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Exploring Patterns of Social Relationships among Food Bloggers on Twitter Using a Social Network Analysis Approach

Allison D. Hepworth, PhD[a] , Jess Kropczynski, PhD[b] , Justin Walden, PhD[c] , and Rachel A. Smith, PhD[d]

Abstract

Background and objective. Nutrition information conveyed by popular entities through online social networking sites (i.e., social media influencers) has the potential to impact consumer eating behavior through mechanisms of social influence. Little is known about how online communities of food-related social media influencers are structured, which could reveal influencers' opportunities to observe and spread nutrition-related content and information design practices. This study explored patterns of social relationships (social capital, conservation of resources, and homophily) within a network of prominent food bloggers on Twitter (N = 44). ***Methods.*** Data on Twitter following/follower relationships and Twitter use (number of tweets, favorited tweets) were collected from bloggers' Twitter profiles. Bloggers represented eight topical subcategories of food blogs (e.g., family cooking, cocktails) and comprised a one-mode social network with directed ties indicating Twitter following/follower relationships. Structural evidence of patterns of social

[,\a]Corresponding author: University of Maryland School of Social Work, 525 W. Redwood St., Baltimore, MD, 21201; hepworth.allison@gmail.com
[b]University of Cincinnati, College of Education, Criminal Justice, & Human Services, School of Information Technology, 2610 McMicken Cir, Cincinnati OH 45221; jess.kropczynski@uc.edu
[c]North Dakota State University, College of Arts, Humanities and Social Sciences, Department of Communication, 338 Minard Hall, Fargo, ND, 58102; justin.walden@ndsu.edu
[d]Pennsylvania State University, College of the Liberal Arts, Department of Communication Arts & Sciences; College of Health and Human Development, Department of Human Development & Family Studies; ras57@psu.edu

relationships was investigated through social network visualization, centrality measures (in-degree/out-degree centrality, density, reciprocity), and inferential tests. ***Results.*** The overall network density of directed ties was 21%, with wide variability in individual blogger centrality across multiple measures. Cocktails, cooking, special diets, and culinary travel bloggers had more dense ties to bloggers in their own subcategories. Within the network, favorited tweets and outreach (Twitter following relationships) were positively associated with popularity (Twitter follower relationships). ***Conclusions.*** Food bloggers in this study formed a partially connected network, supporting the conservation of resources framework. Homophily was evident in some, but not all, topical subcategories. Associations among Twitter use, outreach, and popularity generally supported the social capital framework. Future studies should explore influencers' motivations for connecting on social networking sites, and how content and information design practices spread among influencers.

Keywords: Social media; Social network analysis; Food blogs; Twitter; Influencers; Bloggers

Introduction

Food blogs are a common source of meal ideas in the United States, particularly among Internet users 18 to 34 years of age (Doub, Small, Levin, LeVangie, & Brick, 2016). Food blogs feature recipes, product reviews, and personal stories that further establish a blogger's audience credibility and relatability (Doub, Small, & Birch, 2016a; Lepkowska-White & Kortright, 2018; Lynch, 2012; Schneider, McGovern, Lynch, & Brown, 2013). Popular food bloggers are known as social media influencers, meaning they have the capacity to shape the attitudes and behaviors of individuals who interact with their content (Freberg, Graham, McGaughey, & Freberg, 2011). Relatedly, food blogs that are considered influential based on metrics such as large audience size or high content engagement (e.g., number of comments on blog posts) are targeted for paid partnerships with corporate brands to promote products and services, a practice known as influencer marketing (Galeotti & Goyal, 2009; Lepkowska-White & Kortright, 2018; Stoldt, Wellman, Ekdale, & Tully, 2019). To date, research on food-related social media influencers has been limited, which is a critical gap given the potential reach and impact of nutrition information shared through blogs and social networking sites such as Twitter, Instagram, and Pinterest (Coates, Hardman, Halford, Christiansen, & Boyland, 2019; Korda & Itani, 2013; Li, Barnett, Goodman, Wasserman, & Kemper, 2013).

Although nutrition information can be widely disseminated on blogs and social networking sites (e.g., recommendations for or against specific foods, beverages, and eating behaviors), the quality of nutrition information shared on food blogs varies by blogger credentials (Chan, Drake, & Vollmer, 2018), recipe type (Schneider et al., 2013), and post topic (Doub, Small, & Birch, 2016a). Research identifying factors that influence the content and information design practices of food bloggers such as tone, recipe types, references, and use of photo and video, could guide nutrition education professionals toward understanding and improving the quality of nutrition information disseminated through blogs and social networking sites (Doub, Small, & Birch, 2016b; Dumas, Lapointe, & Desroches, 2018; Leak et al., 2014; Li et al., 2013; Shan et al., 2015; Tobey & Manore, 2014). Importantly, theory and experimental research indicate eating behavior is influenced by behaviors espoused by popular and relatable social models (Coates et al., 2019; Higgs, 2015; König, Giese, Stok, & Renner, 2017), highlighting the need for research that determines how social media influencers generate ideas for the content they share. As a first step, formative research on the community structure of food bloggers is needed to describe how bloggers connect to each other, as these connections create opportunities for bloggers to observe and spread content and information design practices (Agarwal, Liu, Tang, & Yu, 2012; Pei, Muchnik, Tang, Zheng, & Makse, 2015; Sosa, 2010).

Previous research on blogs focused on food (Lepkowska-White & Kortright, 2018), wine (Marlowe, Brown, Schrier, & Zheng, 2017), and travel (Azariah, 2012) suggests that bloggers use social networking sites to promote content from their blogs and establish audience credibility. However, little is known about patterns of social relationships *among* social media influencers, including popular food bloggers, on social networking sites. Such research could reveal connections that facilitate or inhibit the spread of content and information design practices among influencers that ultimately influence appetite. The current study begins to address this gap by leveraging social network analysis and theoretical frameworks of social relationships to explore and interpret patterns of connections among food bloggers on Twitter.

Social Networking Sites Facilitate Connections Among Bloggers

To establish themselves as social media influencers, bloggers must display their identities in an authentic manner online, learn and meet the professional standards of the blogging community, and develop strategies (often commercialized) to maximize audience engagement (Blum-Ross & Livingstone, 2017). Forming connections with other bloggers is thus critical as bloggers assert themselves as a part of a community of social media influencers (Agarwal et al., 2012; Kozinets, de Valck, Wojnicki, & Wilner, 2010). Historically, bloggers first connected to other bloggers by commenting directly on each other's blog posts and referring readers to recommended blogs on blogrolls (Schmidt, 2007). Bloggers also connect through social networking sites (Park, Ok, & Chae, 2016). Blogs and social networking sites are interconnected through "social plug-in" features, which allow users to easily navigate to a blogger's content across multiple platforms. For example, bloggers can include hyperlinks to their social networking site profiles on their blog homepages. Similarly, bloggers can include a hyperlink to their blog homepages in their social networking site profiles. Social networking sites thus play an increasingly important role in connecting bloggers to each other and in helping bloggers establish their online presence (Liang & Kee, 2018).

Social networking sites provide venues for bloggers to assert themselves as a part of a community of social media influencers by building following relationships (signaling outreach to other users) and follower relationships (signaling popularity among other users). Bloggers can also use social networking sites to establish opinion leadership through contributing original content and endorsing, replying to, or disseminating content created by other bloggers (Doub, Small, & Birch, 2016b; Hanna, Rohm, & Crittenden, 2011; Walden, 2013). To better understand how food bloggers use social networking sites to connect to each other and build influence, research is needed that describes the network structure of blogger connections on social networking sites. Research is also needed to test how social networking site use is associated with outreach and popularity among fellow bloggers and among all social networking site users.

Social Network Analysis in the Context of Twitter

Social network analysis is an ideal analytic approach for research questions concerning the structure and patterns of connections within communities (Borgatti, Everett, & Johnson, 2013; Wasserman & Faust, 1994). Social network analysis allows researchers to quantify structural characteristics of individual network members' (i.e., actors') positions in the network (e.g., degree centrality measures of outreach and popularity), characteristics of connections (i.e., ties) between network members (e.g., tie reciprocity), and characteristics of the whole network (e.g., density of ties). This study used social network analysis to quantify structural characteristics of a network of food bloggers on Twitter.

Content creators, including bloggers, seeking to become influencers often promote their own content on social networking sites and reciprocally promote each other's content (Boyd, Golder, & Lotan, 2010; Lewis, Holton, & Coddington, 2014). Twitter has specific platform affordances that enable two users to easily observe and spread each other's content, without requiring tie

reciprocity (Ellison & boyd, 2013). In the context of Twitter, following relationships are directed ties that signal outreach, meaning Blogger A follows Blogger B's content. Follower relationships are directed ties that signal popularity, meaning Blogger B's content is followed by Blogger A. Analyzing the reciprocity of Twitter following and follower relationships using social network analysis can shed light on the hidden community structures of groups of Twitter users with common yet diverse interests, including food bloggers (Himelboim, 2017; Shi & Macy, 2016).

Social Relationships: Capital, Resources, and Homophily

The current study drew upon three theoretical frameworks of social relationships to explore and interpret patterns of connections among food bloggers on Twitter: Social capital (Lin, 1999, 2002), conservation of resources (Hobfoll, Freedy, Lane, & Geller, 1990), and homophily (McPherson, Smith-Lovin, & Cook, 2001; Rogers & Bhowmik, 1970). Social capital broadly relates to an individual's motivation to form social relationships to gain access to resources (Lin, 1999, 2002). Some existing research suggests a positive association between social networking site use and perceived social capital. For example, Facebook users who engaged in relationship maintenance behaviors, such as responding to their friends' good news or information requests, reported higher perceptions of social capital specific to Facebook and social capital generally than users who did not engage in these maintenance behaviors (Ellison, Vitak, Gray, & Lampe, 2014). Food bloggers seeking to establish influence by using Twitter may be motivated to be maximally connected to other bloggers to gain access to resources that promote social capital (and commercialization potential), such as amplified visibility through cross-promotion (e.g., retweets, mentions) and content engagement (e.g., favorites, comments).

Another helpful lens to understand connections among bloggers is the conservation of resources framework, which suggests social ties carry personal costs alongside potential resources (Hobfoll et al., 1990). Bloggers may expect promotion and endorsements in return for those they provide on Twitter, which take time and attention (Lee & Sundar, 2013). Bloggers are also expected to follow norms within communities of like-interested bloggers (Kozinets et al., 2010). Consequently, there may be some missing connections due to anticipated costs. Existing findings on whether connections among bloggers support the conservation of resources framework have been mixed. For example, in a study of wine bloggers, blog readership and incoming comments were positively associated with measures of outreach and input (e.g., reading other blogs, outgoing comments, time spent on blogging, posting frequency), suggesting increasing returns on investments (Marlowe et al., 2017). In contrast, a study of mom bloggers found that 41.1% followed another blogger in this network on Twitter, and only 16.7% mentioned another blogger in this network on Twitter (Burton, Tew, & Thackeray, 2013), demonstrating a pattern of conservative connection and engagement. More research is needed to explore evidence of conservation of resources among prominent food bloggers.

Thirdly, the homophily framework (McPherson et al., 2001; Rogers & Bhowmik, 1970) proposes individuals selectively form relationships with similar individuals. Given the broad range of topics represented in food blogs, food bloggers may selectively establish Twitter following relationships with bloggers focused on similar topical subcategories, such as cooking method (e.g., baking, cooking), niche food interest (e.g., special diets such as gluten-free, cocktails), or cooking context

(e.g., family cooking, regional cuisine; Schmidt, 2007). Previous research suggests that when individuals perceive fellow members of an online network as similar in background, they are more likely to feel supported by individuals in that network (Wright, 2012). The positive association between perceived similarity and social support has implications for how individuals structure and maintain social ties (McPherson et al., 2001). For example, bloggers may believe that connecting to bloggers who produce similar content would maximally amplify their visibility to interested audiences (e.g., through cross-promotion), or establish credibility through ties to popular bloggers in the same subcategory (Agarwal et al., 2012).

Together, these frameworks suggest three possible patterns of connections that were explored in the current study in a network of prominent food bloggers on Twitter: a) a maximally connected network, supporting social capital as bloggers seek to maximize access to potential resources by connecting to all other bloggers; b) a partially connected network in which bloggers do not show differential connections by topical subcategory, supporting conservation of resources without homophily as bloggers seek to minimize potential costs of maintaining social relationships, irrespective of topical subcategory; or c) a partially connected network in which bloggers are differentially connected based on topical subcategory, supporting conservation of resources with homophily as bloggers seek to minimize potential costs of maintaining social relationships, and selectively form ties to bloggers in the same topical subcategory.

Study Aims

The current study had two related exploratory aims that were examined using a social network analysis approach in a sampled network of 44 prominent food bloggers who had Twitter profiles. All bloggers in the study were nominated for a "Best Food Blog" award within eight topical subcategories of food blogs by a popular food-related media company, *Saveur* (Saveur, 2014). Bloggers comprised a one-mode social network (i.e., bloggers connected to bloggers) with directed ties indicating Twitter following and follower relationships. The first aim was to explore structural evidence of social capital, conservation of resources, and homophily, as described above. To further explore structural evidence supporting the social capital or conservation of resources frameworks, the second aim was to test the association between Twitter use (i.e., number of tweets, favorited tweets) and centrality characteristics (i.e., outreach and popularity) within the sampled network of food bloggers and among all Twitter users.

METHODS

Sample

To identify a complete network of prominent food bloggers who had a presence on Twitter and focused on topics that were divided into subcategories, the first author screened the nominees for *Saveur*'s 2014 fifth annual food blog award competition for study inclusion (Saveur, 2014). *Saveur* is a popular food-related media company with digital and physical publications (e.g., a website, social media profiles, and magazine). Blogs that published new content between January 1, 2013 and December 31, 2013 were eligible for an award nomination by blog readers into one or more subcategories of food blogs: Baking and desserts, cocktails, cooking, culinary travel, family

cooking, new blog, original recipes, photography, regional cuisine, special diets, use of video, wine or beer, and writing. Nominations were held from March 31, 2014 through April 9, 2014 and the final nominees (75 unique bloggers) were announced on April 14, 2014. *Saveur* editors, previous *Saveur* food blog award competition winners in each subcategory, and blog reader nominations determined six final nominees in each subcategory.

Sixty-nine out of 75 unique bloggers had Twitter profiles at the time data was collected for the current study (January, 2015). Bloggers nominated for subcategories related only to individual blog or blogger characteristics (i.e., new blog, original recipes, photography, use of video, and writing) rather than for topical blog content were excluded (n = 24). One additional blogger was excluded because they had over four standard deviations above the mean for overall following relationships on Twitter, which may have indicated the account was automated rather than personally maintained. Thus, the final sample included 44 food bloggers who had publicly available Twitter profiles and focused on eight topical subcategories: Baking and desserts (n = 6); cocktails (n = 6); cooking (n = 6); culinary travel (n = 5); family cooking (n = 5); regional cuisine (n = 5); special diets (n = 6); and wine or beer (n = 5). NodeXL (Smith et al., 2010), a software program for social media data collection and analysis, was used to create an adjacency matrix that contained data on the directed Twitter following and follower ties among the 44 bloggers. Review by the authors' respective Institutional Review Boards was not required for this study because information made publicly available on the Internet was not considered human subjects research, as per the United States Department of Health and Human Services guidelines (U.S. Department of Health and Human Services, 2016).

Measures

Structural measures of the network: Centrality, reciprocity, and density. The following structural measures of the social network were calculated using UCINET 6 (Borgatti, Everett, & Freeman, 2002), a social network data analysis software program:

In-degree centrality. In-degree centrality is an actor-level, structural measure of popularity (Wasserman & Faust, 1994). Raw in-degree centrality is the sum of the directed ties present in a network that terminate at a given actor. For comparison purposes, the raw value is standardized by dividing by one less than the total number of actors in the network. In the current study, standardized in-degree values represented the proportion of other bloggers following a given blogger in the network (i.e., Twitter follower relationships). Bloggers with higher standardized in-degree values had more incoming Twitter follower relationships with other bloggers in the network. In tables, in-degree centrality is referred to as "*Saveur* Network Followers."

In-degree centralization is a complementary network-level, structural measure of the focal organization of actors in the network (Freeman, 1979). In-degree centralization values range from 0.00 to 1.00, with lower values indicating more egalitarian networks. In the current study, an in-degree centralization value of 0.00 indicates a completely egalitarian network in which all bloggers are connected through Twitter follower relationships. An in-degree centralization value of 1.00 indicates a star network in which a single focal blogger connects to all other bloggers through Twitter follower relationships, but these other bloggers do not connect to one another.

Out-degree centrality. Out-degree centrality is an actor-level, structural measure of expansiveness (i.e., outreach; Wasserman & Faust, 1994). Raw out-degree centrality is the sum of the directed ties present in a network that originate at a given blogger. For comparison purposes, the raw value is standardized by dividing by one less than the total number of actors in the network. In the current study, standardized out-degree values represented the proportion of other bloggers a given blogger followed (i.e., Twitter following relationships). Bloggers with higher standardized out-degree values had more outgoing Twitter following relationships with other bloggers in the network. In tables, out-degree centrality is referred to as "*Saveur* Network Following."

Out-degree centralization is a complementary network-level, structural measure of the focal organization of actors in the network (Freeman, 1979). Out-degree centralization values range from 0.00 to 1.00, with lower values indicating more egalitarian networks. In the current study, an out-degree centralization value of 0.00 indicates a completely egalitarian network in which all bloggers are connected through Twitter following relationships. An out-degree centralization value of 1.00 indicates a star network in which a single focal blogger connects to all other bloggers through Twitter following relationships, but these other bloggers do not connect to one another.

Dyad reciprocity. Dyad reciprocity is a network-level measure of mutuality; it refers to the proportion of ties that are mutually endorsed within the network (Wasserman & Faust, 1994). Values range from 0.0 to 1.0. A value of 1.0 indicates all ties are reciprocated. In this study, dyad reciprocity was calculated as the proportion of blogger dyads that had reciprocal Twitter following relationships.

Density. Density is a network-level measure of connectivity; it refers to the proportion of observed directed ties divided by the number of all possible directed ties in a network or subgroup (Wasserman & Faust, 1994). Density values range from 0.0 to 1.0. A value of 1.0 indicates a maximally connected network. In this study, density was calculated two ways. First, it was calculated as the number of ties present in the entire network divided by the total number of all possible ties in the entire network. Higher density values indicate a more connected network. Secondly, density was calculated for subgroups of food bloggers defined by their topical subcategories (i.e., the number of ties present among bloggers in the same topical subcategory divided by the total number of all possible ties among bloggers in the same topical subcategory). Higher density values among bloggers in the same topical subcategory indicates homophily.

Twitter use and Twitter centrality. During initial data collection, NodeXL was used to collect the following attribute data for each blogger in the network: Number of tweets posted; number of favorited tweets (outgoing) among all Twitter users (referred to in tables as, "Number of favorited tweets"); number of Twitter following relationships among all Twitter users (referred to in tables as, "Overall Twitter following"); and number of Twitter follower relationships among all Twitter users (referred to in tables as, "Overall Twitter followers.")

Analyses

Network visualization. The structure of the *Saveur* network was visualized as a sociogram in the Fruchterman-Reingold layout (Fruchterman & Reingold, 1991) using the igraph software package

(Csardi & Nepusz, 2006) implemented in the R statistical programming environment (R Core Team, 2018).

Aim 1. To address Aim 1 (explore structural evidence of social capital, conservation of resources, and homophily), in-degree and out-degree centrality, in-degree and out-degree centralization, network-level density, and dyad reciprocity were calculated. Additionally, the density of directed ties within and between subgroups of bloggers defined by their topical subcategory were calculated and a structural blockmodel ANOVA density test was conducted to evaluate the null hypothesis that there was no evidence of homophily (i.e., more dense ties) among food bloggers by topical subcategory. A structural blockmodel ANOVA density test is a permutation-based test that compares the observed density of ties between dyads in the same and different subgroups to randomly generated density values (Hanneman & Riddle, 2005). The ANOVA density test was conducted in UCINET 6 using 10,000 permutations. Results were considered significant at $p < .05$.

Aim 2. To address Aim 2 (test the association between Twitter use, outreach, and popularity), quadratic assignment procedure (QAP) correlations (Hubert & Schultz, 1976) were calculated among the following blogger attributes: Number of tweets posted, number of favorited tweets, overall Twitter following relationships, overall Twitter follower relationships, *Saveur* network following relationships, and *Saveur* network follower relationships. QAP correlation is a permutation-based analysis that accounts for interdependence in social network data by analyzing actor attributes as an adjacency matrix of difference scores (Hubert & Schultz, 1976). QAP correlations were conducted in UCINET 6 using 10,000 permutations. Results were considered significant at $p < .05$.

RESULTS

Social Network Structure of Food Bloggers on Twitter

The network of 44 food bloggers representing eight topical subcategories is displayed in Figure 1. There were 388 directed Twitter following ties present in this network of food bloggers. At the actor-level, the average raw in-degree was 8.6 (*SD* = 6.7; *Range* = 0 to 22; *Median* = 7). The average standardized in-degree was 20% (*SD* = 16%; *Range* = 0% to 51%; *Median* = 16%). These results revealed variance in blogger popularity: Some food bloggers were followed by over half of the other bloggers in the network on Twitter, while some were not followed at all. The average raw out-degree was 8.6 (*SD* = 6.3; *Range* = 0 to 20; *Median* = 10). The average standardized out-degree was 20% (*SD* = 15%; *Range* = 0% to 47%; *Median* = 23%). These results revealed variance in blogger outreach: Some food bloggers followed almost half of the other bloggers in the network on Twitter, while some followed none.

At the network-level, in-degree centralization was 0.27 and out-degree centralization was 0.31, indicating that bloggers tended toward a more egalitarian network, but the network was not complete. The overall network density of directed ties was 21%, indicating approximately one-fifth of all possible directed ties were present in the network. Dyad reciprocity was 58%, indicating that over half of Twitter following relationships in the network were mutual.

Table 1. *Density of Directed Twitter Following and Follower Ties Among Food Bloggers Representing Eight Topical Subcategories of Food Blogs (N = 44)*

	1	2	3	4	5	6	7	8
1. Baking and desserts	.43	.14	.58**	.03	.20	.07	.50*	.07
2. Cocktails	.19	1.0***	.19	.07	.03	.10	.14	.17
3. Cooking	.47	.08	.83**	.20	.23	.03	.58**	.00
4. Culinary travel	.13	.10	.13	.65*	.04	.12	.07	.08
5. Family cooking	.20	.07	.27	.04	.40	.08	.23	.04
6. Regional cuisine	.13	.13	.27	.16	.08	.40	.17	.04
7. Special diet	.39	.03	.64**	.03	.03	.00	.70**	.00
8. Wine or beer	.10	.13	.03	.08	.04	.04	.00	.20

Note. Density values are represented as proportions, with 0.0 indicating none of the possible directed ties were observed, and 1.0 indicating all possible directed ties were observed. Values along the central diagonal are the density of ties among bloggers from the same topical subcategory. Values in the upper right triangle are the density of outgoing ties (i.e., Twitter following relationships). Values in the lower left triangle are the density of incoming ties (i.e., Twitter follower relationships). Significance values were derived from a structural blockmodel ANOVA density test. * $p < .05$. ** $p < .01$. *** $p < .001$.

Food bloggers with the highest popularity (i.e., bloggers with the top five standardized in-degree values) were in the cooking, baking and desserts, and special diets subcategories. The bloggers with the highest popularity were followed by 47% to 51% of other bloggers in the network. The food bloggers showing the most outreach (i.e., bloggers with the top five standardized out-degree values) were in the cooking and baking and desserts subcategories. Bloggers showing the highest outreach established following relationships with 40% to 47% of other bloggers in the network. Three out of five bloggers with the highest popularity also showed the most outreach. One food blogger, a representative of the regional cuisine subcategory, was the only isolate in the network. This blogger followed no one in the network, and no one else in the network followed this blogger on Twitter.

The density of directed ties within and between bloggers in each topical subcategory are displayed in Table 1. The structural blockmodel ANOVA density test revealed evidence of homophily within some, but not all, topical subcategories ($R^2 = .30$, $p < .001$). Differences in the density of directed ties by topical subcategory explained 30% of the variance in blogger-to-blogger ties. As indicated by density values significant at $p < .05$ (see Table 2), topical subcategory homophily was observed for cocktails, cooking, culinary travel, and special diets bloggers. Unexpectedly, results also showed a higher density of directed ties between bloggers in some different topical subcategories. Cooking bloggers had more Twitter following and follower relationships with special diets bloggers. Baking and desserts bloggers were more likely to be followed by cooking and special diets bloggers on Twitter. The high density of ties among baking and desserts, cooking, and special diets bloggers is reflected in the proximity of the individual blogger nodes in the network visualization (Figure 1).

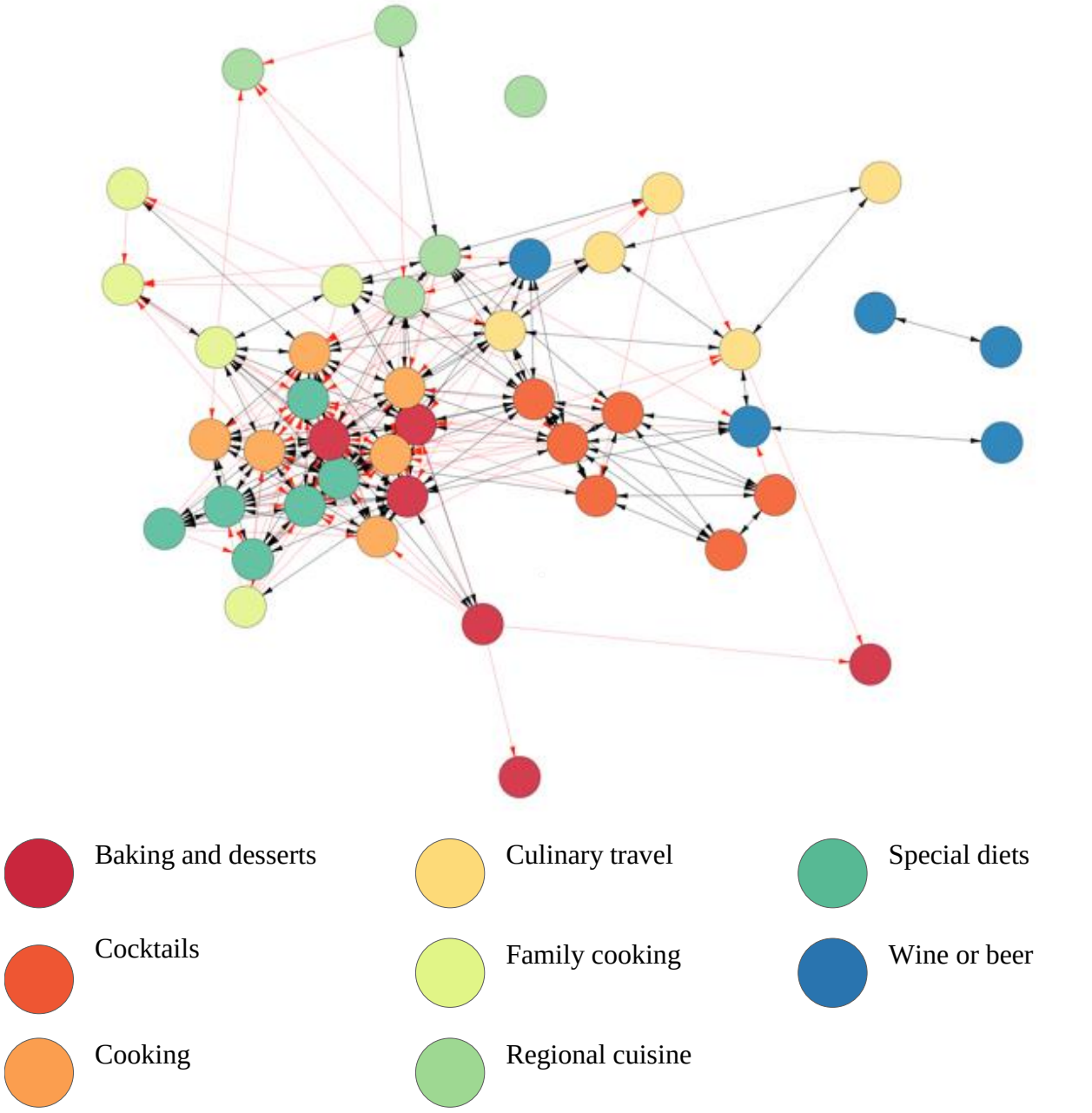

Figure 1. Fruchterman-Reingold layout of directed Twitter following/follower ties among *Saveuer* network food bloggers (N = 44). Nodes represent individual food bloggers, color-coded by topical subcategory. Arrow color indicates tie reciprocity: Black arrows indicate reciprocal ties; Red arrows indicate unreciprocated ties. Node spacing is algorithmically determined by the density of ties.

Table 2. *Descriptive Statistics of Blogger Attributes: Twitter Use, Outreach, and Popularity* (*N* = 44)

Attribute	Mean	Standard Deviation	Median	Range (min-max)
Number of tweets	5667	6564	3075	132 to 27966
Number of favorited tweets	1197	1901	470	0 to 9595
Overall Twitter following	784	724	539	6 to 3199
Overall Twitter followers	3808	5022	2170	177 to 30529
Saveur network following	9	6	10	0 to 20
Saveur network followers	9	7	7	0 to 22

Note. Number of tweets and favorited tweets are measures of Twitter use. Twitter following relationships (Overall Twitter and *Saveur* Network following) are measures of outreach. Twitter follower relationships (Overall Twitter and *Saveur* Network followers) are measures of popularity.

Table 3. *Quadratic Assignment Procedure (QAP) Correlations Among Differences in Blogger Attributes: Twitter Use, Outreach, and Popularity (N = 44)*

Variable	1	2	3	4	5	6
1. Number of tweets	--					
2. Number of favorited tweets	0.39*	--				
3. Overall Twitter following	0.58**	0.02	--			
4. Overall Twitter followers	0.60***	0.09	0.57***	--		
5. *Saveur* network following	-0.13	0.25*	-0.03	-0.19	--	
6. *Saveur* network followers	-0.13	0.32*	-0.18	0.09	0.73***	--

Note. Number of tweets and favorited tweets are measures of Twitter use. Twitter following relationships (Overall Twitter and *Saveur* Network following) are measures of outreach. Twitter follower relationships (Overall Twitter and *Saveur* Network followers) are measures of popularity. * $p < .05$. ** $p < .01$. *** $p < .001$.

Associations Among Twitter Use, Outreach, and Popularity

Descriptive statistics for bloggers' Twitter use, outreach, and popularity overall and within the *Saveur* network are shown in Table 2. QAP correlation results are shown in Table 3. As may be expected, bloggers who had posted more tweets also favorited more tweets. Bloggers who had posted more tweets showed more outreach and were more popular among all Twitter users. In contrast, within the *Saveur* network, number of tweets was not associated with blogger outreach or popularity. However, bloggers who favorited more tweets showed more outreach and were more popular within the *Saveur* network. Blogger outreach and popularity were positively correlated among Twitter users and within the *Saveur* network respective to each context. However, blogger outreach and popularity among all Twitter users were not associated with outreach and popularity within the *Saveur* network.

DISCUSSION

This study explored the structure and patterns of social relationships among a network of prominent food bloggers on Twitter. These food bloggers were divided into topical subcategories (e.g., baking and desserts, cooking, regional cuisine). Three theoretical frameworks of social relationships guided this study: Social capital (Lin, 1999, 2002), conservation of resources (Hobfoll et al., 1990), and homophily (McPherson et al., 2001; Rogers & Bhowmik, 1970). Results provided some support for all three frameworks.

Social Network Structure of Food Bloggers on Twitter

The overall network density of directed ties was 21%, revealing a partially connected network. Moderately low values of in-degree (0.27) and out-degree (0.31) centralization suggested that the network tended toward an egalitarian structure rather than organization around a few focal bloggers. At the individual level, however, there was wide variability in the centrality of individual bloggers across multiple measures. For example, some bloggers followed almost half of the other bloggers in the network on Twitter, potentially increasing their access to social capital, but some did not follow any of the other bloggers in the network, potentially to conserve resources. Further, the high level of dyad reciprocity (58%) revealed that when a blogger initiated a Twitter following relationship with another blogger in the network, it was likely to be reciprocated. This finding may suggest that bloggers perceive mutual Twitter following relationships as an opportunity to increase social capital. However, results showed bloggers were following and followed by only 20% of the other bloggers in the network, revealing many missing connections.

Overall, these findings lend more support to the conservation of resources framework than social capital, and were consistent with the partially connected network observed in a previous study of mom bloggers on Twitter (Burton et al., 2013). Interestingly, the organization of the network was more egalitarian than observed in previous studies of social media users who are more diverse in influence, which tended toward organize around focal actors (Himelboim, 2017). Future studies should explore how network structure affects the spread of content and design practices in subgroups and larger communities of food-related social media influencers.

Homophily was evident in multiple findings, however, the extent to which bloggers formed ties to other bloggers based on the topic of their blogs varied by subcategory. Specifically, bloggers focused on cocktails, cooking, culinary travel, and special diets had high densities of ties to bloggers in their own subcategories. Bloggers that focused on cocktails or culinary travel, in particular, formed cohesive subgroups such that most-to-all bloggers within these subcategories were connected, but there were few connections to other bloggers within the network that focused on different topics. Cocktail and culinary travel bloggers may believe they share similarities with bloggers in the same subcategory but have little in common with bloggers in other subcategories, supporting a stringent definition of homophily. In contrast, baking and desserts, family cooking, regional cuisine, and wine or beer bloggers did not have higher tie densities to bloggers in their own subcategories within the network on Twitter. More research on homophily among prominent bloggers representing diverse subgroups is needed to compare and contrast these findings, as

research along these lines has been limited to date (Agarwal et al., 2012; Pei et al., 2015; Peng et al., 2018; SanMiguel & Sádaba, 2018).

Interestingly, baking and desserts, cooking, and special diets bloggers shared several close connections. Cooking and special diets bloggers were more likely to follow and be followed by bloggers in each other's subcategories on Twitter. Additionally, baking and desserts bloggers were more likely to be followed by cooking and special diets bloggers. Bloggers in these three subcategories may perceive each other's Twitter content as relevant because their blogs may occasionally include similar recipes, even though their primary subcategories are named differently. For example, special diets bloggers may follow cooking and baking and desserts bloggers to obtain inspiration for traditionally-prepared foods that could be modified to meet dietary restrictions (Sosa, 2010). Although the stringent definition of homophily applied in this study suggested bloggers would selectively form ties to bloggers within their own subcategories, a more moderate definition of homophily would suggest that bloggers could perceive some likeness to bloggers that focus on other closely related topics.

Wine or beer bloggers had few ties with bloggers in the network, either within- or between-topical subcategories. It may be that wine or beer bloggers focus on highly specialized topics and select who they follow on Twitter based on niche traits not measured in this study (e.g., wine region, home brewing methods). Previous research on wine bloggers on Twitter found that bloggers with more wine credentials had more followers among all Twitter users (Marlowe et al., 2017). Together, these findings suggest future research should examine how niche interests and credentialing determine patterns of relationships among influencers in the beverage category.

Our initial research question concerning homophily in this network was that bloggers would selectively form ties based on the topics of their blogs. It is also possible that bloggers might selectively form ties based on overall Twitter followers - an observable characteristic that may signal similarity in the blogger's degree of influence (i.e., audience size or popularity) within the social networking site. To explore whether *Saveur* network bloggers selectively formed ties based on overall Twitter followers, we conducted a post-hoc structural blockmodel ANOVA density test using 10,000 permutations. We divided bloggers into terciles representing their overall number of Twitter followers: High = 3,974 to 30,529 (n = 15); Medium = 1,297 to 3,973 (n = 15); Low = 77 to 1,296 (n = 14). Results revealed that differences in the density of directed ties by overall Twitter followers explained only 4% of the variance in *Saveur* network blogger-to-blogger ties (p = .06). Within this marginally significant model, results suggested that *Saveur* network bloggers with the most overall Twitter followers were more likely to follow each other (density = .33, p = .03), and be followed by bloggers with medium (density = .31, p = .03) and low overall Twitter followers (density = .28, p < .01). Although there was some evidence of preferential ties to bloggers with the most overall Twitter followers, the low amount of variance explained suggests this characteristic was not particularly salient in determining blogger-to-blogger ties. The rapidly changing professional dynamics concerning social media influencers highlights the need for additional research investigating how audience size on social networking sites affects the formation of ties between influencers (Stoldt et al., 2019).

Associations Among Twitter Use, Outreach, and Popularity

Greater uses of Twitter were associated with higher outreach and popularity, although there were contextual variations. For example, bloggers who favorited more tweets had more following and follower relationships within the *Saveur* network, but favorited tweets were not associated with overall Twitter user following or follower relationships. This finding may indicate that bloggers were endorsing (i.e., "favoriting") content shared within the *Saveur* network of food bloggers. Favoriting online content can convey multiple meanings, including signaling social support (Doub, Small, Levin, et al., 2016; Hayes, Carr, & Wohn, 2016). Interpreted through the social capital framework, bloggers may favorite tweets to attract attention from fellow bloggers, potentially increasing access to social capital that increases audience visibility and builds credibility (e.g., mentions, retweets). Longitudinal research is needed to investigate how social media content endorsement predicts tie reciprocity, content engagement, and audience growth among social media influencers over time. Further insight into the relative importance of these predictors could be elucidated through multivariate analytic approaches (e.g., Multiple Regression QAP tests).

Bloggers' Twitter following and follower relationships were highly and positively correlated within the sampled *Saveur* network and among all Twitter users respective to each context. Results regarding *Saveur* network outreach and popularity are consistent with the high level of tie reciprocity observed at the entire network level. However, outreach and popularity within the *Saveur* network were not associated with outreach and popularity among all Twitter users. Interpreted through the conservation of resources framework, this finding may suggest that prominent food bloggers are more interested in curating relationships with other bloggers based on shared attributes rather than popularity with generalized audiences. Additional longitudinal research is needed to determine how popularity among generalized and niche audiences influences the development of ties with fellow social media influencers and vice-versa over time (Peng et al., 2018).

Future Directions

Results of this study indicate several directions for future research that could improve the understanding the spread of content and information design practices among food-related social media influencers. For example, studies could directly investigate bloggers' motivations for forming relationships on social networking sites using qualitative and/or survey research methods to reveal how bloggers draw on each other to inform their content and audience engagement strategies. Prospective or retrospective longitudinal studies could investigate a specific information design practice (e.g., brief video-based recipe tutorials) to illustrate how an information design practice spreads across network members over time. As evidence accumulates on how bloggers connect and interact through social networking sites, experimental research could manipulate these connections and/or the content bloggers exchange to increase health-promoting behaviors among bloggers and their audiences. For example, nutrition education professionals could partner with food-related social media influencers and advise influencers to follow evidence-based social media accounts (e.g., USDA MyPlate; Post, Eder, Maniscalco, Johnson-Bailey, & Bard, 2013), and/or offer ideas for social media content that espouses evidence-based guidelines for dietary health. Research along these lines would advance the understanding of how to leverage

social networking sites for evidence-based nutrition education (Dumas et al., 2018; Leak et al., 2014; Li et al., 2013; Tobey, Mouzong, Angulo, Bowman, & Manore, 2019).

Strengths and Limitations

The current study is among the first to investigate patterns of social relationships among food-related social media influencers, which is an important population to understand given their potential to influence nutrition behavior at a broad scale (Coates et al., 2019; Doub, Small, & Birch, 2016b). Research on food-related social media in the academic sector is important to advance public health, particularly as corporations increasingly use social media data to influence consumer behavior (Edney et al., 2018; Stoldt et al., 2019; Weber, Mandl, & Kohane, 2014). There are a few limitations to this study related to sampling and data collection. First, not all bloggers nominated for a 2014 *Saveur* food blog award had active Twitter accounts; thus, it was not possible for every blogger in this social network to connect. Not having a Twitter account may be similar to abstaining from engaging in the network and these bloggers could be isolates. Secondly, due to limits on the Twitter application programming interface (API), NodeXL searched for ties within a blogger's most recent 2,000 following/follower relationships. It is possible that some network member ties were missed among bloggers following more than 2,000 Twitter profiles ($n = 5$). Data on the duration of time the blogger had an active Twitter account was not collected, which is another measure of Twitter use that could be examined in future studies. Additionally, data on comments, replies, mentions, retweets, or favorited tweets (incoming) were not collected, which could be included in future work to construct and analyze weighted social networks. Data on the complete ego networks of each member of this network were not collected, which could more fully describe the potential spread of content and design practices among food bloggers and their audiences on Twitter. Lastly, Twitter following relationships were measured after blog nominations were publicly announced, which may have increased ties observed in the *Saveur* network (i.e., created a more dense network) due to increased visibility and shared awareness.

Conclusions

Nutrition information conveyed by popular social models through online platforms (i.e., social media influencers) has the potential to broadly impact eating behavior through mechanisms of social influence (Doub, Small, & Birch, 2016b). Little is known about the online community structure of food-related social media influencers, which could reveal bloggers' opportunities to observe and spread content and information design practices. This study makes a novel contribution to the literature by examining patterns of social relationships among prominent food bloggers on Twitter. Results revealed a partially connected network with bloggers in some subcategories showing more dense ties to other bloggers focused on the same topic. This pattern of social connections generally supported the conservation of resources framework with homophily. Cocktail and culinary travel bloggers were more likely to follow bloggers in their own subcategories alone on Twitter. Cooking and special diets bloggers were more likely to follow bloggers in their own subcategories, as well as bloggers in each other's subcategories, and baking and desserts bloggers on Twitter. Further, individual bloggers in these subcategories (cooking, baking and desserts, and special diets) were the most central in the network. These results suggest bloggers focused on cooking, baking and desserts, and special diets had among the broadest

opportunities to observe and spread nutrition information among other bloggers in this network. Additional research is needed to test whether this observation is consistent in larger networks of food bloggers.

There was also some evidence of social capital, which may impact the dissemination potential of a given bloggers' content and information design practices. Notably, among all Twitter users, bloggers in the network who posted more tweets were more popular. Among the bloggers in the network, bloggers who favorited more tweets were more popular. Respective to each context, bloggers who showed more outreach were more popular. These results may suggest that broader audiences reward social media influencers who produce more content, while fellow social media influencers reward peer-supportive behaviors that increase their own social capital. Context specific outreach was associated with popularity among all social networking site users and among fellow social media influencers, revealing outreach may be a critical aspect of establishing an identity as a food-related social media influencer. Longitudinal research on bloggers' social networking site use, outreach, and popularity is needed to establish the direction of these associations. Future research should build on and expand these findings to examine bloggers' motivations for forming connections with general users and other influencers on social networking sites. Studies should also explore how the structure of connections among influencers, including food bloggers, on social networking sites influences the spread of content and design practices among influencers. Research along these lines will reveal important insights about the generation of popular online content that can influence eating behavior on a broad scale.

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