A Magazine or Spider Web?
Using Metaphors to Identify Folk Theories of Social Feeds

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ABSTRACT
Folk theories of cyber-social systems are people's intuitive theories developed to explain the consequences of technological systems. This paper introduces the Discover-Identify-Specify (DIS) method for examining folk theories and compares folk theories across two social feeds, the Facebook News Feed and the Twitter Feed. The DIS method (1) elicits metaphors about how a system operates, (2) uses factor analysis to identify underlying folk theories, and (3) applies semantic differentials to specify the attitudes and beliefs associated with each folk theory. The results from the three stages (N=6,529) reveal that there are four primary folk theories for the Facebook News Feed and Twitter Feed: the *Rational Assistant*, the *Unwanted Observer*, the *Transparent Platform* and the *Corporate Black Box*. There are, however, important differences in the strengths in which the four folk theories are held between the two systems.

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INTRODUCTION
Computational systems that support social behavior, from social network sites to online dating services, are incredibly complex. Not only do these kinds of cyber-social systems involve sophisticated software and network infrastructure they also encompass the behavior and interactions of millions of other people. Social network sites, like Facebook and Twitter, process billions of pieces of data from millions of different people every day, and these companies have developed sophisticated algorithms to make all this data usable and interesting to users.

While recent research has begun to make the presence of algorithms and the complexity of such systems more salient [9], it remains unclear how users make sense of the role that these algorithms and other computational processes play in their social lives.

Of course, humans are accustomed to engaging with complex social and physical phenomena other than social network sites. For example, knowing that gravity has specific effects on physical objects allows people to move safely through the world, though few people have a grasp of the physics of gravitational forces. Understanding how another person might feel after being socially rejected is important for predicting how that person might react with sadness or anger [5], though few people are versed in social neuroscience. People must regularly reason and predict how systems operate without fully understanding how they work [9, 23]. To accomplish their goals within these complex systems people rely on *folk theories* [9], which refer to the implicit but causal and explanatory understanding people hold about a system, whether its gravity or other minds.

The goal of the present paper is to examine the folk theories that people hold about cyber-social systems, which involve complex interplays of one's own behavior, the behavior of others, and computational processes. In the context of cyber-social systems, we draw on [6]'s definition of folk theories as "intuitive, informal theories that individuals develop to explain the outcomes, effects, or consequences of technological systems, which guide reactions to and behavior towards said systems" (pg. 3). We focus on folk theories of one specific, but pervasive form of cyber-social system, the social feed, comparing across two prominent social network sites, Facebook and Twitter.

Folk Theories and Cyber-Social Systems
There are several motivations for understanding people's folk theories about cyber-social systems that can help researchers and designers better understand users, as well as help guide system design. First, a user's beliefs about how cyber-social systems work can help contextualize why people behave in certain ways when using these systems [8]. Second, technology design can be enhanced when a user's reasoning about the technology is understood and incorporated in the design process [19]. Understanding user

expectations can help a system avoid violations of those expectations by better communicating how the system works or adapting the system to fit expectations.

Though algorithms operate in the background, past research suggests that people engage in sense-making processes to understand algorithmic output. Research on work management algorithms found that drivers for Uber, a car-sharing application, rejected and accepted drive assignments depending on if the algorithm's decision made sense to them, even accepting inconvenient assignments as long as they believed they understood the reasons behind the decision [18]. Previous work on the Facebook News Feed found that many users first noticed the algorithm when they experienced expectation violations, including posts presented in non- chronological order [22]. When expectations were violated, users often speculated about the algorithm, constructing theories about what the News Feed was trying to show them (e.g., interesting posts), or how it was making its decisions (e.g., I see posts by people I comment on) [8].

Building on this initial work, Eslami et al. [7] outlined a detailed list of folk theories that users have about how the Facebook News Feed organizes their content. In their sample, less than half of participants were aware that the News Feed was filtered at all by an algorithm. Amongst the people that were aware, a large proportion of people held a *personal engagement folk theory*, where people reasoned that one's own behavior was important to the algorithm, such as the posts people liked and commented on. Some users held a *global popularity folk theory*, which was associated with beliefs that posts receiving a large amount of engagement were prioritized. Other users held a *narcissus folk theory*, which reasoned that posts from people with similar interests were prioritized.

Using a different approach, Devito et al. [6] identified people's folk theories of the Twitter Feed through a content analysis of tweets reacting to the news of a potential algorithmic change. In contrast to the specificity of folk theories uncovered by [7], Devito et al. [6] found that most people conceptualize algorithms abstractly as either generic forces that affect content ordering, an absence of chronological ordering, or as a force that acts similarly across all platforms. While some held abstract folk theories, the authors found that others held more operationally-oriented folk theories, identifying criteria they believed would influence the curation of the feed, such as the popularity and relevance of a tweet, as well as the extent that Twitter could benefit from promoting a tweet [6].

This line of work highlights that folk theories can be identified in a number of ways. Folk theories can be elicited by direct questioning [e.g., 7,8], and these theories take a concrete, mechanistic form, where people outline specific causal explanations for system operations (e.g., I am seeing this post because I interact frequently with the poster). Folk theories can also be elicited indirectly, using methods like content analysis [e.g., 6,14]. In contrast to direct elicitation, the folk theories elicited indirectly were more abstract, partially formed, and rarely explicitly articulated. These folk theories were also more global and included beliefs about not only the algorithm, but also about the interplay between the company and the algorithm [6].

The Discover, Identify and Specify (DIS) Folk Theory Method

Folk theory research has provided a foundation for understanding how people reason about social feeds. However, previous work has been limited to examining a single platform and has emphasized either the abstract or concrete nature of folk theories. As a result, it is difficult to synthesize and draw conclusions across extant studies. The present paper integrates these aspects of the literature by (1) mapping people's abstract folk theories onto concrete attitudes and beliefs about how a system works and (2) generalizing folk theories beyond a single system by comparing the Facebook News Feed and Twitter Feed.

To do this, we developed the Discover, Identify and Specify (DIS) method for assessing folk theories in cyber-social systems. The DIS method involves three distinct but inter-related stages. The *Discover* stage elicits metaphors about a system by using Wiki-survey, a collaborative form of survey that allows respondents to submit user-generated metaphors about a system [24]. The *Identify* stage uses factor analysis to identify metaphors that are highly correlated. Metaphors that load together on a factor are conceptualized as representing an underlying folk theory. The *Specify* stage uses semantic differentials to assess the attitudes and beliefs associated with each folk theory (e.g., is the feed informative, is the feed curated, etc.).

We apply the DIS method to the algorithmic component of two important cyber-social systems, the Facebook News Feed and Twitter Feed. Twitter and Facebook share some functions and have similar affordances. They both establish connections between people via friends or followers, provide a form of self-representation via a profile or bio, and afford the sharing of information between people via status updates or tweets, and aggregate that sharing into some sort of feed for users [5]. However, these systems differ in important ways. Both the Facebook News Feed and Twitter feed are algorithmically curated, but present this information to users in different ways. Twitter will collapse tweets into a "Show Me More" button to reduce content overload and "Tweets you may have missed" to surface older content. In contrast, Facebook's News Feed is determined by a proprietary algorithm that ranks content based on a number of factors, such as how frequently a post has been liked or the popularity of the poster [20].

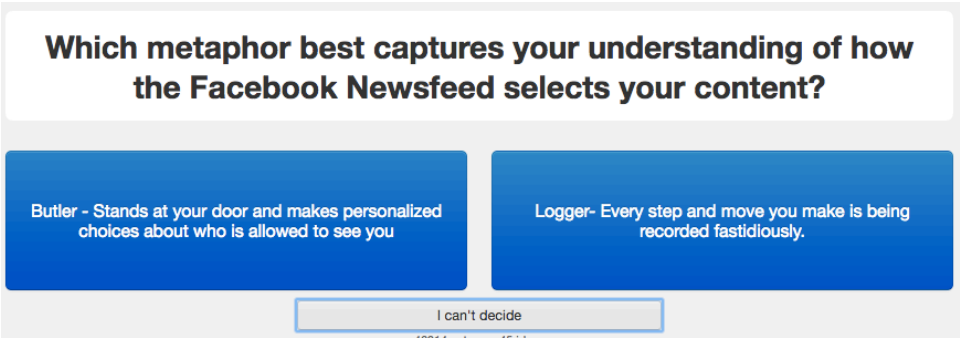

Figure 1. Wiki-survey Interface

However, Facebook relies on a seamless design that does not provide people any signposts indicating curated content [7]. The similarities and differences make these two social network sites useful points of comparison for understanding how people think about systems designed to share and communicate social information.

Our findings from applying the DIS method to both of these systems reveal that there are four remarkably similar folk theories for both the Facebook News Feed and the Twitter Feed, suggesting that a small number of core folk theories may be able to capture people's current beliefs about social media feeds. There are, however, important differences in the strengths in which the four folk theories are held for the two systems.

STAGE 1: METAPHOR DISCOVERY

The first objective in folk theory research is uncovering the unarticulated notions of how a complex system operates. An important characteristic of folk theories is that they are unstated and implicit [2, 9], which makes uncovering folk theories methodologically challenging. When prompted, people often will construct explanations in the moment, often believing they understand the system more than they actually do [23].

The use of metaphors is a common way people convey novel information, including information about system design [16,17]. Email clients rely on an 'email is postal mail' metaphor to convey that an email will be sent to only the recipient. Mac computers rely on a 'deleting files is throwing away garbage' metaphor to convey that files will remain in the trashcan until the trash is emptied. These metaphors reveal information about how systems work by leveraging knowledge of familiar objects. Sease [25] argues that metaphors act as bridges between abstract concepts and concrete attributes and thus can act as a bridge between the user interface and a user's understanding of the system. We leverage this notion by using people's metaphors for the Facebook News Feed and Twitter Feed as insights into their implicit folk theories of how these systems operate.

To do this, we used a novel class of survey instrument, called a Wiki-survey that allows participants to contribute items to the survey instrument itself [24]. The collaborative nature of the survey permitted respondents to provide metaphors for the two feeds that were not anticipated by the researcher. Unlike traditional surveys that provide an "other" box, any new metaphors from participants were presented to future respondents for evaluation. Thus, the survey construction is partially created by its respondents, making it ideally suited for exploratory research.

Methods

Participants were recruited from Mturk and paid $0.25 total for participating. We recruited participants until two stopping conditions were met: first that no unique metaphors were being added to the Wiki-survey instrument by participants, and second that the ranking of the metaphors stabilized such that the votes of new participants were unlikely to change the ranking of the metaphors. For the Facebook sample, N = 1471 people voted 46,914 times. For the Twitter sample, N = 1,904 people voted a total of 39,487. The median number of times a participant voted on the Facebook Wiki-survey was 9 and on Twitter was 6. Note that the Wiki-survey [24] did not have the functionality to collect demographic data.

Procedure

On Amazon Mechanical Turk, participants were given instructions that they would be presented with two words that are unrelated to the Facebook News Feed/Twitter Feed and were asked to choose which one they believed was a better metaphor for how the feed selects the content it shows. They were told that they had the option to enter their own word if they thought of a more appropriate comparison We defined 'metaphor' broadly for participants as identifying similarities or making connections between two seemingly unrelated things.

Participants were then provided a link to Salganik & Levy [24]'s All Our Ideas Wiki-survey where they saw the question, "What is the best metaphor for how the Facebook News Feed [Twitter Feed] selects your content?" Participants were presented with two metaphor options in a head-to-head comparison, or they could choose to submit their own response that then enters that metaphor for future voters. For both the Facebook and Twitter samples we seeded the Wiki-survey with 13 initial metaphors (decision tree, coin sorting, butler, night club bouncer, recipe, water

Facebook Feed		P(win)	Twitter Feed		P(win)
Magazine*	collection of various stories/topics that might interest you	.60	**Surprise***	Never know what will show up there	.75
Personal Shopper*	choosing and offering just the content I am most likely to want and interact with	.59	**Tree***	There are thousands of leaves and you can look at the ones you find interesting	.68
Paparazzi*	Scrambling to show you what's hot and popular	.59	**Spider Web***	Conversations going off in all directions	.67
Network TV*	They pick what you see and you decide what to watch	.58	**Newspaper***	"What's new in the world today" sort of feed	.65
Decision Tree	You make a series of choices, which together determine some result	.57	**Large Salad***	Mixes all the ingredients from different sources gives them back to you	.63
Spy*	Consolidating your viewing, browsing and messaging into a readable format	.57	**Coin Sorting**	Types of content are sorted and responded to if they satisfy	.61
Jigsaw Puzzle*	I see little pieces of everything	.56	**Grocery Store***	Each topic is separated into departments, and your viewing is based on what you've shown to buy most	.60
Personal Assistant*	Makes use of things that are important to you and presents it	.56	**Bad Assistant***	Personalized content they think you want, but don't really	.60
Coin Sorting	Types of content are sorted and responded to if they satisfy	.56	**Decision Tree**	You make a series of choices, which together determine some result	.60
Menu*	This is what we want you to see and you can only choose from what we offer you	.55	**Grocery Store***	Topics sorted into departments and your shown what you "buy" the most	.60

Table 1. Top 10 metaphors for the two feeds. Asterisks indicate that metaphor was user-generated.

filter, black box, input-output, Rube Goldberg machine, magic, dominos, lock, and e-mail). The authors and research assistants chose the seeded metaphors after iterative discussions of potential folk theories of social feeds and relevant metaphors.

The format of the Wiki-survey options included the metaphor and a one-sentence elaboration. For example, a participant could choose option A (e.g., black box – you put some input in and some output comes out) or option B (e.g., coin sorting – types of content are sorted and responded to if they meet set criteria) or they could enter their own response (e.g., Stalker – watches everything you do). Subsequent participants would then see this new option in future pairwise comparisons.

After a choice was made, a new pair-wise comparison between two metaphors was automatically generated from the metaphor list, which included the seed metaphors and the participant-generated metaphors. Participants were only asked to complete one pairwise comparison, but were free to continue if they wished (see [24] for how repeated votes were modeled). After they made their choice(s), they were asked to return to the Amazon Mechanical Turk site to indicate which metaphor they preferred overall as an indicator of completion and then, exited the HIT.

Results and Discussion

The All Our Ideas survey uses responses to construct an opinion matrix, and summarizes the matrix to calculate the probability that any response would be chosen over a randomly chosen option by a randomly chosen respondent (for review see [24]). The top ten metaphors for each platform are presented in Table 1 with their probability of winning a random head-to-head comparison (with 0.50 being equally likely to win or lose).

The *Discover* stage elicited 30 metaphors from participants in the Facebook Wiki-survey and 32 metaphors in the Twitter Wiki-survey. Of the top metaphors, eight out of ten (8/10) for Facebook and eight out of ten (8/10) for Twitter

were submitted by users. The fact that most of the top metaphors were user-generated highlights the benefit of using collaborative surveys that combat researcher assumptions about how people think about technologies.

Amongst the top ten metaphors for the Facebook News Feed, several themes are apparent. First, the inclusion of personal shopper and personal assistant suggest beliefs that the News Feed is in some way personalized. The explanations included for these metaphors were "choosing and offering just the content I am most likely to interact with" and "presents things that are important to you," respectively.

The inclusion of mass media platforms, such as Magazine and Network TV, highlights that for some users the News Feed has features similar to broadcast media, where content is curated for general appeal, and then users have freedom to choose which content they engage with. The explanation included for Network T.V., was " they pick what you see and you decide what to watch." Similar beliefs inspired the metaphor, "Menu," which included the explanation "provides the options and you can only select from those offerings."

In addition to metaphors that highlight the subjective nature of the News Feed, the top ten also included metaphors that emphasize the rational, rule-based nature of algorithms, such as coin sorting and decision tree. In stark contrast to some of the more positive metaphors, such as personal shopper, several metaphors had deeply negative connotations that highlight beliefs about the invasions of privacy, asymmetric access to information, and use of information for other people's gain, such as spy, stalker, and paparazzi.

Though the top metaphors of the Twitter Feed are very different from those elicited for the Facebook News Feed, there are several similar themes. Some of the Twitter metaphors also had negative connotations, such as bad assistant, chaos, train wreck and mess, similar to the paparazzi, spy, and stalker of the Facebook News Feed. However, the negative metaphors for Twitter focused more on the ineffectiveness of the feed, rather than the intrusiveness of the negative Facebook News Feed metaphors.

While several metaphors for Facebook focused on personalization (personal shopper, etc.), several metaphors for Twitter focused on a linear process, such as queue, chain reaction, and dominos. Other metaphors for Twitter described objects that branch off in several directions, such as spider web, highway, and tree that were not surfaced for the Facebook News Feed. This may reflect how people engage differently with these feeds. People may be more likely to actively navigate links on Twitter compared to the passive consumption of the Facebook News Feed.

STAGE 2: FOLK THEORY IDENTIFICATION

The metaphors in the *Discover* stage uncovered the intuitive but typically unarticulated ways that people conceptualize social feeds. The next stage in the DIS method is to understand how the metaphors we elicited relate to one another. In this stage we use exploratory factor analysis to identify underlying folk theories.

Methods

We recruited respondents using Amazon's Mechanical Turk. MTurk workers were exclusively from the USA who were paid $0.50 for participating. Our Facebook sample was N = 758 (56% female, 1% other), with 70% white, 5% Black or African American, 5% Hispanic or Latino, 8% Asian and the remainder indicated bi- or multi-racial. The average age was 31.69 (SD = 9.65). Our Twitter sample was N = 799 (49% female), with 73% white, 8% black or African American, 7% of Asian descent and the remainder indicated bi- or multi-racial. The average age was 33.65 (SD = 10.42).

Procedure

Participants were directed to a Qualtrics survey, where they viewed a consent form explaining the study. If they decided to participate, they were asked to rate the suitability of each of the metaphors from the Discover Stage that had a probability of winning pairwise competition above 0.50. Each metaphor was rated on a Likert scale of 1 (strongly disagree) to 7 (strongly agree). In total, there were 28 metaphors for Twitter and 23 metaphors for Facebook. Participants were asked to rate the extent that "The Facebook News Feed [Twitter Feed] is like a [Metaphor]." These ratings were factor analyzed to identify the latent folk theories underlying the diverse range of metaphors discovered in the first stage.

Results and Discussion

The first step in the exploratory factor analysis was to determine how many factors should be extracted. A common method in determining the appropriate number of factors uses the number of eigenvalues greater than one. However, relying on eigenvalues is known to overestimate the number of latent factors. Previous work has established that parallel analysis provides the most accurate number of underlying factors [11]. Parallel analysis is a method that creates a random dataset with the same numbers of observations and variables as the original data. When the eigenvalues from the random data are larger than the eigenvalues from the factor analysis then the factors are mostly random noise. Parallel analysis indicated that there were four latent factors for both Facebook and Twitter.

The factor analysis was conducted with a varimax rotation, and the factor loadings were examined to determine which metaphors loaded together. Given the exploratory nature of this work, metaphors that loaded greater than 0.35 on a single factor and loaded less than 0.30 on the rest of the factors were retained.

For Facebook, three metaphors were dropped because they didn't load on any factors and two metaphors were dropped because they loaded on multiple factors. Seven metaphors loaded on factor 1; three metaphors loaded on factor 2; four metaphors on factor 3; and three metaphors on factor 4. For Twitter, five metaphors were dropped because they didn't load on any factors and five metaphors were dropped because they loaded on multiple factors. Ten metaphors loaded on factor 1; four metaphors loaded on factor 2; four factors loaded on factor 3; two metaphors loaded on factor 4.

Looking at the factors uncovered for Facebook, one factor included comparisons to traditional content providers, such as platform, network T.V., and magazine. Another factor consisted entirely of negatively valenced metaphors, such as spy and stalker The third factor included metaphors for entities that were disorganized or needed work, such as untended garden and jigsaw puzzle. Finally, the last factor included personal help and process-based metaphors, such as personal assistant, butler, decision tree, and coin-sorting.

For Twitter, one factor captured linear processes metaphors such as input-output, chain reaction, and dominos. The second factor consisted of metaphors with negative connotations, such as bad assistant, chaos, and mess. The third factor included two metaphors that revolved around organizing objects including coin sorting and egg sorting. Finally, the last factor included a diverse range of metaphors around choice, such as decision tree and flower picking, but also more whimsical metaphors such a time traveling and gift.

When comparing the four factors that emerged from the factor analyses of the two feeds, each has a factor consisting of only metaphors that clearly have negative connotations (e.g., stalker for the Facebook feed; train wreck for the Twitter feed). The other folk theories, however, are more difficult to interpret without knowing what aspects of the social feed they tap into. Therefore we held off labeling the folk theories until we in specified their semantic profiles in the final stage.

STAGE 3: FOLK THEORY SPECIFICATION

In the final stage of the DIS method, folk theory specification examines the attitudes and beliefs associated with each of the folk theories identified in the *Identify* stage. Given the multivariate and global nature of implicit folk theories, we explore beliefs about several aspects of social feeds including beliefs about the content, of the feed, influence over the algorithm, and the system as the whole.

To do this, we used semantic differentials. Semantic differentials present a continuum anchored by opposing terms on a given dimensions and are frequently employed to measure perceptions of technology [3]. Across five dimensions, we examined 1) the extent people evaluated their feed positively, as well as the extent that they believed their feed 2) is curated, 3) is dependent on behavior, 4) is transparent, and 5) prioritizes the company.

Overall Evaluation (Negatively Evaluated – Positively Evaluated) assessed the perceived utility and personal meaning of the feed. Osgood [21] proposed that evaluation is one of the main factors that make up people's perceptions of objects. Participants were asked to think about the Facebook News Feed [Twitter Feed] in general, and to rate the extent that the feed is: (1) useless-useful, (2) ineffective-effective, (3) unimportant-important, (4) meaningless-meaningful, (5) uninformative-informative, and (6) powerless-powerful, where higher values indicate more positive evaluations

Level of Curation (Uncurated – Curated) measured the extent that people believed that the feed curates the people or content types that appear. Prior work suggests that people's awareness of algorithmic involvement in social feeds is highly variable [7]. To measure perceived curation, participants were asked to think about the posts that appear in their Facebook News Feed [Twitter Feed] and rate the extent that the feed: (1) shows me a limited variety of content - wide variety of content, (2) shows me limited variety of people I follow - a wide variety of people I follow, (3) shows me nothing my friends post - shows me everything my friends post, (4) shows me all negative content - shows me all positive content. For this dimension, higher values indicate higher perceived curation of the feed.

Dependence on Behavior (Independent – Dependent) measured the extent to which people believe that behavior influences their social feed. Participants were asked to think about what how the Facebook News Feed [Twitter Feed] selects the posts that show in their feed, and rate the extent that the feed is: (1) independent of my behavior - dependent on my behavior and (2) independent of the behavior of others - dependent on the behavior of others, where higher values indicate beliefs that the feed is dependent on behavior.

Transparency (Opaque – Transparent) measured the perceived clarity of how the feed works and perceived ability to influence the content of the feed. Participants were asked to think about what factors influence the Facebook News Feed [Twitter Feed] and rate the extent that the feed: (1) is difficult to influence - easy to influence, (2) unclear how the it works - clear how it works and (3) allows no control over content - complete control over content, where higher values indicate higher levels of perceived transparency.

System Bias (Prioritizes the User – Prioritizes the Company) assessed people's beliefs about the system as a whole by measuring their beliefs about bias built into the system and whose interest the bias serves. Participants were asked to think about the priorities of the Facebook News Feed [Twitter Feed] and asked to rate the extent that the feed: (1) prioritizes my interest – prioritize the company's

		Factor 1		Factor 2		Factor 3		Factor 4	
Facebook	**B0**	**β**	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**
Positively Evaluated	3.24	0.30***	0.05	0.23***	0.04	-0.09**	0.03	-0.10**	0.04
Curated	4.02	-0.01	0.04	0.14***	0.03	-0.07**	0.03	-0.01	0.03
Dependent on Behavior	4.89	-0.14**	0.05	0.09*	0.04	0.07*	0.03	-0.08*	0.03
Transparent	3.83	0.03	0.05	0.16***	0.04	0.02	0.04	-0.11**	0.04
Prioritizes the Company	4.44	-0.23***	0.03	-0.04	0.03	0.11***	0.02	0.09***	0.03
Twitter	**B0**	**β**	**SE**	**β**	**SE**	**β**	**SE**	**β**	**SE**
Positively Evaluated	4.35	0.25***	0.04	0.16***	0.03	0.28**	0.03	0.03	0.03
Curated	4.35	-0.05	0.03	0.14***	0.03	-0.08**	0.02	0.01	0.02
Dependent on Behavior	4.68	-0.05	0.04	0.09**	0.04	-0.01	0.03	-0.07*	0.03
Transparent	4.07	0.06	0.04	0.22***	0.03	-0.15***	0.03	-0.04	0.03
Prioritizes the Company	3.76	-0.13***	0.03	-0.02	0.02	0.17***	0.02	0.04***	0.02

Table 2. Regression output for all 5 dimensions for Facebook and Twitter

interest, (2) uses too little of my personal data - uses too much of my personal data, (3) understands me completely – understands me not at all, (4) represents my personalized interest – represents general interest, (5) is unbiased - biased, and (6) rational - emotional, where higher values indicates perceived bias towards the company.

Methods

We recruited respondents using Amazon's Mechanical Turk. MTurk workers were exclusively from the USA who were paid $0.50 for participating. Our Facebook sample included 758 (57% female, 1% other) people, with 81% white, 5% Black or African American, 5% Hispanic or Latino, 8% Asian and the remainder indicated bi- or multi-racial. The average age was 32 (*SD* = 9.65). Our Twitter sample included 839 (53% female) people, with 70% white, 7% black or African American, 7% of Asian descent and the remainder indicated bi- or multi-racial. The average age was 34.95 (*SD* = 11.82).

Procedure

Participants first replicated the task from the *Identify* Phase, rating how much they agreed with each of the metaphors that made up the four factors. Each metaphor was rated on a Likert scale of 1 (strongly disagree) to 7 (strongly agree). The items were formatted as "The Facebook News Feed [Twitter Feed] is like a [Metaphor]."

In addition to indicating the strength of their agreement with each of the metaphors, participants also rated the Facebook News Feed [Twitter Feed] on the five dimensions described above that included overall evaluation of the feed, level of curation, dependence on behavior, transparency, and system bias. The reliability of the items for each index was acceptable (alphas > 0.60).

Using the same process to measure folk theories as in the *Identify* stage, we examined how the strength of each of the folk theories was associated with beliefs and attitudes about either the Facebook News Feed or Twitter using these five dimensions.

Results and Discussion

Given the exploratory nature of this work, the first step for the third study was a replication of the factor analysis from Study 2 for the metaphor agreement portion of the study. Thirteen out of fourteen (13/14) for Twitter and fourteen out of sixteen (14/16) metaphors for Facebook replicated the factor loading from Study 2. This replication suggests that the underlying four factors of the metaphors for both systems were highly stable. We therefore used the original factor compositions from Study 2 to analyze the semantic differential data in Study 3. The factors were not conceptualized as mutually exclusive, so each participant had a score for each of the four factors for either Facebook or Twitter.

To assess the attributes associated with each folk theory, the four folk theory scores were entered into a linear regression predicting each of our semantic differential dimensions. Overall, five regressions were run for each system, one for each dimension, with ten in total across the feeds. To

Factor	Facebook News Feed		Twitter Feed		Folk Theory
	Metaphors	**Semantic Analysis**	**Metaphors**	**Semantic Analysis**	
1	Personal Shopper Butler, Bouncer, Coin Sorter, Decision Tree Recipe, Scientific Method	Positively Evaluated Prioritizes User Independent of Behavior	Salad, Decision Tree Flower Picking Time-traveling Gift, Cat, Sketchbook	Positively Evaluated Prioritizes User	**Rational Assistant**
2	Platform, Network T.V. Magazine	Positively Evaluated Transparent Uncurated	Dominos, Chain Reaction, Input-Output	Positively Evaluated Transparent Uncurated	**Transparent Platform**
3	Spy, Stalker, Private Investigator Paparazzi	Negatively Evaluated Prioritizes Company Curated	Bad assistant, Mess Chaos, Train Wreck Nosy Mother	Negatively Evaluated Prioritizes Company Opaque	**Unwanted Observer**
4	Jigsaw Puzzle, Untended Garden, Highway	Prioritizes Company Negatively Evaluated Opaque	Coin Sorting, Egg Sorting	Negatively Evaluated	**Corporate Black Box**

Table 3. Summary of the metaphors and semantic characteristics associated with the four folk theories.

correct for multiple tests, *bonferroni* correction was applied. Table 3 summarizes dimensions that were significantly associated with each folk theory for both Twitter and Facebook.

For both Facebook and Twitter, folk theory 1 was associated with positive evaluations of the platform and beliefs that the platform prioritizes users' interests over the company's interest. For Facebook, folk theory 1 was also associated with beliefs that content is independent of their and other's behavior.

For both Facebook and Twitter, folk theory 2 was associated with positive evaluations, beliefs that the system is easy to understand and influence, and beliefs that the feed is not curated, showing wide variety of content and wide variety of people they follow.

In stark contrast to folk theory 1, for both Facebook and Twitter, folk theory 3 was associated with negative evaluations of the system, beliefs that the feed prioritizes the company's interest over the user, and beliefs that the platform is curated in some way, showing a limited variety of content and limited range of people they follow. For Twitter, this folk theory was also associated with beliefs that the process underlying the feed is opaque and difficult to influence.

Finally, folk theory 4, for both Facebook and Twitter, was associated with beliefs that the feed works in the company's interest. For Facebook, folk theory 4 was also associated with negative evaluations and beliefs that the feed is opaque and difficult to influence.

Despite the striking differences in the metaphor samples that were used to derive the folk theories for Facebook and Twitter, they have very similar semantic profiles. This strong semantic similarity across the factors suggests that there are four underlying folk theories of social feeds that capture overall attitudes about the platform, beliefs about transparency and control of the feed, and beliefs about whose interests are prioritized in the curation process. Based on the semantic qualities of the four folk theories and the metaphors that load on each of them, we call these four folk theories: the *Rational Assistant*, *Transparent Platform*, *Unwanted Observer*, and the *Corporate Black Box*.

The *Rational Assistant* folk theory is characterized by positive evaluations of the feed and beliefs that the feed understands and prioritizes their interests. *Transparent Platform* is characterized by positive evaluations and beliefs that the feed is not curated. *Unwanted Observer* is characterized by negative evaluations and beliefs that the feed is overreaching in their use of personal data to serve the company's interests. Finally, *Corporate Black Box* is the least coherent of the four folk theories. However, this

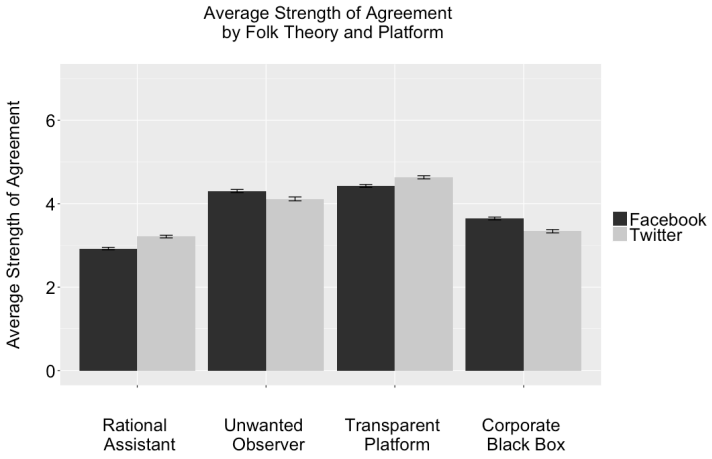

Figure 2. Average strength of each folk theory by platform

folk theory is associated with beliefs that the feed prioritizes the company's interest. Our results also suggest that *Corporate Black Box*, in the case of Twitter, is associated with beliefs that the process underlying the feed is opaque and difficult to control.

Folk Theory Strength across Facebook and Twitter

Our analysis so far, across two studies, suggests that there are four primary folk theories that account for the metaphors that people use to understand social feeds. An important question is whether there are any differences in how strongly those folk theories are held for the two systems.

To examine how strongly the four folk theories were held across the two social feeds we compared the average score for each of the four folk theories across the Facebook and Twitter samples. For each folk theory we calculated the average agreement with all of the metaphors that comprise that folk theory. We then entered these average agreement scores into a mixed model, with folk theories and social feed (Facebook vs. Twitter) entered as fixed factors and participant nested in platform as a random effect to control for the non-independence of repeated measures.

The results are displayed in Figure 2. The effect of system did not reach significance, ($F(1,7) = 3.40$, $p = 0.07$), but the analysis revealed a significant effect of folk theory ($F(3,7) = 450.87$, $p < 0.001$) and a significant interaction between system and folk theories ($F(3,7) = 21.81$, $p < 0.001$).

Post-hoc comparisons revealed significant differences between Twitter and Facebook for each of the four folk theories (p's < 0.001). People held the *Unwanted Observer* folk theory for Facebook more strongly than for Twitter and held the *Rational Assistant* folk theory more strongly for Twitter than Facebook. Overall, this finding suggests that people evaluated the system and the system's intent more positively for Twitter than Facebook. Furthermore, people held the *Transparent Platform* folk theory more strongly for Twitter than Facebook, suggesting that it is believed to be less curated than Facebook.

GENERAL DISCUSSION

Humans have developed ways to interact with systems they may not fully understand by relying on folk theories, or their own intuitive explanations [6, 9]. The present research shows that folk theories are also developed for cyber-social systems, in which algorithms mediate social behavior.

The results from the DIS method reveal four primary folk theories for the Facebook's and Twitter's social feeds. First, the *Transparent Platform* was associated with positive evaluations, beliefs that the underlying process is transparent, and beliefs that the feed can be easily influenced. Second, the *Rational Assistant* was associated with positive evaluations and beliefs prioritized user's interests. In contrast, the *Unwanted Observer* folk theory was associated with negative evaluations and beliefs that the social feed prioritizes the company's interest over the user. Finally, the last folk theory, *Corporate Black Box,* was associated with beliefs that the feed prioritizes the company's interest, as well as beliefs that the feed is opaque and difficult to influence.

Despite the consistency of the characteristics of the four folk theories across the two systems, people held the folk theories at different strengths, suggesting that the underlying components of folk theories are similar across the different social feeds, but the prevalence of the folk theories are different. Given the similarities in affordances between Facebook and Twitter, the difference between platforms raises interesting questions about how interface design, technical literacy, and company reputation contribute to the prevalence of a particular folk theory.

Systems likely shape people's folk theories. However, understanding folk theories of cyber-social systems also provides important insight into how people engage and interact with these systems. In one study, researchers found that dog owners were more likely to cooperate with a dog-like agent than non-dog owners in a Prisoner's Dilemma game [15]. The authors conclude that the dog owners held different beliefs about the personality of dogs than non-dog owners that led them to be more trusting that a dog-like agent would cooperate as well. This finding suggests that one's beliefs about dogs not only transferred to a computer, but guided how one chose to interact with the system (i.e. be more cooperative).

In the same way, folk theories of cyber-social systems should shape how people interact with technology. For example, people who strongly hold the *Unwanted Observer* folk theory may be less likely like to trust system changes, believing that changes serve the company's interests over the user's interests. On the other hand, people who strongly hold the *Rational Assistant* folk theory may be more likely to welcome changes believing the system is working to make their experience better. This individual difference is

important given that algorithmic changes are prevalent within cyber-social systems [10].

Folk theories may also shape how people perceive other actors within cyber-social systems. The *Transparent Platform* folk theory is associated with beliefs that social feeds show a wide variety of friends and content. If a person who strongly holds the *Transparent Platform* folk theory posts and does not receive the attention they expected, they may attribute the lack of response to the post or to others in the network rather than the algorithmic curation of the feed.

Prior work has shown that folk theories can be usefully applied to cyber-social systems [7,8,9]. While some prior work revealed how people make sense of the mechanistic aspects of the operation of social feeds [7,8], other research focused on the more abstract aspects of a social feed, such as the attitudes and opinions people held about how a system worked [9]. These studies also focused on a single system. The present research builds on the extant work in two important ways. First, we developed a systematic method of using semantic differentials to assess both the mechanistic and attitudinal characteristics of folk theories. Second, the DIS method allows for cross-platform comparisons. By focusing on implicit beliefs about systems that can be tapped using metaphor generation, we were able to identify people's global folk theories about social feeds that transcend specific systems and allow cross-platform comparisons.

Limitations and Future Directions

Across three studies totaling over 6,000 participants, we identified a set of folk theories that transcend a specific social network site. However, it is important to note that our sample is not representative of all social network site users, and thus we must be cautious in generalizing findings. In addition, this paper examined people's folk theories of these systems in 2016. The algorithms underlying the Facebook News Feed and Twitter Feed are likely to change and people's experiences with the feeds will grow. It is unclear how persistent these four folk theories will be over time.

However, this work provides a foundation to explore how folk theories evolve with systems, as well as explore how folk theories differ across types of users and non-users. Prior work suggests that unexpected events can prompt a re-evaluation of one's understanding of the system [22]. Future work could examine how folk theories change in response to experience online. A person with a strong *Transparent Platform* folk theory may abandon this folk theory once they become aware of algorithmic curation after not receiving the expected response, while a person who holds a *Rational Assistant* folk theory may become more skeptical of the system's intentions after receiving oddly specific personalized advertising.

Furthermore, the DIS method provides opportunities to explore how folk theories differ between cyber-social systems with different goals, such as online dating sites. Online dating systems do not just order content, but match and rank motivated by very specific relational goals. By mapping concrete beliefs onto the abstract associations embedded in people's metaphors, future work can begin to examine how people make connections and distinctions between different types of cyber-social systems.

CONCLUSIONS

The present paper introduced the DIS method, a systematic method for identifying folk theories of cyber-social systems, and examined the folk theories of two cyber-social systems, the Facebook News Feed and Twitter Feed. We find four common underlying folk theories that significantly predict people's beliefs and attitudes about the social feeds embedded in these platforms. By leveraging the power of metaphors, the four core folk theories tap into people's implicit understanding of social feeds and provide a framework for future work to explore how folk theories predict behavior on social network sites, and provide a method to identify folk theories in other cyber-social systems.

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