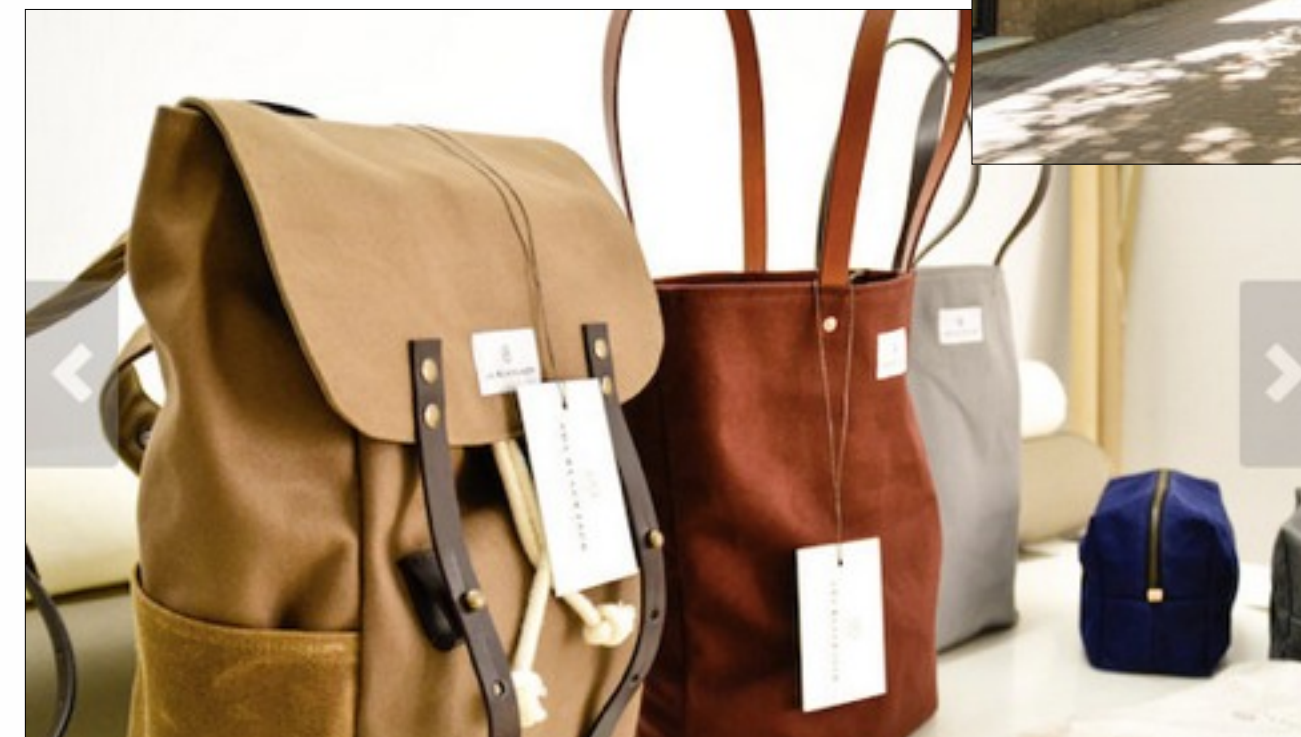
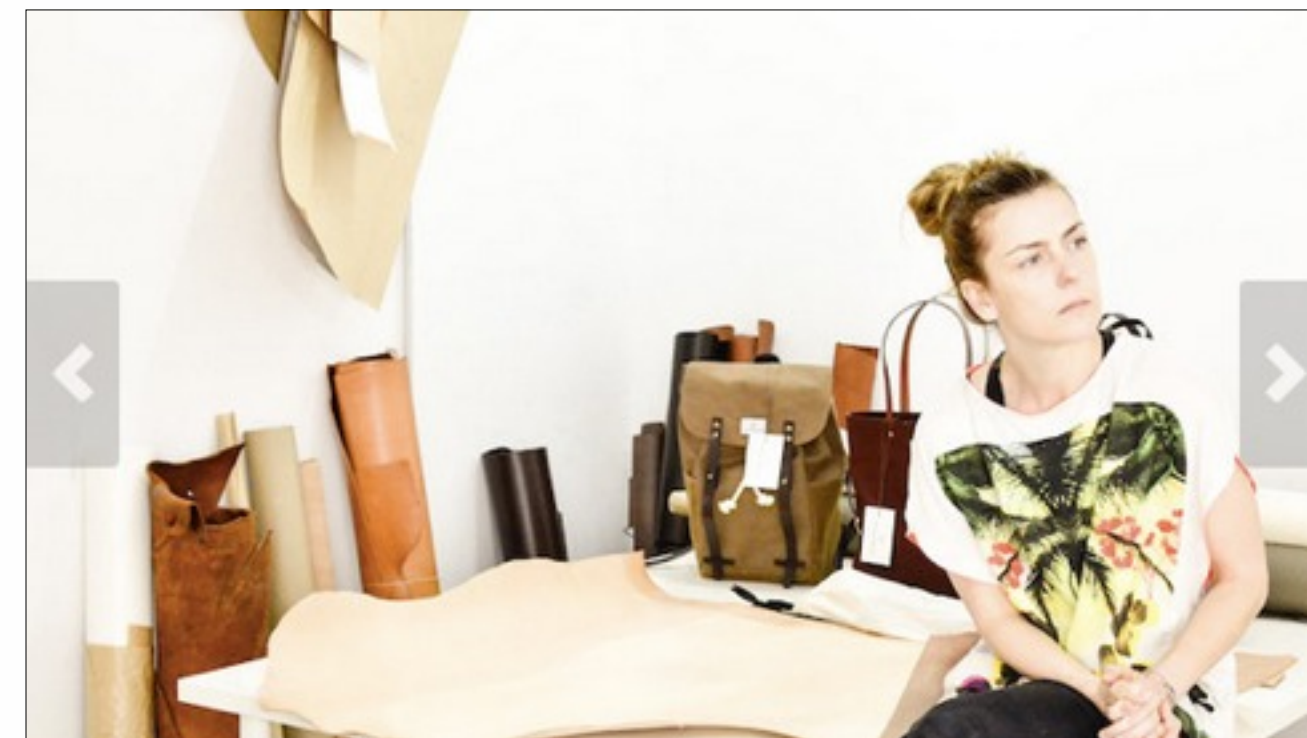
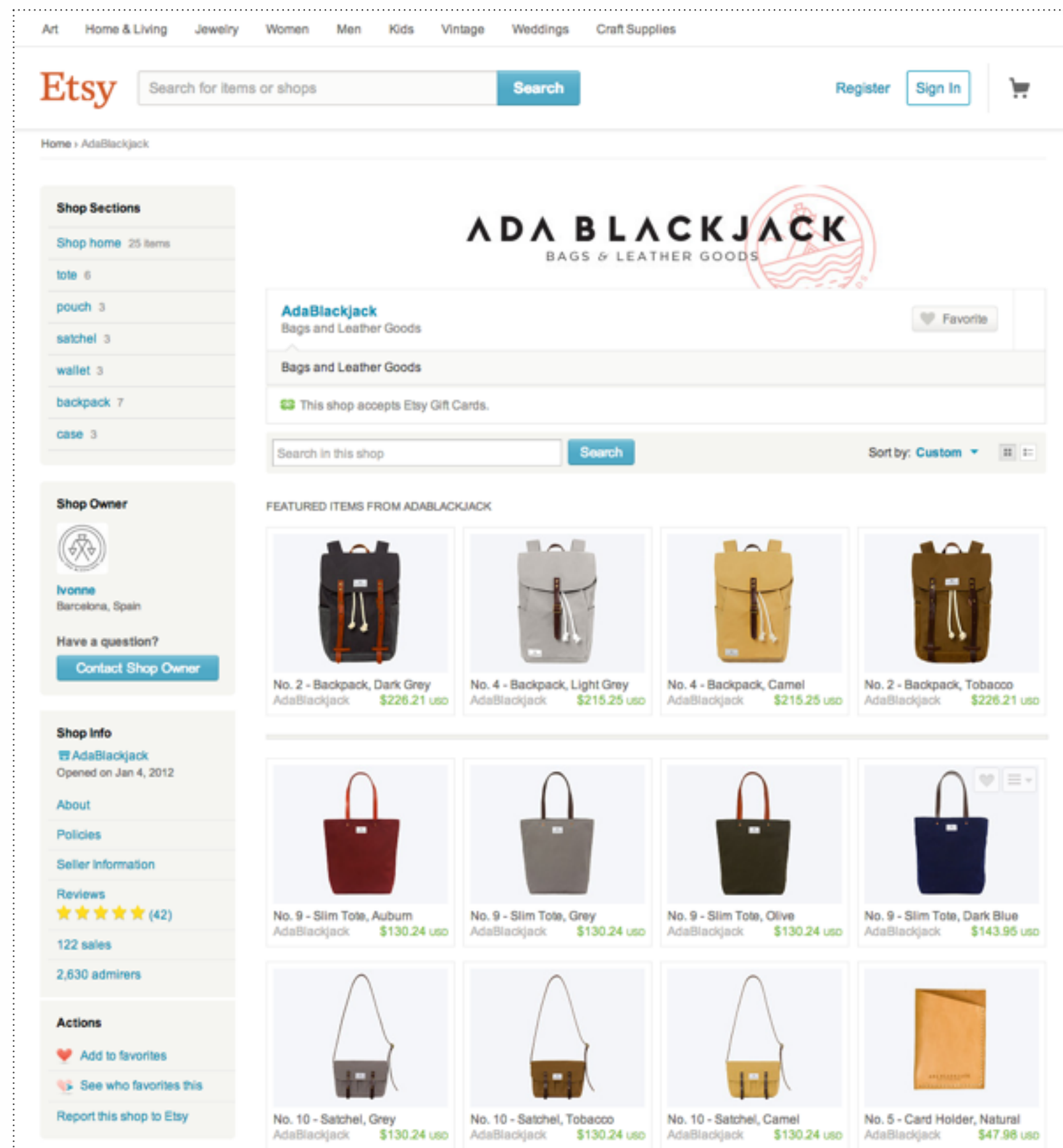
Overview

01 | Etsy Overview

02 | Discovering User Styles

03 | Generating Recommendations

Etsy is an online marketplace where people connect to buy and sell **unique** goods: Handmade, vintage, or craft supplies



Ivonne Schippers
Lucas Onofre
Barcelona, Spain

Etsy is an online marketplace where people connect to buy and sell **unique** goods: Handmade, vintage, or craft supplies

40M

Users

1M

Shops

26M

Listings

9

Languages

200

Countries

How to build recommender systems
for such a unique marketplace?

How do people typically use Etsy?

1

Browse
(Unintentional)

via the front page, browse pages or the activity feed

Search
(Intentional)
for a specific item

2

Favorite

an item or shop, and
add to collections with coherent
theme/style

Follow

another user with similar
style/interest

3

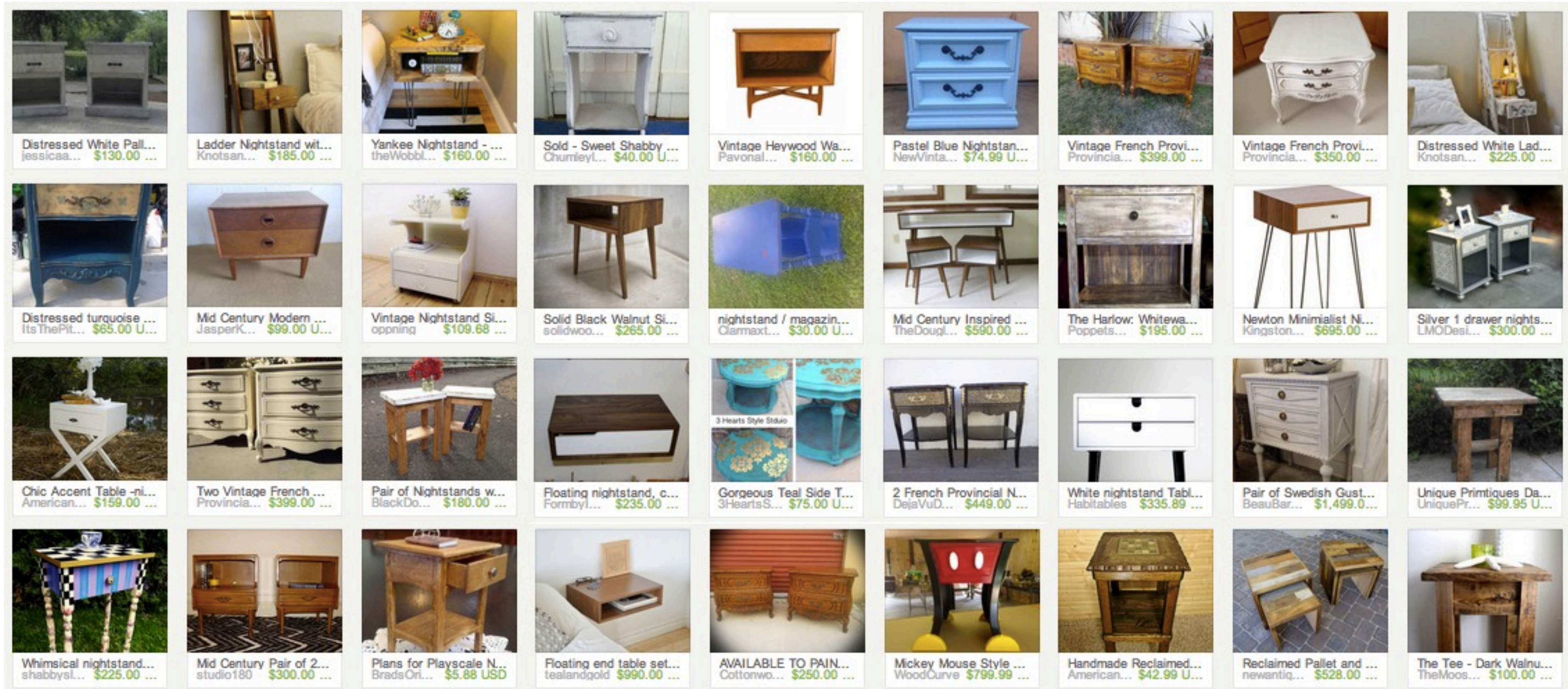
Purchase

an item

..... Typical E-Commerce Usage

















How do people decide what to buy?

Function and style. Example: search results for "nightstand" - 100+ pages







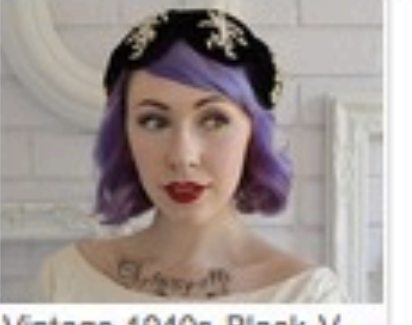











How to describe style?

Curated by Diane.

 <p>Wooden table lamp Lumetto 45 Luminairebois \$164.81 USD</p>	 <p>Vintage Mid Century Rolling Cart - b... ethanollie Sold</p>	 <p>50% SALE 4 kodawood mid century... misovintage \$1,250.00 USD</p>	 <p>white and tan vintage book collectio... LegalMissSun... Sold</p>
 <p>W1009 Washable Kraft Paper File F... Oliday \$13.00 USD</p>	 <p>C106 Brown Leather Camera Bag w... Oliday \$65.00 USD</p>	 <p>Vintage Pot by Melitta 1,0L Bauhaus... TheVintageSh... Sold</p>	 <p>Cado Wall Unit Mid Century Modula... OtherTimesVin... Sold</p>
 <p>Re-creation wood crate case moder... modernarchae... Sold</p>	 <p>many different colours! casual bag, ... lisberryhandm... \$254.30 USD</p>	 <p>Triple Shot Straight - 3 Bulb Hangin... dylangrey \$265.00 USD</p>	 <p>Felt Rock Box FaceAndEdges \$50.00 USD</p>
 <p>Terrain Tumblers - Set of two cerami... ssamnichots \$38.00 USD</p>	 <p>Small Grey White Wool Felt Genuin... FancyfeltShop \$54.00 USD</p>	 <p>Himmeli Diamond Star Light Penda... panselinos \$350.00 USD</p>	 <p>Tiny vintage style wooden box 'Rom... MissVintageW... Sold</p>

Curated by Laura and Steve.

 <p>NEW- Voodoo Black L... Debauch... \$10.00 USD</p>	 <p>antique boots / Antiqu... Planetcl... \$175.00 USD</p>	 <p>1800's Medical Blood ... richmond... \$511.45 USD</p>	 <p>Paper Garland - Black ... ScoutAn... \$14.08 USD</p>
 <p>1930s shoes / Depres... Planetcl... \$138.00 USD</p>	 <p>vintage biology model ... BerlinoVL... Sold</p>	 <p>Vintage 1940s Black V... Nevermo... Sold</p>	 <p>I Kiss and Tell - Circa ... CallMeC... \$105.00 USD</p>
 <p>beak baby mudstuff \$28.00 USD</p>	 <p>Rare French Antique C... EpoqueV... \$326.26 USD</p>	 <p>SET of 2 LARGE antiq... VintageP... Sold</p>	 <p>Vintage Hat 60s Black... charialana \$24.00 USD</p>
 <p>Owl moon. Owl talon c... BloodMilk \$150.00 USD</p>	 <p>Heart Lollipops, Black ... SweetCa... \$12.00 USD</p>	 <p>Vintage MONET Black ... SilentWh... \$32.00 USD</p>	 <p>Vintage 1950s Black L... SLVintage \$95.00 USD</p>

What Personalization Looks Like on Etsy

Recommendations
for **multiple intents**

Enhance browsing
experience, not just
purchases

Recommendations
for **multiple content types**

Develop unified method
for recommending shops,
items, users

Recommendations
based on **visual styles**

Identify user styles and
interests in a visually
transparent way

Overview

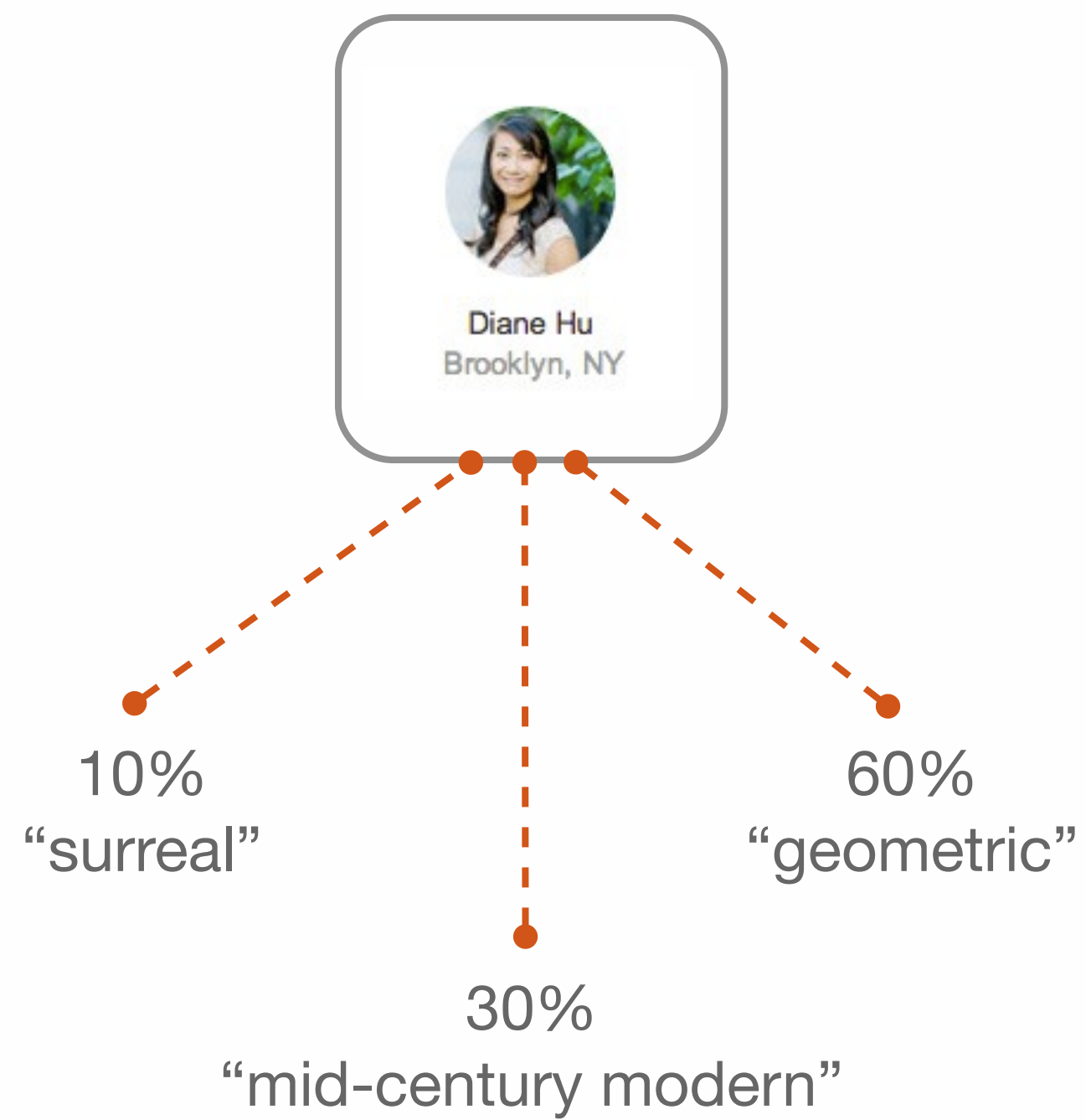
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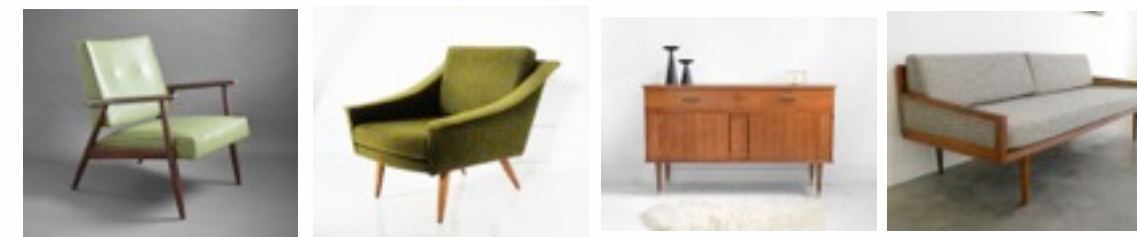
03 | Generating Recommendations

Solution Overview

1 Learn **style profiles** for each user using LDA

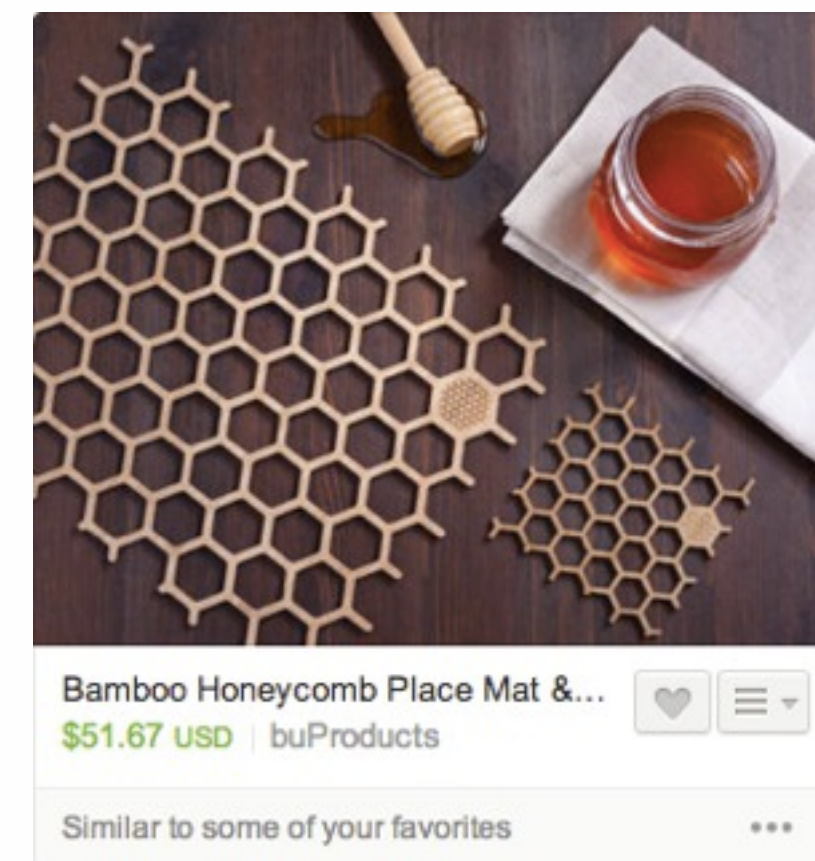


2 Define what each style looks like

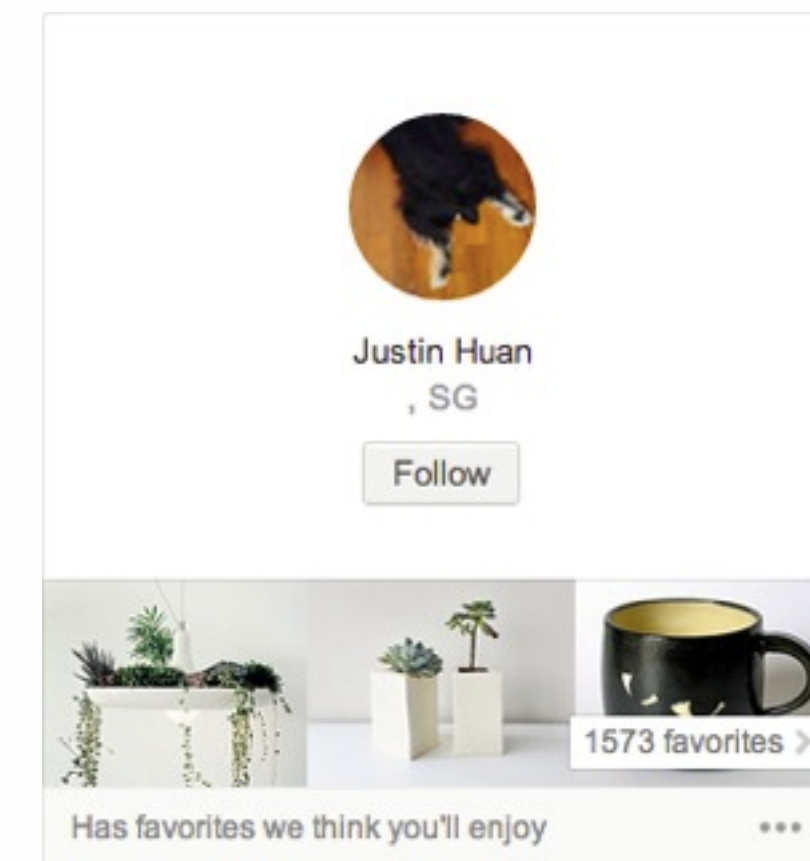


= "mid-century modern"

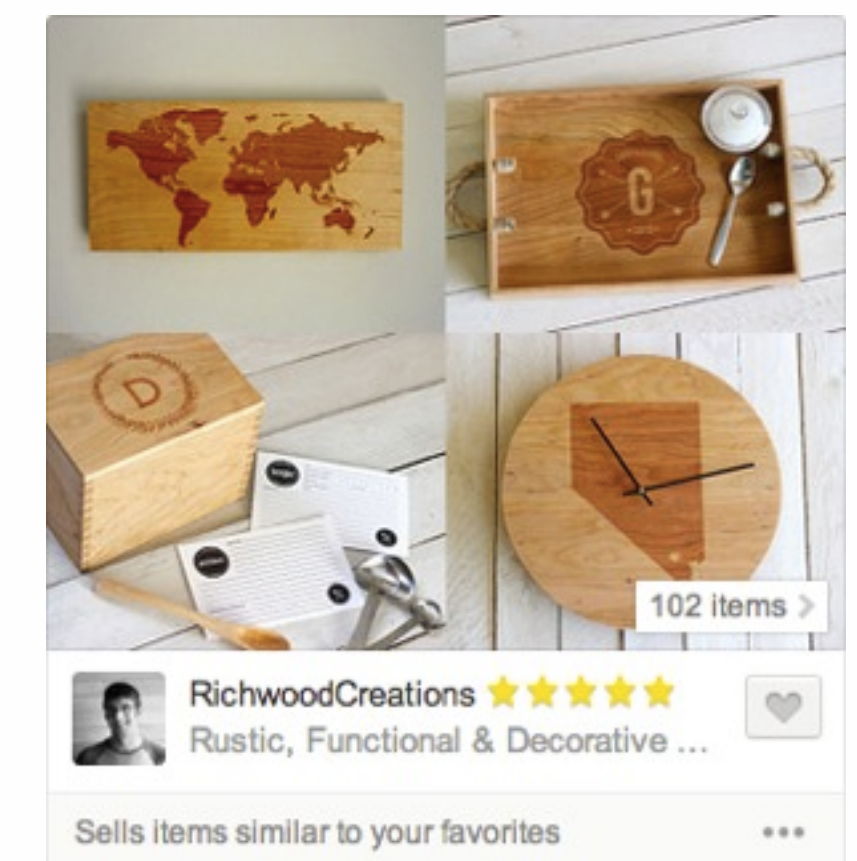
3 User style profiles to generate personalized content



ITEM RECS



USER REC



SHOP REC

Latent Dirichlet Allocation (LDA) for Discovering Styles

Assume: Each user's favorited items are generated by this process:

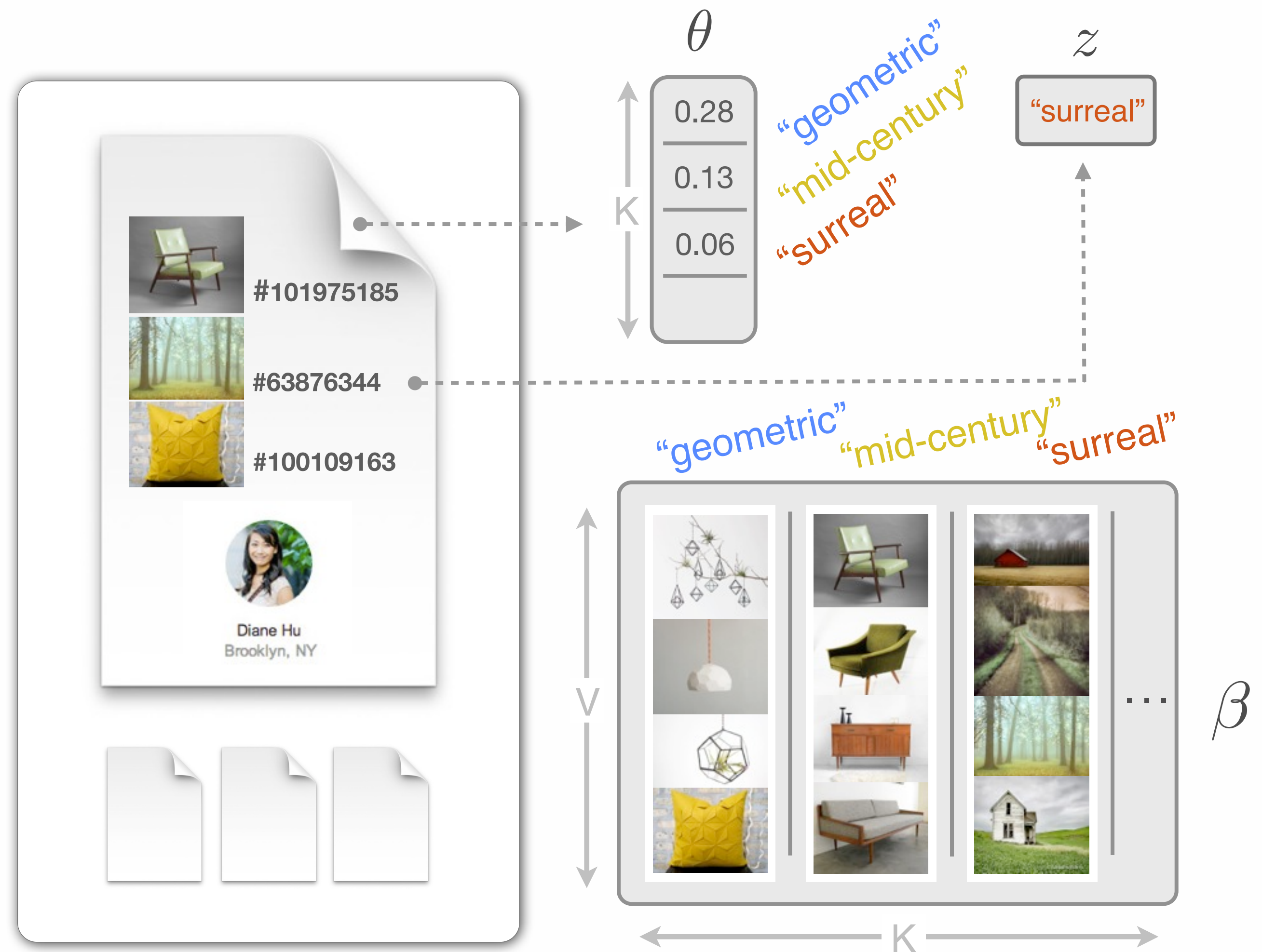
For each user u ,

1. Draw a style profile:
 $\theta \sim \text{Dirichlet}(\alpha)$

2. For each item, x_n
 that user u has favorited,

(a) Draw a style:
 $z_n \sim \text{Multinomial}(\theta)$

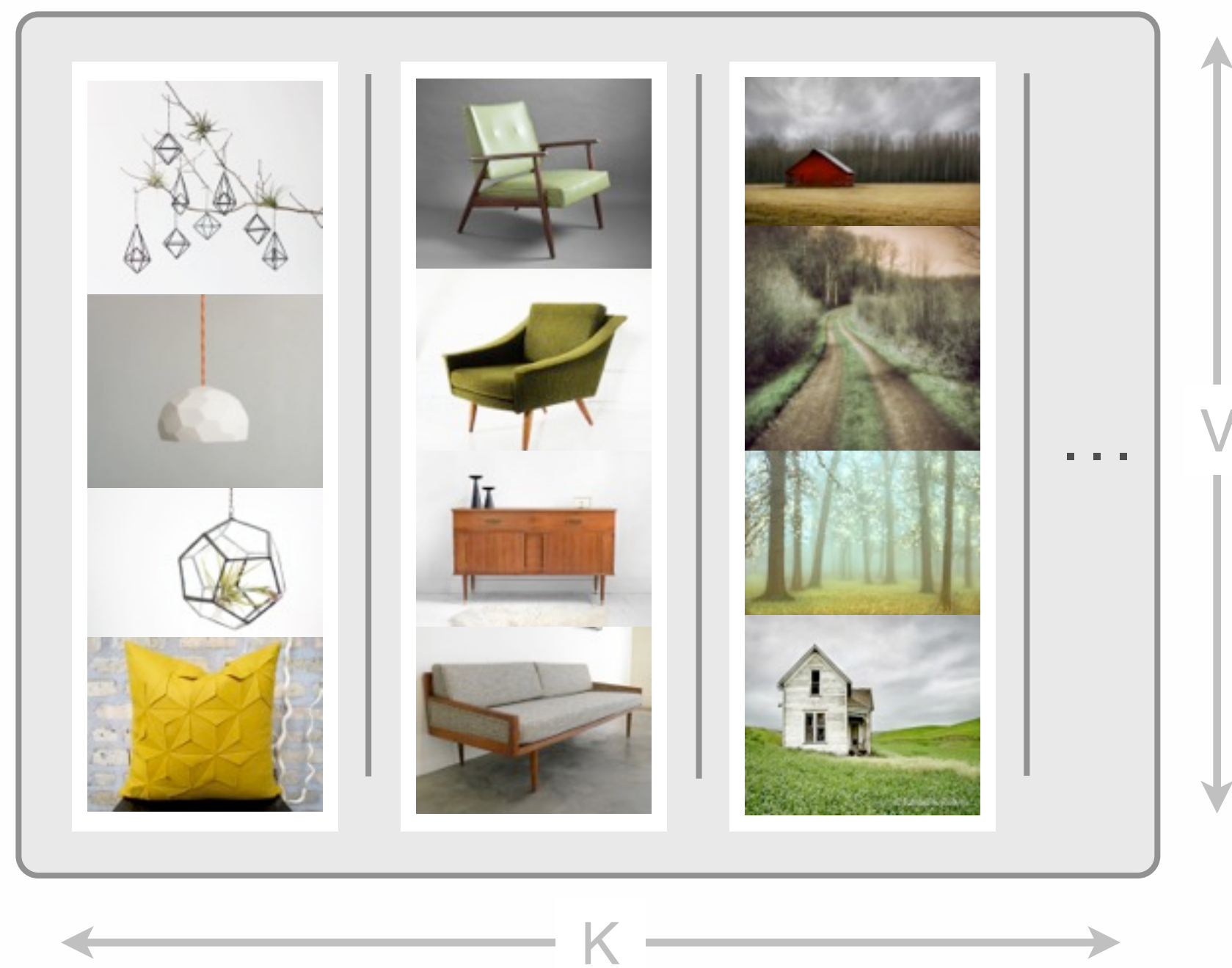
(b) Draw an item:
 $x_n \sim \text{Multinomial}(\beta_{z_n})$



Latent Dirichlet Allocation (LDA) for Discovering Styles

Discover popular styles on Etsy as a distribution over items

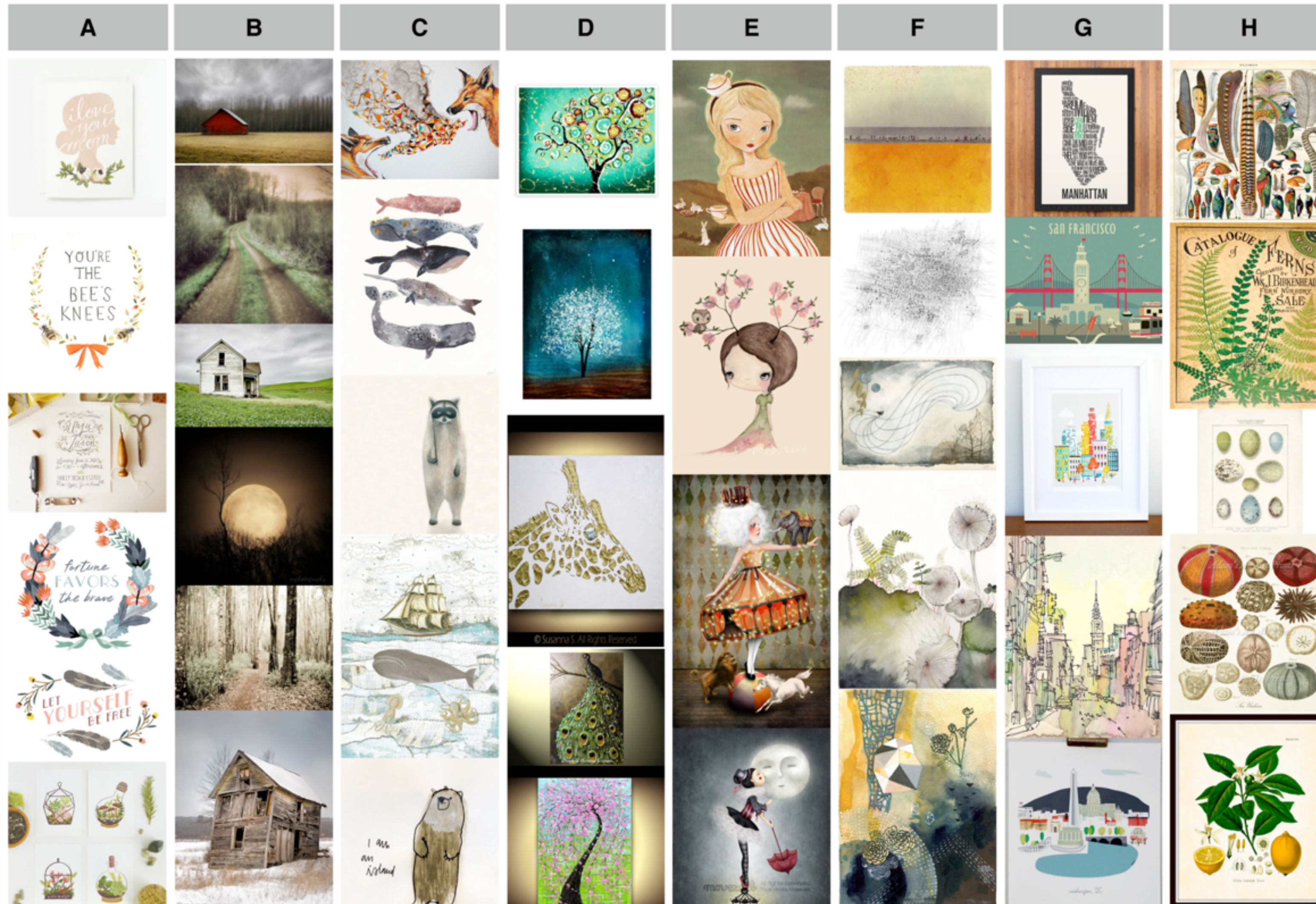
“geometric” “mid-century” “surreal”



Represent each user as a distribution over popular styles, i.e. “style profile”



Different styles discovered by LDA



Example of learned styles that contain art prints:

A = Botanical

B = Surreal landscapes

C = Whimsical

D = Acrylic/Abstract

E = French Dolls

F = Whimsical/Abstract

G = Cities

H = Vintage

Different styles discovered by LDA

ANIMALS



TENTACLES



GEOMETRIC



MID-CENTURY MODERN



Overview

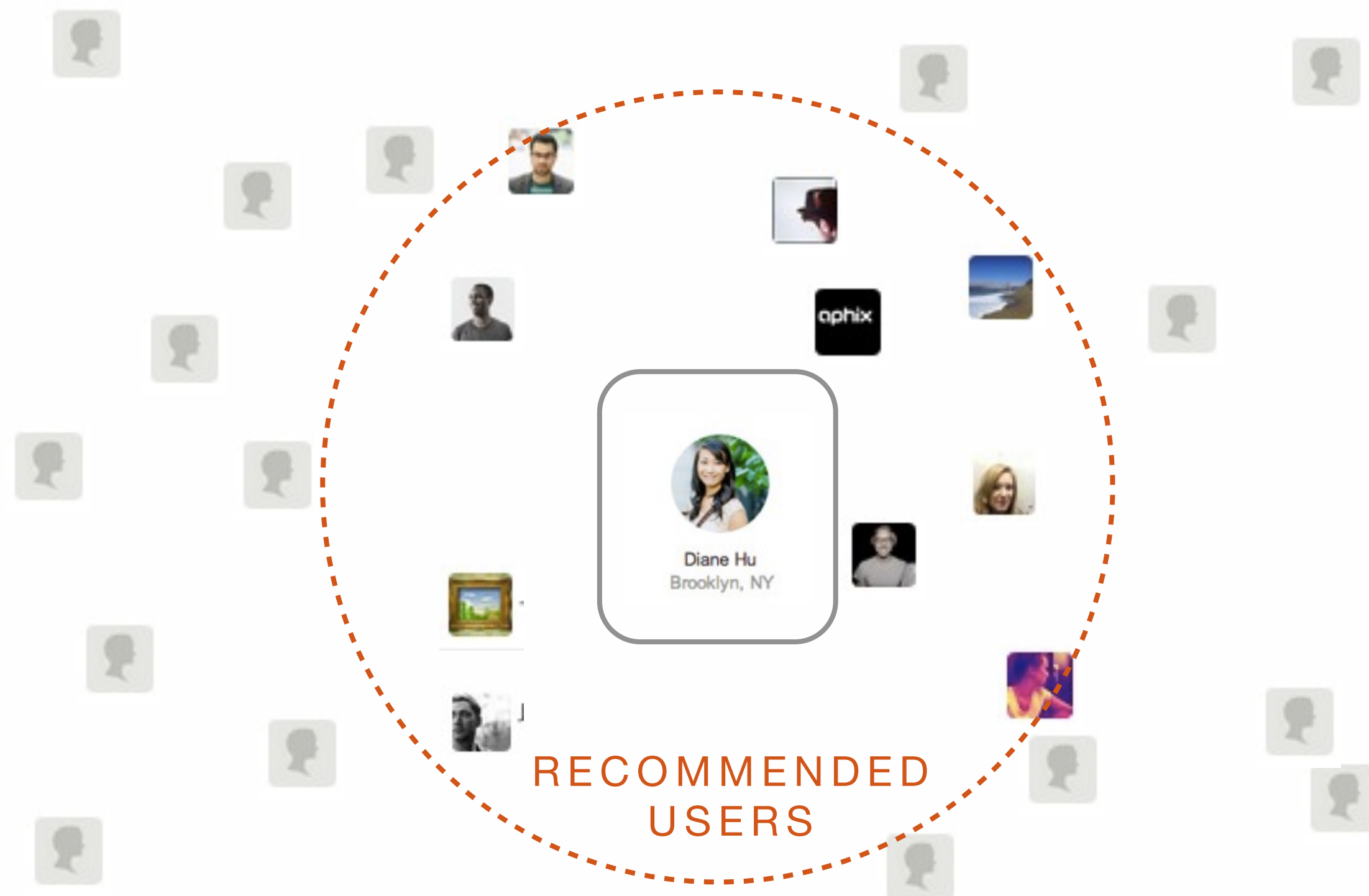
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User Recommendations

Given that each user has an style profile: **Recommend N users with most similar style profiles.**



Brute-force K-NN is too expensive. Hash similar users into the same bins, and perform K-NN within each bin

- **Locality Sensitive Hashing (LSH).** Create hash based on which side of a series of random planes the user falls onto.
- **"Top-K" Hashing.** Create hash based on set of all pairs of top-k topic indices.

Item Recommendations

Given that each user has an style profile: **Sample items most highly weighted styles**

USER'S FAVORITES



ITEM RECOMMENDATIONS



STYLE #428

STYLE #54



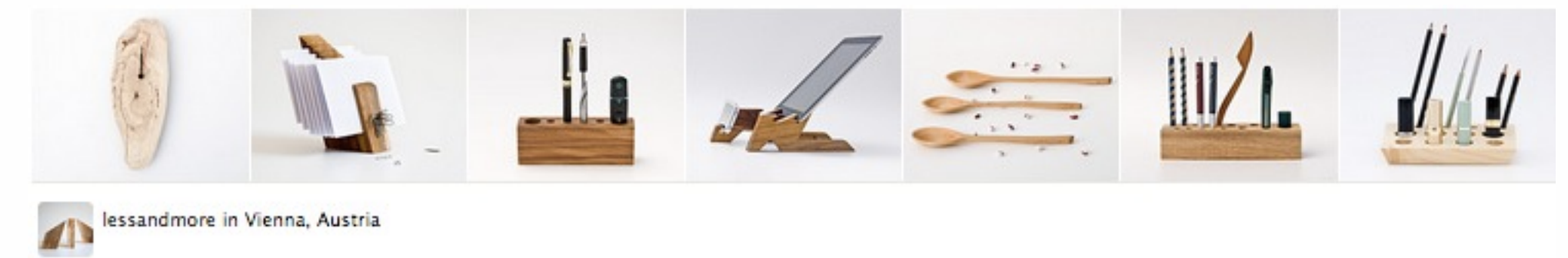
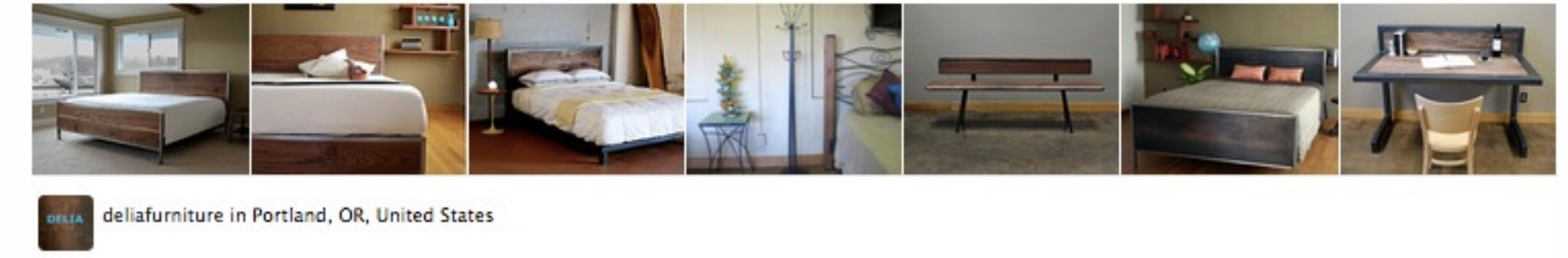
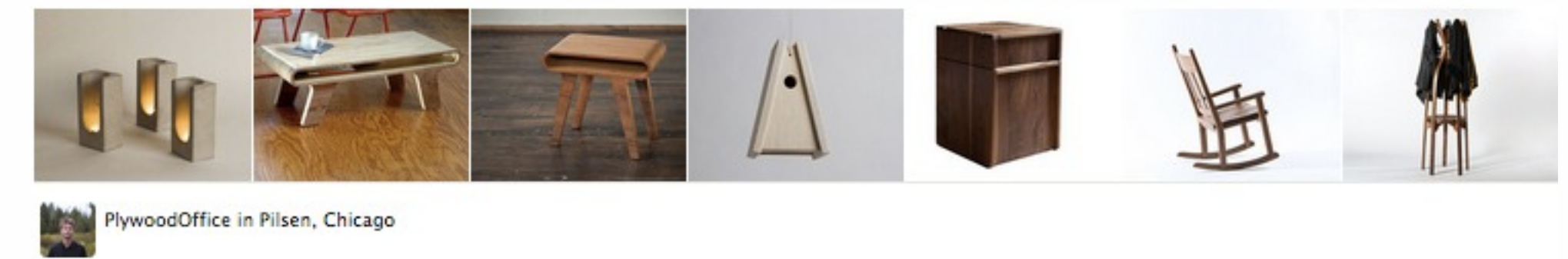
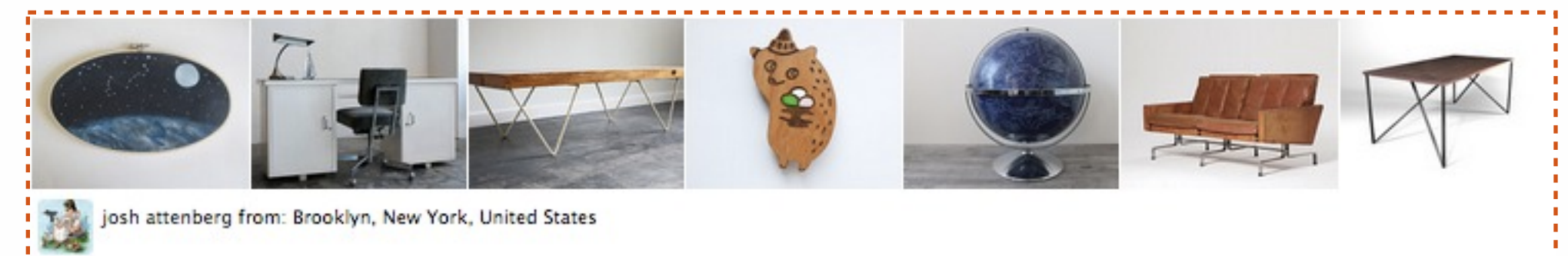
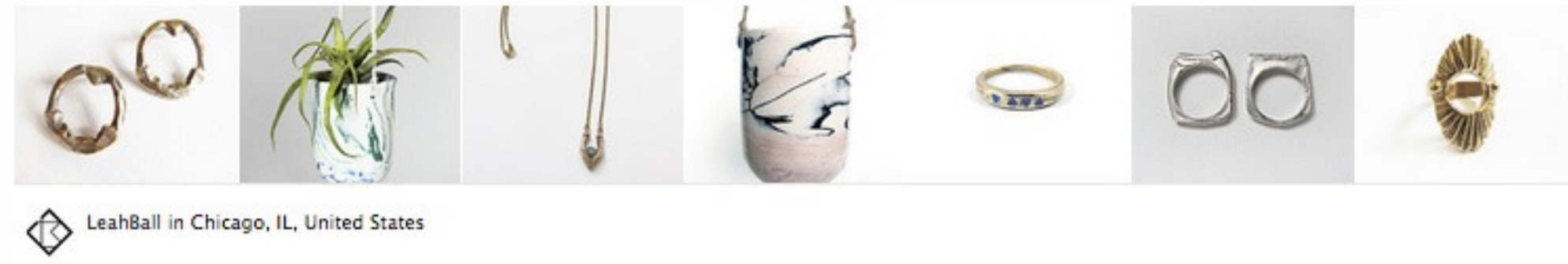
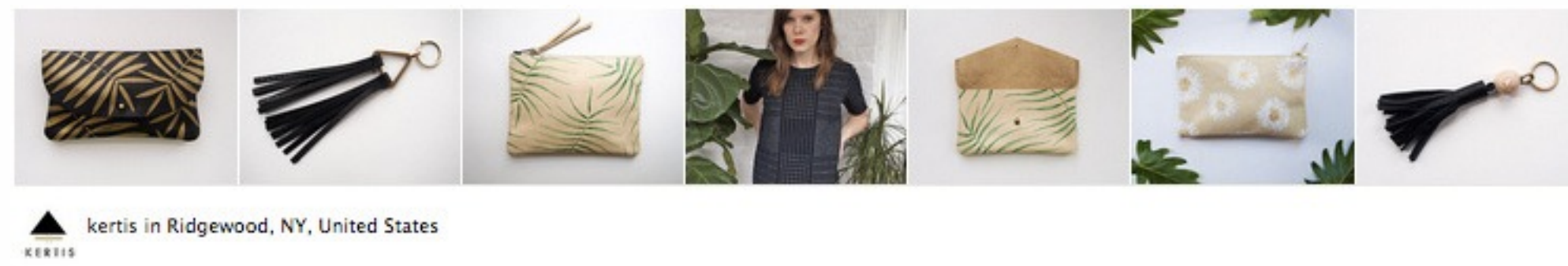
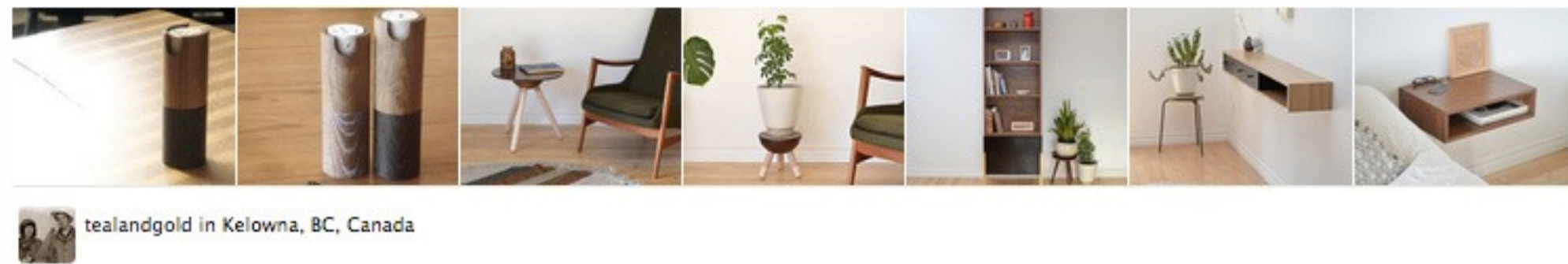
STYLE #655



STYLE #87

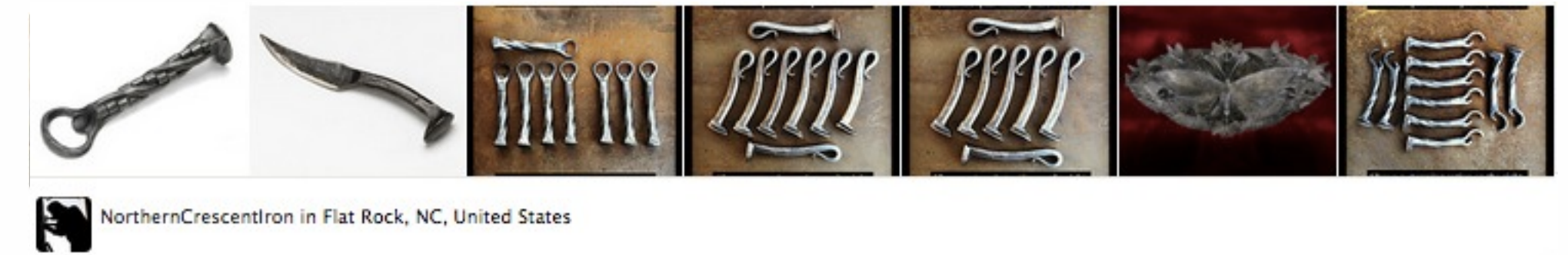
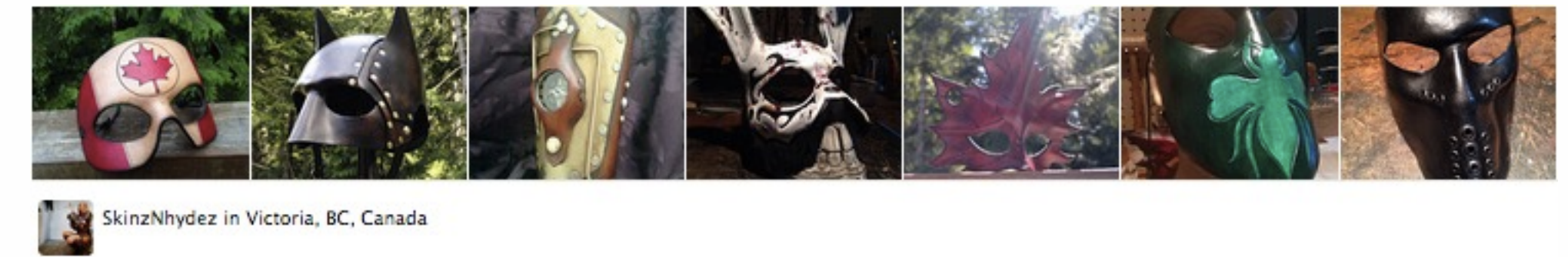
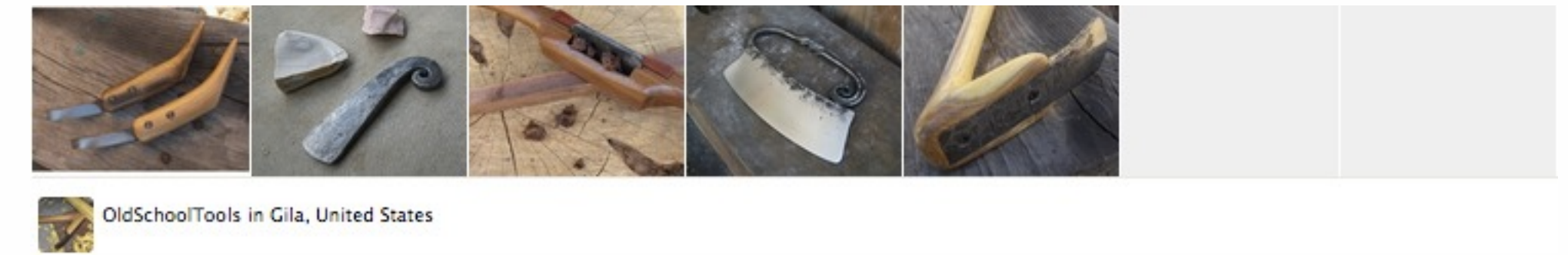
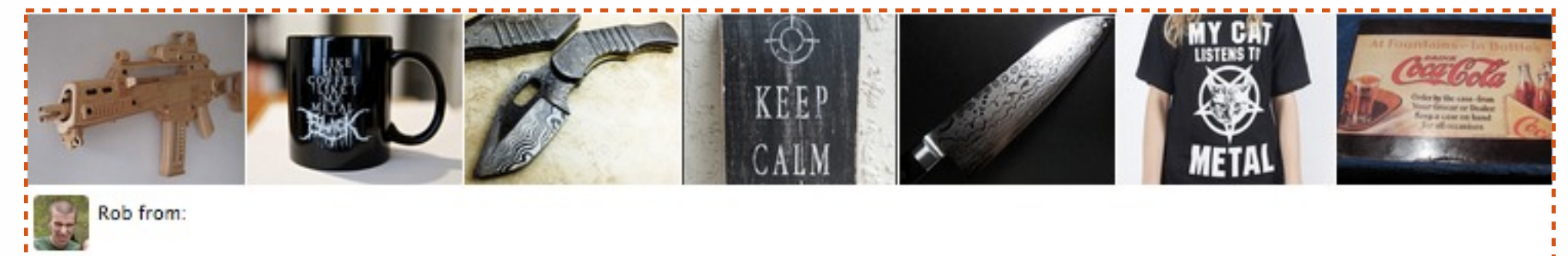
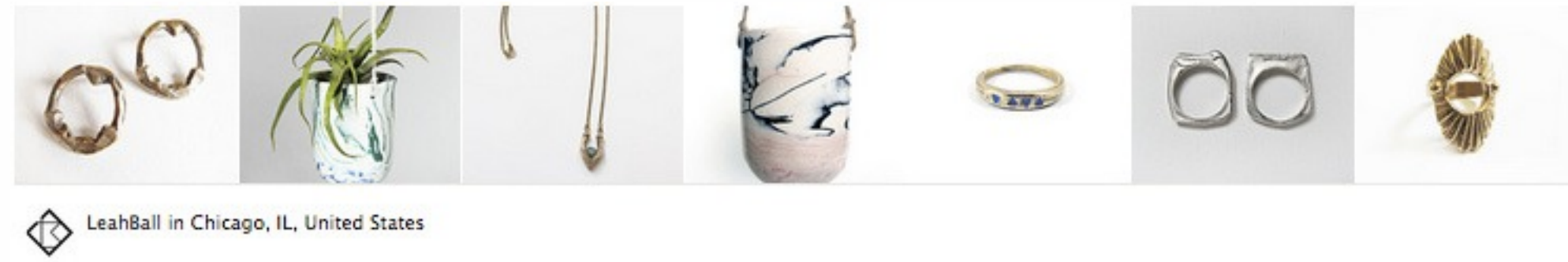
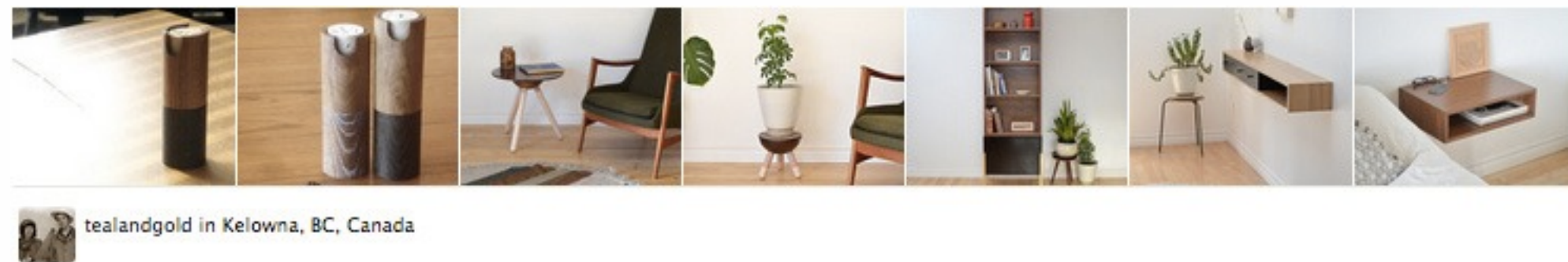
Shop Recommendations

Re-learn topic models substituting item ids with shop ids. **Sample shops from highly weighted styles**



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Re-learn topic models substituting item ids with shop ids. **Sample shops from highly weighted styles**



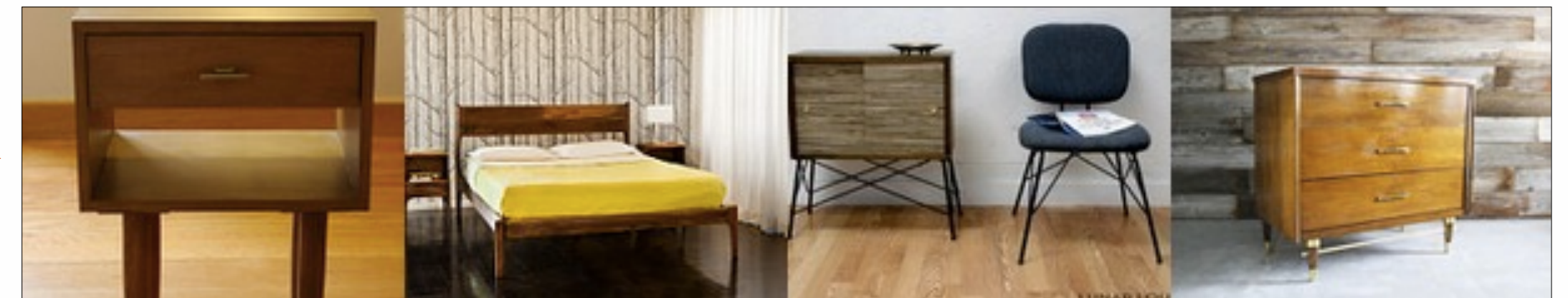
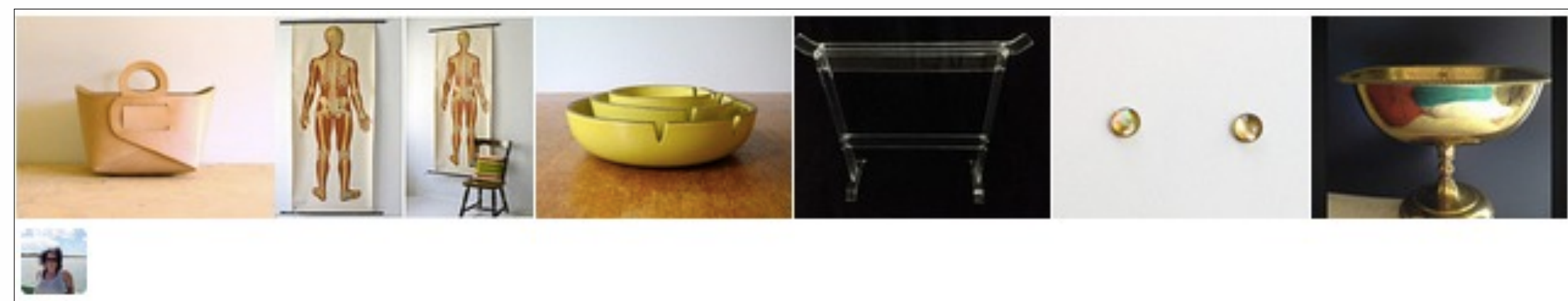
Recommending Styles within Categories

Find how overall styles translate into specific categories

USER'S RECENT FAVORITED ITEMS



RECOMMENDATIONS IN "NIGHTSTANDS"



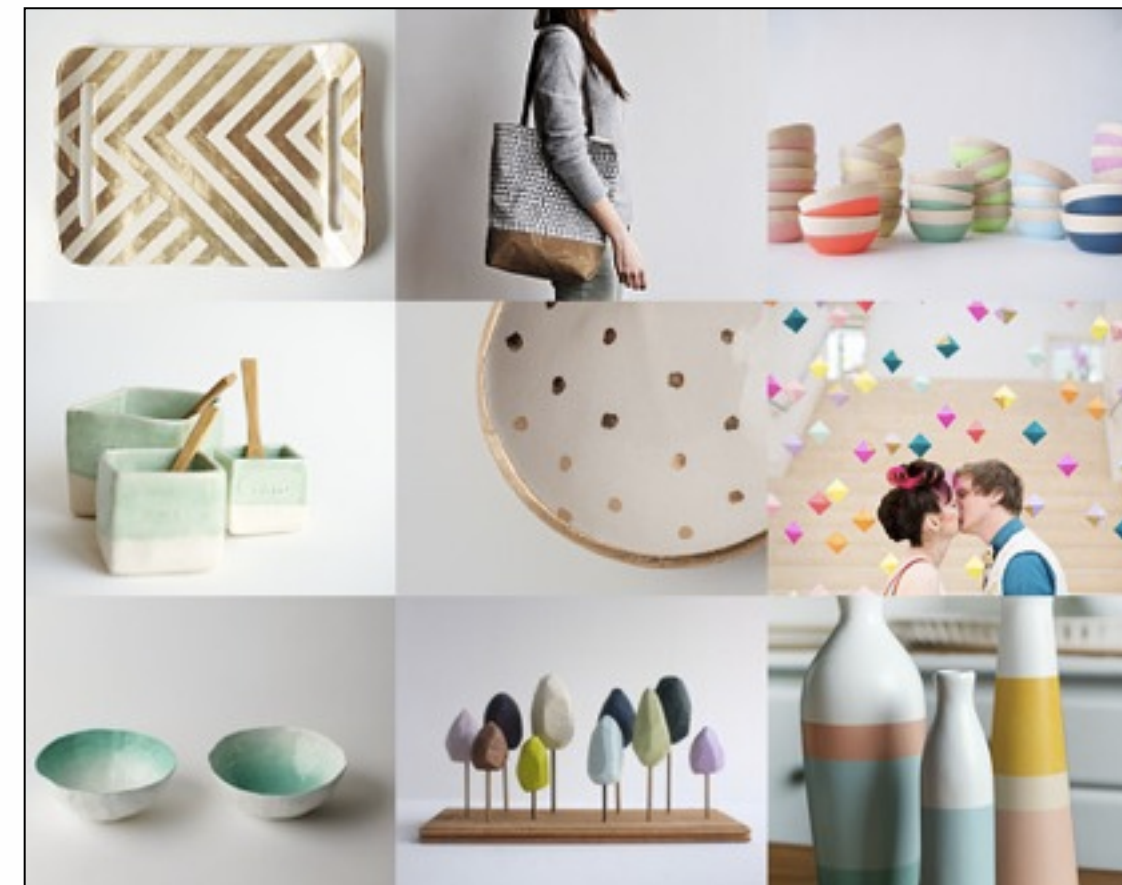
Visualizing Related Topics

Learn topic correlations from users' style-profiles.

STYLE #1



STYLE #2



STYLE #3



STYLE #4

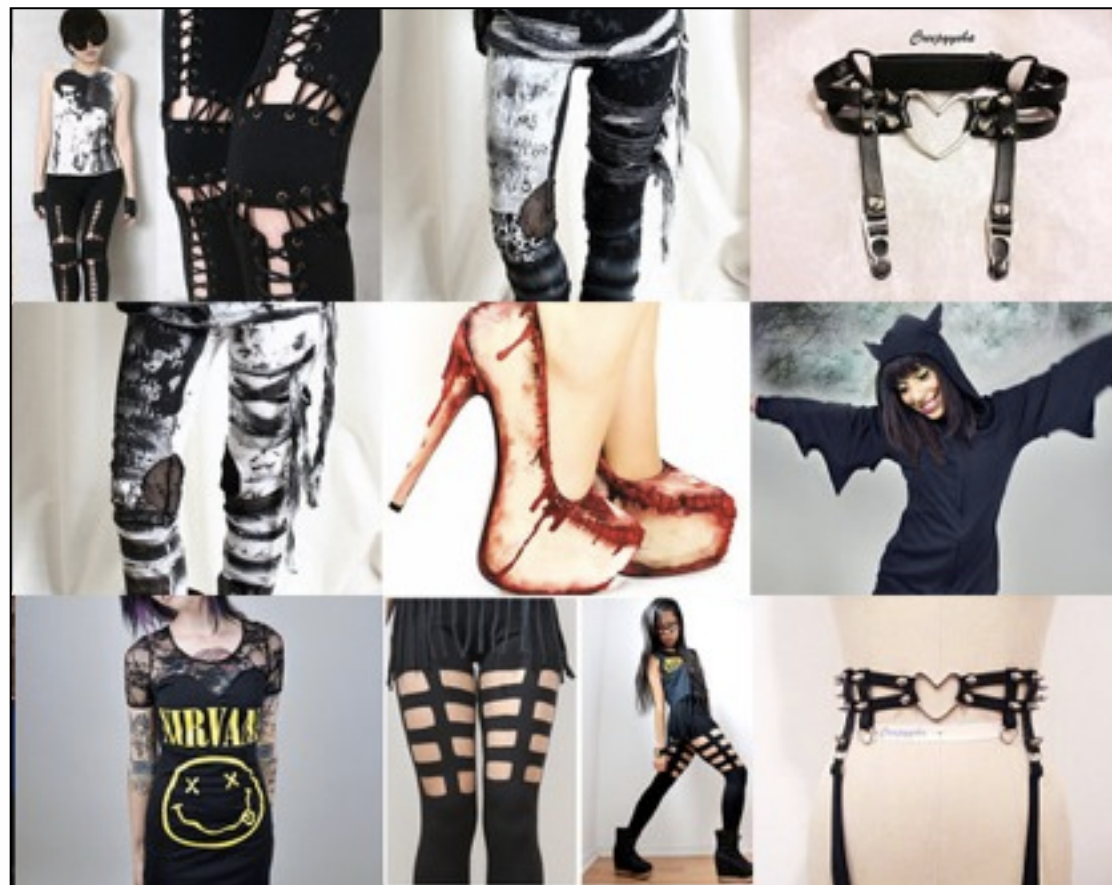


“Bright, Whimsical”

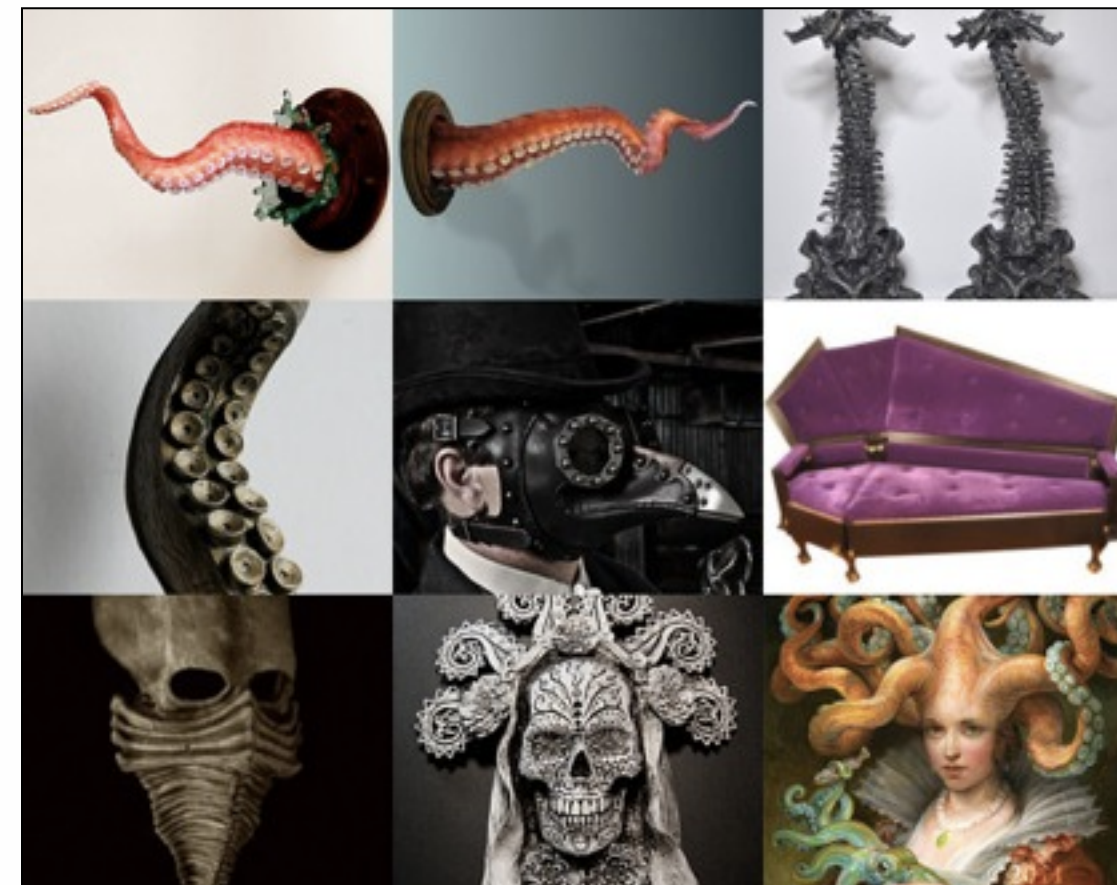
Visualizing Related Topics

Learn topic correlations from users' style-profiles.

STYLE #1



STYLE #2



STYLE #3

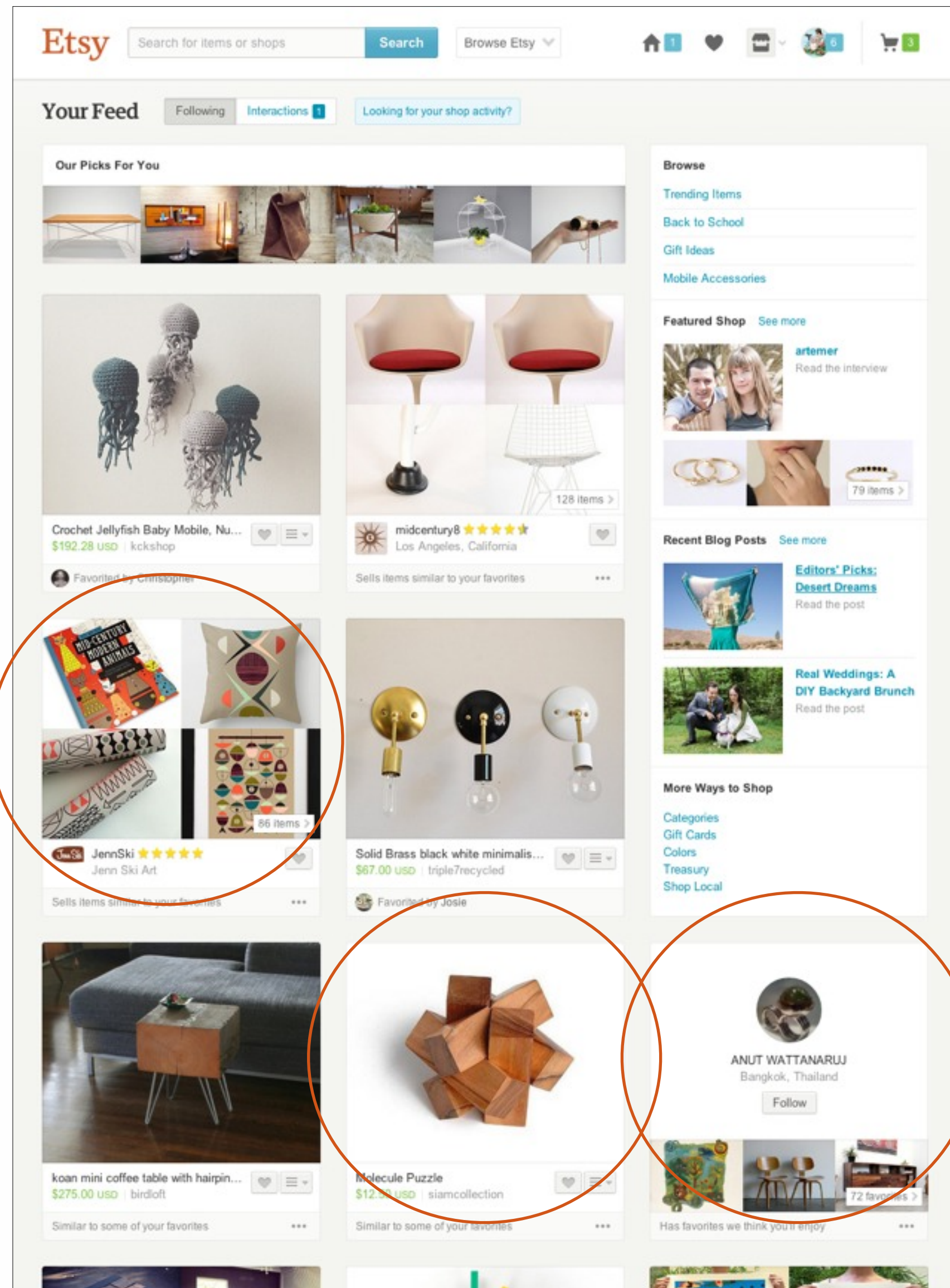


STYLE #4



“Gothic Punk”

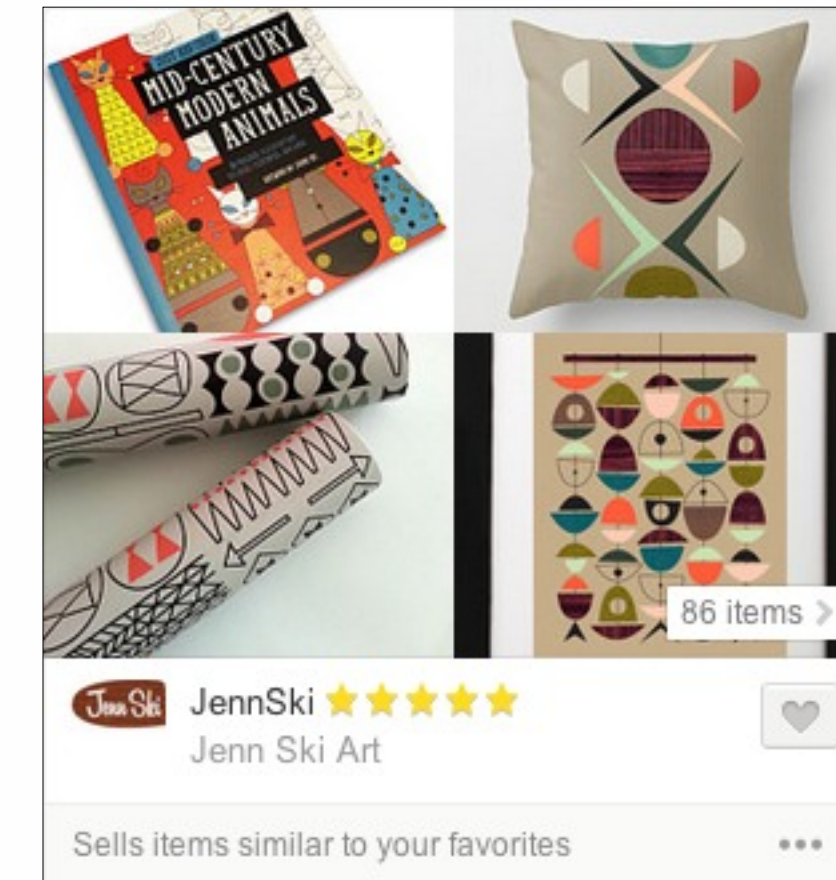
Recommendations in the Activity Feed



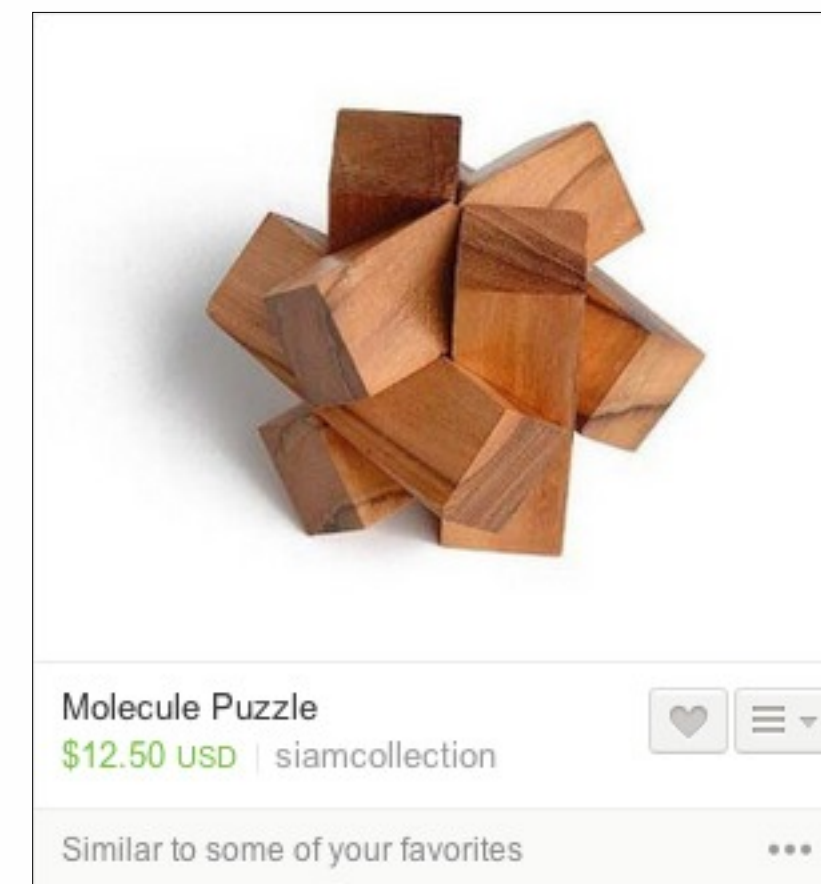
ORGANIC



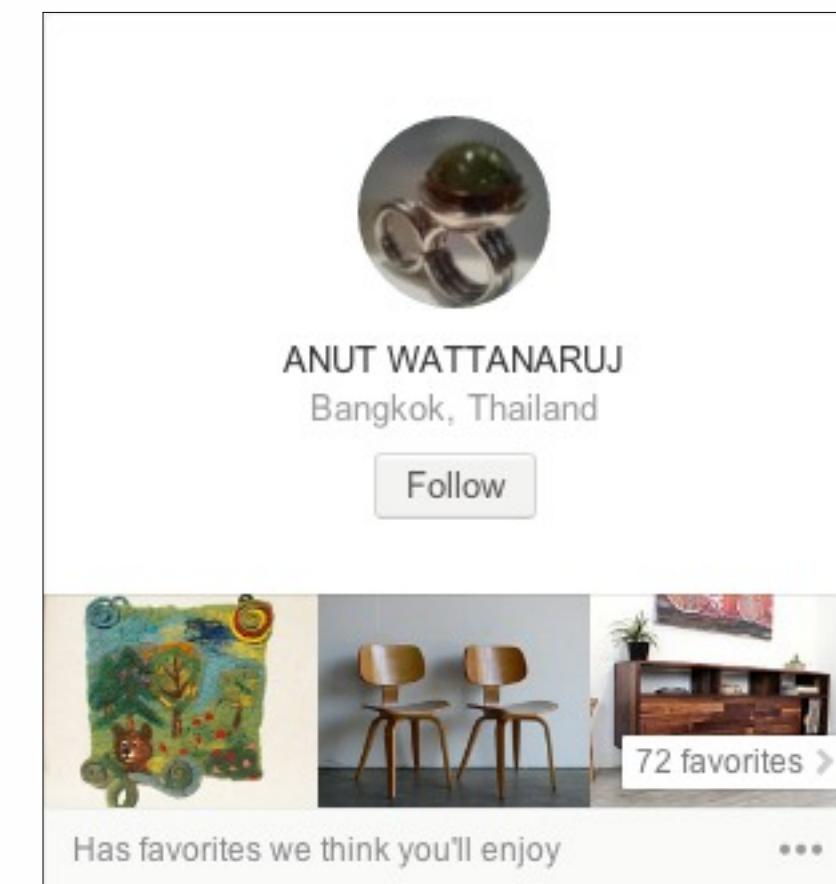
SHOP REC



ITEM REC



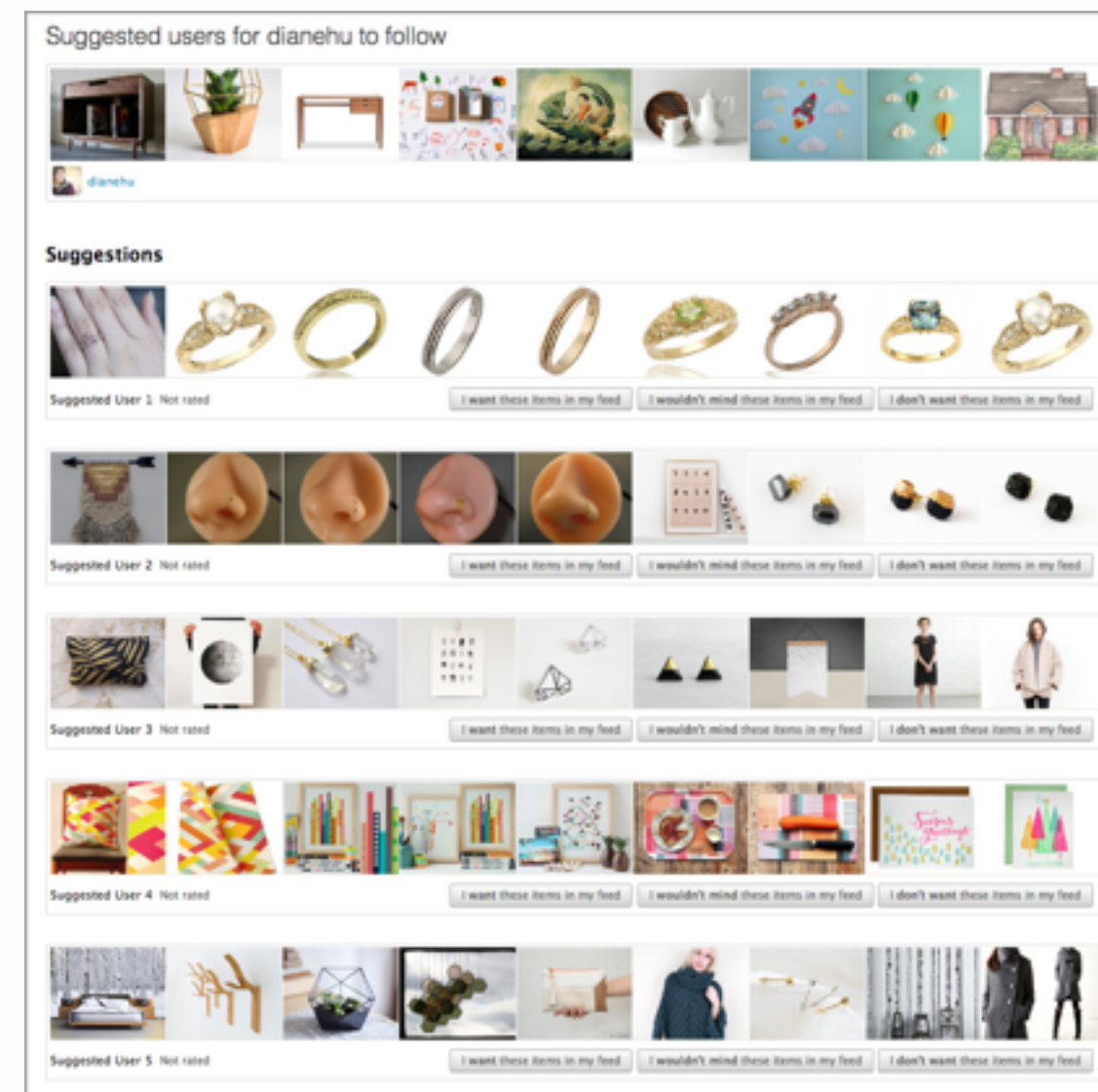
USER REC



User Recommendation Experiments

Side-by-Side User Study

- Randomly interleave user recs from 3 algorithms: (1) LDA, (2) TF-IDF w/ Cosine Similarity, (3) Triadic Closure
- User rated each recommendation positive, neutral, negative
- LDA was overwhelming winner



A/B Testing in Activity Feed

Phase One:

- LDA vs. No recs
- Significantly increased all business metrics

Phase Two:

- Different variants of LDA vs. Matrix Factorization (using Stochastic SVD)
- Matrix factorization and LDA comparable across business metrics

Conclusion

What We Did

- Identify styles across Etsy as a visual experience
- Generate style profiles that are visually transparent and capture diverse taste
- Build large-scale recommender systems:
 - for multiple content types
 - for enhancing browse experience
- Improve key business metrics

More Details On

- System/hard-ware set-up
- Scaling algorithms to ~40M users
- Experimental set-up and outcomes
- Product design for recommendations

Etsy