NEGATIVE TIES AND SIGNED GRAPHS RESEARCH: STIMULATING RESEARCH ON DISSOCIATIVE FORCES IN SOCIAL NETWORKS

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1. Introduction

Some relationships harm. Others are characterised by avoidance, dislike, or conflict. These relationships – known in the social networks literature as negative ties – are pervasive, arising in virtually all settings, including the family, workplace, school, neighbourhood, politics, within and between organisations, and international relations. While generally rarer than positive ties, the consequences of negative ties – whether they be gossip, conflict, bullying, violence, or war – are often considerably greater than their positive counterparts. Despite their importance, negative ties and signed graphs remain a relatively neglected area of social network research.

In this introduction to the special Issue of Social Networks on negative ties and signed graphs, we provide a brief overview of past academic research in this domain. We begin by examining why this research area is so important to the study of social networks and society more generally. We then introduce briefly the existing literature, dividing it into three themes: (1) typologies, (2) causes, and (3) consequences of negative ties and signed graphs. As we review these themes, we situate the contributions made by the articles in this special issue, and end with some thoughts on future directions for the study of negative ties and signed graphs.

1.1 What is a negative tie? What is a signed graph?

In social network analysis, a tie is a relationship. Traditionally such relationships have been conceptualised as *positive ties* – which convey something of benefit, such as friendship, advice, and social support – or *neutral ties* – which signify interaction but not necessarily benefit, such as being in a shared school or classroom or company department, or being involved in formal communication, such as email. The last few decades have seen an increasing focus on the study of a third type of tie, the *negative tie* – which convey something detrimental, such as harm or hostility – and the associated study of networks composed of a mix of negative and positive ties, which are called *signed graphs* or *signed networks*.

Signed graphs are an extension of the idea of negative ties to a conceptualisation of human (and animal) social networks as multiplex networks (i.e. networks composed of many types of ties) of both negative and positive ties (Cartwright and Harary, 1956: 282). Signed networks that have been studied include friendship and bullying at school (e.g. Huitsing et al., 2012), positive and negative gossip in the workplace (e.g. Ellwardt et al., 2012), voting with and against in

parliaments or courts (e.g. Mendonça et al., 2015, Mrvar & Doreian, 2009), and even alliances and wars between nations (e.g. Corbetta & Grant, 2012, Smith et al., 2014).

2. Why study negative ties and signed graphs?

Why do we, as researchers, study signed graphs? We see three interconnected reasons which motivate most of us: (1) the pervasiveness of negative ties; (2) the disproportionate consequences of negative ties (especially when compared to their positive tie counterparts); (3) the relative neglect of the study of negative ties; and (4) the unique dynamics of negative ties and signed graphs.

2.1 Pervasiveness

Negative ties are (almost) everywhere. There exists within almost all networks some form of negative tie: arguments, disputes, losing one's temper, gossip, poor work performance, abusive managerial behavior, school bullying, hostility, even murder and war. Negative ties surround us, and this makes them important to study.

We attempt to illustrate the pervasiveness of negative ties in Table 1. We list virtually all major social settings for social networks in the first column, and examples of actors in these settings in the second. In the third, we list types of negative ties – relationships between actors that are detrimental in some fashion to at least one of the actors – that could potentially be measured. What is clear from Table 1 is how widespread negative ties are, being found in almost every social network setting where positive ties exist.

Setting	Actors	Potential Negative Ties
1. Family	Family members	Conflict, dislike, avoidance, domestic violence, arguments, defensiveness, silence, contempt, tease/bully
2. Workplace	Employees/staff	Negative gossip, discipline, bullying, avoidance, arguments, exploitation, sacking/terminate, judge incompetent, sabotage/undermine legitimate interests
3. School	Students	Bullying, avoidance, dislike, conflict, arguments
4. Romantic and sexual relations	Persons	Reject, find unattractive, avoid, break-up, argue, violence, give STD, harrassment, assault, rape
5. Friendship/ socialising	Persons	Conflict, argue, dislike, avoid, hit, tease
6. Social Media	Persons/accounts	Argue against, negative retweet, express dislike, distain, etc.
7. Internet	Wikipedia accounts	Delete/reverse edits, vote against
8. Neighbourhoods	Persons/Households	Argue, conflict, dislike, avoid, legal/police complaint, robbery/theft
9. International relations	Nation states	Public criticism, vote against in UN committees (or similar), sanctions, threats of aggression, aggression (war)
10. Economic relations	Nation states	sanctions, tariffs, currency manipulation, boycotts/bans, quotas, non-tariff barriers
11. Politics	Parliamentarians/ Ministers/Parties/ Lobby groups	Vote against, Public criticism, negative advertisements, conflicting policy positions
12. Voluntary organisations	Organisations	Public/media criticism, campaigns against
13. Inter-firm	Firms	Legal suits, Public criticisms, Competing products/markets
14. International organisations	Organisations	Public criticism, conflicting policy positions, vote against

Table 1: Examples of potential negative ties across a range of social network settings.

2.2 Consequences

We are hard-wired to remember bad experiences involving people that might pose a threat to us, and we spend a lot of mental effort evaluating those individuals and behavioral effort in trying to minimize their potential harm to us. This, in part, explains why negative ties have disproportionate consequences on a per-tie basis when compared to their positive tie counter parts (for a summary of the literature see Baumeister et al., 2001, Labianca & Brass, 2006). While negative ties are, in general, considerably rarer (there are fewer negative ties per actor in most networks), the disproportionate consequence makes the study of negative ties particularly important in many fields. Archetypal examples of this "negative asymmetry" include: the greater impact on mental health of negative social undermining compared to positive social support (Lee et al., 2019, Pagel et al., 1987); the greater impact of negative interactions than positive interactions on relationship quality and health outcomes (e.g. Eaker et al, 2007, Newsom, et al, 2003); and the greater impact of negative relationships than positive relationships on perceptions of trust and conflict in the workplace (Burt and Knez, 1995, 1996, Labianca, Brass, and Gray, 1998). While negative asymmetries might not occur in every setting, or for every outcome, they occur in enough of them to make it theoretically critical to study negative ties if one is attempting to understand the relationships between social networks and outcomes.

2.3 Neglect

A third major motivation for researching negative ties and signed graphs is simply their relative neglect by academic researchers. As we know, science, including social science, progresses – in part – through finding gaps in our existing knowledge, and then attempting to fill these gaps. The saturation of various fields of academic research is often overwhelming for new researchers, struggling to find a way to make a contribution.

In a world of such saturation, the area of negative ties and signed graphs is something of an exception. To illustrate the relative neglect of negative ties and signed graphs, we compared the number of articles returned in a Google Scholar search for the exact phrases "negative ties" and "signed graphs", with those for the exact phrases "social network analysis" and "social network". We looked at every five year period since 1970. The results were striking: in the 2016 to 2019 period, for every article containing the phrase "negative ties" or "signed graphs", 13 articles were published containing the phrase "social network analysis", and 71 articles were published containing the phrase "social networks". In the period 2016 to 2019, the absolute

quantities were approximately 550 articles per year for “negative ties” or “signed graphs”, 7,600 articles per year for “social network analysis”, and 40,000 articles per year for “social networks”.

This relative neglect, however, is accompanied by a more positive story: since 2000, the publication of articles on negative ties and signed graphs have seen considerably faster rates of growth than the overall social networks field – albeit from a very low base – with the number of publications (per year) doubling every five years for the last 20 years (2001-5: 67/year; 2006-10: 135/year; 2011-15: 299/year; 2016-19: 560/year).

Both the relative neglect, and the rapid growth in publications in recent years, points towards opportunities for the ambitious researcher looking for an area of research to make an impact.

2.4 Unique dynamics

Negative ties have unique dynamics which justify their study as a separate domain of social network analysis. Three examples illustrate how conceptually and empirically different negative tie and signed graph dynamics are from those of positive ties: measures of centrality, dynamics of transitivity, and the dynamics of reciprocity.

With respect to centrality, many positive tie centrality measures (such as closeness) have built into them the idea that positive tie centrality cascades upwards – receiving positive ties from people who have a lot of positive ties are normally, and rightly, considered to be more valuable. Positive ties flow. Receiving a tie from a popular person makes the recipient even more central. For negative ties, in most settings, this mechanism does not work. Receiving a dislike tie from the most disliked person in a group is not mathematically or conceptually the same as receiving a liking tie from the most liked person in a group. Negative ties, generally speaking, don’t ‘flow’ or ‘cascade’ through a network. Because of this, we need both a different conceptual and analytical framework to understand centrality and other important nodal positions in signed networks. This has led to innovations such as a new measure of centrality for signed graphs, Positive Negative (PN) Centrality (Everett & Borgatti, 2014), as well as a new measure of powerful nodal positions, the Political Independence Index, based on allies’ and adversaries’ political dependence on each other (Smith, et al, 2013), but a great deal more needs to be done with regards to understanding advantageous nodal positions in signed networks.

With respect to transitivity, the dynamics of positive ties are very different to those of negative ties and signed graphs: negative ties have no reason to 'close' like positive ties. If A has a negative tie to B and B has a negative tie to C, there is actually very little likelihood of A and C developing a negative tie, in spite of the fact that this would create a structurally balanced triad (Cartwright & Harary, 1956). Negative tie transitivity is not explainable as a sub-theory of positive tie transitivity. Negative ties and signed graphs instead need their own theories of transitivity, such as those involving modifying structural balance (Hummon & Doreian, 2003, Lerner, 2016) or introducing new theories such as status theory (Leskovec et al., 2010).

With respect to reciprocity, there is also strong evidence that the dynamics of negative and signed ties are qualitatively different, and can't simply be considered a subset or derivative of positive tie theories. Positive tie reciprocity tends to capture concepts like mutual admiration, strong friendships, mutual support, or mutually beneficial exchange. Negative tie reciprocity tends to capture mutual hatred, revenge, defensiveness, and inter-actor conflict. We know that positive tie reciprocity is much more likely to occur than negative tie reciprocity. Beyond that, conceptually there are very few similarities between these social phenomena, except their ability to be represented by a particular subgraph in modelling. In signed graphs – with both positive and negative ties – the dynamics are even more complex. While we might expect positive ties to be protective against reciprocation with negative ties, the opposite is often true; Harrigan and Yap (2017: 137) show that esteem ties tend to be reciprocated with disesteem ties, and Wittek et al. (this issue) show that proximity in the friendship network *increases* the chances of a violence tie in a dyad. Positive ties imply social proximity and greater interaction – a pre-condition for many negative ties – and positive ties can also represent a tie to a higher-status other, who might be more likely to return the positive tie with a negative one, reflecting the social positions and relative power of the actors. Thus, there are good reasons to expect reciprocation of positive ties with negative ties, and vice versa. Again, this points to negative tie and signed graph research being a separate domain of knowledge, necessitating its own theories, models, and contributions to generalised knowledge.

3. Theme 1. Typologies and Taxonomies

In the next three sections, we review major themes within the existing negative ties and signed graphs literature – typologies and taxonomies; causes of negative ties; and their consequences – and then highlight how the articles in this special issue contribute to this literature. We begin with the theme of typologies and taxonomies.

3.1 Existing Literature

One of the fundamental tasks of thinking is the development of categories. Categories provide us with boxes to put objects and events into, and once we have done this, we can then look at patterns - such as correlations - between these various categories. Within the literature on the development of categories in networks, at least two important distinctions can be drawn: between typologies and taxonomies (Meyer, Tsui, Hinings, 1993); and between classification of ties and actors. We briefly review typologies of ties, and then taxonomies of both ties and actors.

3.1.1 Tie typologies

Typologies are said to be conceptually derived classifications (as opposed to empirically derived taxonomies). Many typologies from the positive tie literature apply equally well to negative and signed ties. Such useful typologies include relational states (e.g. long-term hatred) versus relational events (e.g. an episode of conflict that might occur within the context of a long-term friendship) (Lopez-Kidwell, et al, 2018); or interactions (e.g. a fight) versus flows (e.g. spreading misinformation) (Borgatti, Everett, and Johnson, 2013: 4). Other typologies have been developed specifically for the negative tie and signed graph literature, such as the application of the tripartite model of interpersonal attitudes (Breckler, 1984) to negative ties (Labianca, 2014, Yang et al., 2019). This tripartite model distinguishes affective, behavioral, and cognitive negative ties. This typology allows us to think with analytical precision about the nature of any particular tie: Is it a feeling, which might be involuntary (an affective tie)? Is it an action, which is generally observable by third parties and researchers (a behavioral tie)? Is it a judgement, which requires reasoning, inference, and decision making (a cognitive tie)? This distinction is particularly important for those interested in studying the prismatic or reputational effects of negative ties; arguments suggesting, for example, that being tied to someone who is very unpopular can drag down one's own popularity (e.g., in politics) inherently view ties as having reputational value that helps to place individuals within a social hierarchy. These prismatic effects, however, assume that third parties have knowledge of positive and negative ties and that this, in turn, colors their judgment of the individuals involved; however, these audience effects are more likely with behaviorally-based negative ties that are more easily observable (e.g., violence, dissing, negative gossip) as compared to affective or cognitive judgments (e.g., disliking, distrust) which are internal to the individuals involved.

Within the existing literature there are also nascent and implicit typologies of negative ties which are built into research design and theory building: between general dislike and bullying (Huitsing et al., 2012); between dislike and disdain (Yap and Harrigan, 2015, Harrigan and Yap, 2017); between hate, dislike, weak negative, and strong negative ties (Fig. 10 in Vörös and Snijders, 2017); and between violence and dislike (Wittek, Kroneberg, and Lammermann, 2019). We expect in the near future these conceptual distinctions will be elaborated into more detailed typologies.

3.1.2 Actor taxonomies

While typologies are derived conceptually, and are true by definition, taxonomies are derived empirically, and shown to exist though inductive methods like cluster analysis, block modelling, factor analysis, and multidimensional scaling (Meyer, et al, 1993). Actor taxonomies of negative ties and signed graphs have identified and classified actors (nodes) across a wide variety of settings, including the US Supreme Court (Mrvar and Doreian, 2009), US Congress (Waugh et al. 2011), and the UN General Assembly (Macon, Mucha, and Porter, 2012; Doreian, Lloyd, and Mrvar, 2013). This literature has focused on both identifying substantively important groupings in each setting, and on advancing network methods so as to better detect underlying groups, and do so with computational efficiency. The general underlying innovation is to find efficient and effective ways to maximize positive ties and minimize negative ties within groups or communities, while maximizing intergroup negative ties and minimizing their positive ties, which often better represents reality than approaches focused only on the presence or absence of positive ties (Traag and Bruggeman, 2009).

3.1.3 Tie taxonomies

The literature on tie taxonomies for negative ties and signed graphs is more sparse than that on actor taxonomies. One of the difficulties in this area is collecting enough networks on the same set of actors to be able to identify groups or clusters of tie types. Two important papers on tie taxonomies involving negative ties and signed graphs are the three factor model of De Lange et al. (2004) and the three dimension model of Vörös and Snijders (2017). De Lange et al.'s (2004) model finds three bipolar (negative to positive) dimensions of ties in a workplace network: a friendship dimension (from superficial/hostile/distrustful to profound/friendly/trusting); a work advice dimension; and a social support and companionship dimension. In Vörös and Snijders' (2017) work in classroom settings, three clusters of tie types

are identified: positive (pretty, funny, kind, clever); role (help, trust, look up, organise, dispute, decides, protects); and negative (nerd, shy, gossipy, teachers pet, smug, look down).

3.2 Special issue contribution to typologies and taxonomies

A number of papers published in this special issue help to advance the methods for analysing, and our understanding of, the typologies and taxonomies of negative ties and signed graphs, as we discuss below.

3.2.1 Methodological contributions

The Arinik, Labatut, and Figuereido (2019 - this issue) paper make a considerable contribution to methods for identifying actor taxonomies in the setting of the EU parliament. They propose a novel method of partitioning multiplex signed networks involving votes for and against various pieces of legislation: they partition each layer of the network separately, and then group partitions by similarity. Through this method, Arinik et al. are able to identify five distinct voting patterns - rather than simply groups of parliamentarians - providing a considerably more nuanced analysis than previous political science research.

Yang, Hua, and Yu (2019 - this issue) also make a significant methodological contribution to the actor taxonomy literature through developing a fast clustering algorithm specifically designed for large signed graphs (such as would be found in large online networks). Their method is both much less computationally-intensive and performs better than existing approaches, such as Doreian and Mrvar's (1996, 2009) structural blockmodeling. This advancement allows signed graph research to be conducted on far larger networks than have been the case to date, which should allow for greater use of digital trace data in negative tie research.

The Stadtfeld, Takacs, and Vörös (2019 - this issue) paper also shows how it is important to incorporate mixed positive and negative tie parameters into increasingly popular analytical tools, such as stochastic actor-oriented models, if we are to better simulate real world networks. They show how such methods are a substantial advancement, but that even these methods generate (in longer run simulations) networks that are too stylized to be realistic - presenting a challenge and opportunity for future researchers to improve upon their work.

3.2.2 Contributions to tie and actor taxonomies

Wittek, Kroneberg, and Lammermann (2019 - this issue) contribute to tie taxonomy by showing that there is a substantive difference between two types of negative ties in school settings: dislike and violent behaviour. They find that dislike tends to be directed at those who are socially distant (e.g., in a different ethnic group), while violence is directed towards those who are socially closer. One manifestation of this is the greater tendency for violence between same-ethnic peers, while there is a greater tendency for dislike between those of different ethnicities.

The Neal (2019 - this issue) paper makes a substantial contribution to actor taxonomies and our understanding of polarisation within the U.S. Congress. Neal argues that most political network research has ignored adversarial relationships, and this can lead to an incomplete and potentially even erroneous view of what is happening within the network. He shows that the results of previous studies - which have focused only on the absence of positive ties - are indeed replicated when negative ties are explicitly measured and modelled. He further shows that two types of polarisation -- the first based on the absence of ties (weak polarisation) and the second on negative ties (strong polarisation) -- are both increasing in the U.S. Congress over time, suggesting less possibility for cohesive action in the future.

4. Theme 2: Predictors, Antecedents, and Causes of Negative Ties

Why do negative ties form in the first place? What predicts whether one school child will bully another? What is it about the person in the workplace who is the continual object of negative office gossip? Why do some nations form alliances, and others go to war? An important question in the negative ties and signed graph literature is what predicts, precedes, and causes them to occur at all.

4.1 Existing Literature

We classify the literature on causes of negative ties and signed graphs into two main types: internal motivators and external constraints. Given the enormous complexity of causality, and the number of potential framings, we acknowledge this classification is just one of many ways to approach this literature.

4.1.1 Internal Motivators

Humans have desires, and these desires motivate us to form and dissolve relationships with each other. Of the wide range of human motivators, the most studied in the negative ties and

signed graph literature is that of the desire to reduce cognitive dissonance - the psychological motivation that drives classical balance theory (Hummon and Doreian, 2003). This desire compels us, it is argued, to ensure our relationships with others are in balance - we find it stressful to find ourselves allied with parties who are on opposite sides of an argument. We don't like to be caught with conflicting loyalties. However, this is not the only human desire that drives signed ties. Many authors argue our signed ties are driven by status seeking, status enforcement, and dominance considerations (Leskovec et al., 2010, Papachristos, 2009). We also can be motivated by our underlying need for self-esteem, and need to protect our social identity, and because of this show ingroup-favouritism in our ties (Boda and Neray, 2015). Our ties can also be driven by our normative orientation, our cognitive beliefs, and our more or less fixed personality structure (Klein et al., 2004). In addition, we can be motivated by our need to live and work in functional social and economic formations - sending signed ties on the basis of judgements about competence, incompetence, and the need to punish norm-violating behaviour (Ellwardt, Labianca, and Wittek, 2012).

4.1.2 External Constraints

Human relationships are also shaped by their context. We are constrained in the relationships we can form by biology, geography, and social institutions. Some of the most fundamental constraints - and drivers - of signed ties are demographic characteristics, such as age, gender, ethnicity (e.g. gender in Yap and Harrigan, 2015; gender, age, sexual orientation in Felmlee and Faris, 2016; race in Doreian and Conti, 2012). Our relationships are also constrained and conditioned by the settings we occupy - school, work, social media, courts, or international relations (e.g. geography, trade, development in Lerner, 2016; social and spatial contexts in Doreian and Conti, 2012) - and the social roles we fill - as managers or subordinates, parents or children, spouse, friend, family member, or neighbour (e.g. executive members vs ordinary students in Yap and Harrigan, 2015; major power status in Lerner, 2016; work role in Doreian and Conti, 2012). Within social network analysis, we also have a wide range of ways of describing social contexts created by network ties themselves, which then give rise to further ties. In this literature, social context is captured by network structures which surround actors and their ties - popular actors, ties that can be or are reciprocated, ties entrained by other types of ties, transitive closure of paths between third parties, and occupying structural holes (gaps in networks between individuals and groups who are not connected, but who could benefit from beginning brought closer together) (e.g. all network structural coefficients in Yap and Harrigan, 2015, Doreian and Conti, 2012, Felmlee and Faris, 2016). In addition we can think about more

abstract constructions of the social context that gives rise to signed ties - such as the tie strength of surrounding ties, the consequences of tie formation, the visibility of such ties, and the social norms of the society we are operating within.

4.2 Special Issue Papers on Antecedents

In this special issue, a considerable number of papers advance our understanding of the predictors, antecedents, and causes of negative ties and signed graphs.

4.2.1 Balance, status, and retaliation

The paper by Lerner and Lomi (2019) defines a negative tie as an individual contributor going into a Wikipedia page and undoing another contributor's work. By examining 60 million of these interactions in a self-organizing user-generated community, Lerner and Lomi are able to examine the underlying motivations behind undoing someone else's work. They found that ties between individuals working on controversial Wikipedia articles generally follow structural balance theory and form into ingroups and outgroups that work to protect their versions of the article from others' undoing attempts. However, they also found that reputational status is also a driver of tie formation: lower-status individuals are much more likely to have negative ties directed at them than are higher-status individuals. Finally, they found that once a negative tie was initiated and reciprocated between two individuals, they become locked in an escalating cycle of negative interactions. These latter two findings would be much more difficult to elicit from a survey and point to how we can take similar approaches in the future to investigate how, for example, specific conflict episodes can escalate into enduring negative relationships.

4.2.2 Status as motivator

Multiple papers on school bullying in this special issue point towards status as a factor that appears to motivate negative tie formation. van der Ploeg, Steglich, and Veenstra (2019) show that as children age, the negative ties they send have a beneficial prismatic effect for bullies, with bullies gaining in social status and using bullying to maintain their status. In a similar vein, Kisfalusi, Pal, and Boda (2019) show that secondary school students tend to bully peers that they perceive as being identified with a lower-status social group (the Roma in their case) as compared to non-Roma students, suggesting that bullying is being used as a means of expressing and/or maintaining an inter-ethnic social order. Finally, Wittek, Kroneberg, and Lammermann (2019 - this issue) study also shows that two different dynamics are in operation for dislike and violence ties, with dislike among secondary school students directed from the

ethnic ingroup to the outgroup, while violent behavior tends to be more likely within ethnic ingroups and is used to contest and maintain social status within the group.

4.2.3 Context as constraint

Several papers in the special issue speak indirectly to the importance of social context for determining causes (and consequences) of negative ties, particularly those motivated by desires for status. Halgin, Borgatti, and Huang (2019) take us into an unusual setting – the world of rap artists – to understand dissing behavior. These put-downs by one artist of another artist are overt, intentional, directed negative behaviors, clearly representing a negative interaction tie. But the effect of these ties, and likely intention, is to raise the social status of lower-ranked artists. Halgin et al.'s work reminds us that network ties have more meaning beyond the flows and exchanges between the two individuals involved; external audiences bear witness to some of these negative interactions and draw conclusions about the social world from them. Who you are tied to can both elevate your social standing (Sauder, Lynn, & Podolny, 2012) or denigrate it (de Klepper et al., 2017). Halgin et al. (2019) show explicitly that overt negative interactions in this setting not only reflect back on the dyad's reputation, but can have a prismatic effect, where they raise an individual's standing within the social hierarchy. However, the social context matters, and while dissing someone higher in status and hoping that they retaliate might be a good career move for rappers playing to a *market* audience, it is unlikely to have the same beneficial outcomes if an employee attempted the same behavior against a manager with formal authority over their career outcomes within an *organization*. van der Ploeg et al.'s work on bullying in schools also points to the importance of context in determining the impact of ties: amongst younger children bullying results in retaliation - not a good consequence for the bully - while at older ages, bullying ties raise and maintain social status. As these cases illustrate, social context provides a hard external constraint on effective methods individuals can use to achieve their internally motivated goals.

4.2.4 Are negative ties reality or perception?

Most of the research on negative ties proceeds under the assumption that the individuals involved in the tie perceive it accurately; this is not unique within negative tie research, as the same is true with positive tie research. However, there is mounting evidence that this is not a good assumption to make, and it might be particularly a problem for negative ties. The Tatum and Grund (2019) paper in this issue on teen-aged students is a good illustration of this; they show that there is very little corroboration between perceptions of whom ego feels they are

bullying and those presumed victims expressing that they are the targets of that individual's behaviors. Similarly, those alters' perceptions of being bullied by a particular ego are also not corroborated through bullying confessions, and these perceptual discrepancies are even worse in same-gendered dyads. Kisafalusi et al.(2019) also found that victims' bullying reports did not align with bullies' confessions. Beyond the research implications of our ties not necessarily being what we think them to be, these findings have implications for policy interventions. Tatum and Grund's (2019) results suggest that policy interventions might need to incorporate surfacing of these victim perceptions and helping individuals see how others view their behaviors, and perhaps even helping others to confess their own bullying behavior to an otherwise oblivious victim.

5. Theme 3: Consequences, effects, and outcomes

We classify research on the consequences of negative ties according to whether the detrimental or beneficial consequences occur at the nodal, dyadic, triadic, or group level (e.g., Agneessens, 2019; Yang et al., 2019). The nodal level considers how an individual's position in a signed graph (e.g., their centrality) impacts individual outcomes, such as performance, satisfaction, or reputational status; the dyadic level considers how a negative tie between two individuals might impact the likelihood of other types of ties between the two occurring (e.g., seeking advice from one another); the triadic level examines how a negative tie between two individuals creates consequences for connected third parties (e.g., stress, performance outcomes); and the group level, which examines how the number and location of negative ties impacts overall group/network functioning.

5.1 Existing literature

5.1.1 Nodal consequences

Detrimental outcomes. Much of negative tie research has focused on the individual's nodal position in the network (e.g., their degree centrality) and their outcomes (e.g., individual performance, happiness, being the object of negative gossip). As with studies at the dyadic level, this research has largely focused on the detrimental consequences of having more negative ties. For example, individuals with more negative ties experience less satisfaction with their social rewards (e.g., Venkataramani, Labianca, & Grosser, 2013) and can be hindered from having good performance at work (Sparrowe et al., 2001).

A good deal of research suggests that negative ties play a role in determining individuals' relative social standing within groups. Research in school classrooms find that individuals use bullying to establish themselves as informal leaders, and ostracizing in order to reduce rivals' relative social standing in a group (e.g., Sijtsema, Veenstra, Lindenberg, & Salmivalli, 2009); research on adults in organizations suggest that similar dynamics are at play in organizations, with employees using direct control of others' behavior in order to derogate others' status within the group (e.g., de Klepper et al, 2017).

Buffering hypothesis. Research has also examined whether these types of detrimental consequences can be mitigated by having positive ties that can provide offsetting support and resources. For example, Venkataramani et al (2013) found that social satisfaction at work is lowest when individuals have both high indegree negative network centrality (i.e., they are being actively avoided by others) and low indegree positive network centrality (i.e., no one is naming them as friends); indeed, such individuals are also more likely to be targeted as objects of negative gossip (Ellwardt, et al, 2012). However, Venkataramani et al's (2013) results also show that even individuals with high negative network centrality can experience strong social satisfaction if they had a high number of positive ties, suggesting that positive ties can act as a buffer against the stresses and detriments of negative ties.

5.1.2 Dyadic consequences

At the dyadic level, much of the research on consequences has taken the perspective that the presence of a negative tie between two people will have a detrimental impact on the interactions, perceptions, and interpersonal behavior between the two persons. Negative ties inhibit the emergence of positive ties (e.g., communication or resource sharing ties), with the underlying arguments being that individuals are more likely to withdraw from interactions with those they are tied to negatively and are, thus, less likely to share information or resources with them (e.g., Marineau, Labianca, & Kane, 2016). Negative ties can also generate other types of negative ties, such as harming (e.g., Venkataramani & Dalal, 2007; Lyons & Scott, 2012; Yuan, Carboni, & Ehrlich, 2014) or bullying (e.g., Huitsing, van Duijn, Snijders, Wang, Sainio, Salmivalli, & Veenstra, 2012). They are also more likely to generate negative moods, relational dissatisfaction, and stress, which can in turn elicit counterproductive interpersonal behaviors to relieve that stress, such as negative gossip (e.g., Ellwardt, Labianca, & Wittek, 2012).

Negative ties are sometimes good. More recent research takes a more nuanced view of negative ties' consequences, suggesting that they can have beneficial consequences, particularly for more cognitively-based negative ties. For example, Marineau, Hood, & Labianca (2018) found that individuals experiencing task conflict, a negative tie characterized by disagreements over how to accomplish a task, are more likely to seek one another out for advice. Similarly, Brennecke (forthcoming) found that employees with more "dissonant" ties -- where they held a negative cognition-based tie with an individual (i.e., they found them "difficult" to work with), but also sought out that same individual for problem-solving advice (a positive cognition-based tie), their job performance was improved. These studies suggest that individuals recognize their interpersonal differences and recognize the value of those differences in deciding what to do in the future.

5.1.3 Triadic consequences

Where network research shines in comparison to other types of research on interpersonal relationships is in understanding how dyads can affect bystanders -- that is, in moving beyond the two individuals in the tie to see how it affects third parties. Negative tie research examining consequences at this triadic level generally theorize either negative or positive spillover effects.

Negative spillover effects. The negative spillover effect, whereby the negative tie in the focal dyad causes the third party to suffer detrimental outcomes such as stress, is rooted in the belief that negative ties generate so much negative affect, behavior, and/or cognitive attention that it creates a toxic atmosphere that spills over into others' lives and diminishes their outcomes as well (Labianca & Brass, 2006). Conflict researchers often implicitly employ this perspective to explain why third parties attempt to mediate away conflict between two individuals (e.g., Collett, 2011). From a negative spillover perspective, the optimal place to be in a network is as far away from the negative tie as possible, which is reflected in the original formulation of Social Ledger Theory (Labianca & Brass, 2006).

Positive spillover effects. The positive spillover effect, in contrast, suggests that negative ties can create opportunities for third parties to exploit in order to improve their own outcomes (Marineau, Labianca, & Kane, 2016). For example, political independence theory (Smith et al., 2014) suggests that when networks are politically charged (e.g., in legislatures, work organizations, classrooms, among nations), individuals are focused on countering any perceived threats, particularly from adversaries. When ego encounters an adversary, ego

attempts to counter the adversarial threat by forging alliances with other actors. In order to entice those alliances, ego gives that third party something of value, thereby increasing that individual's outcomes. The fewer alternatives ego has for a potential alliance partner, the more value ego should be willing to provide the ally; thus, the extent to which they are politically dependent on the third party affects that individual's outcomes. While this theory is fairly specific to politically charged networks, one can also imagine positive spillovers occurring in non-political networks and with regard to different types of relations (e.g., children of divorced parents might be less likely to divorce, having borne witness to the detrimental outcomes of divorce).

5.1.4 Group-level consequences

Number of negative ties. There has not been a great deal of network research on how negative ties affect the functioning of groups overall, and what little has been conducted has tended not to take the social structure into great account. For example, some research has merely examined whether a group has even a single negative tie, which ultimately impacts its function. Humphrey et al. (2017) showed that the presence of any dyad with high levels of relationship conflict in a work team early in its life can affect the team throughout its lifespan, as it hinders information exchange within the team. Lacking this information exchange, there is unlikely to be as much group-level task conflict later in the group's life, which suggests that the teams will be unlikely to think critically about their tasks and discuss different possible solutions. Similarly, de Jong, Curşeu, and Leenders (2014) found that the presence of a dislike relationship in a team reduces team cohesion, which in turn harms team performance. Other research has merely aggregated the number of negative ties in the group and argued that negative tie density will affect group functioning. For example, Sparrowe et al. (2001) found that the presence of more hindrance ties within a work team (i.e., a high density of hindrance ties) has a detrimental effect on group performance. These types of research do not make full use of understanding where in the social structure a negative tie is emerging and whether this creates different consequences for the group's functioning, but instead count up the number of negative ties in the group.

Configurational approaches. More recent research moves beyond counting ties and takes a greater interest in a "configural" approach to understanding group outcomes. For example, Kane and Labianca (2011) examined avoidance ties between doctors and the information systems their teams had adopted and its relationship to patient outcomes (efficiency and quality

of care); while the overall extent to which doctors avoided information systems and had others use the system on their behalf (i.e., the density of negative ties) did not affect patient outcomes, if the doctors who avoided the most were also in a central position in the team's social network, patient outcomes were significantly worse than in those teams where more peripheral doctors were avoiding the systems. This suggests that when informally influential, central individuals are ignoring the agreed-upon use of information systems, the entire group's functioning can be hampered, with ill effects for those external constituents who rely on the group's outputs. Park, Mathieu, and Grosser (forthcoming) have similarly argued that two teams with identical negative tie densities with respect to conflict could have very different outcomes; for example, a team where all the relationship conflict is focused on one individual (e.g., the team leader) might have very different conflict dynamics and group outcomes, and require different types of conflict resolution techniques, as compared to a team that has developed two sub-groups in conflict with each other. While much of this research and theorizing is in the organizational realm, we could easily see the same logic being applied to research in other areas; for example, it would be interesting to know whether bullying and victimization in classrooms affects student outcomes (e.g., learning outcomes, absenteeism, health outcomes for the entire classroom, rather than the targets of these negative behaviors) differently depending on the configuration of these negative ties in the classroom social network, as compared to the overall density of these ties (cf., Salmivalli, 2004). We encourage work taking a network configural approach on group outcomes (e.g., Crawford & LePine, 2013) as a fruitful avenue for future research.

5.2 This special issue's papers focused on consequences

In this special issue, three papers examine the consequences of negative and signed ties. Halgin et al.'s (2019) study of dissing ties amongst rappers shows that there can be positive node-level benefits of negative ties. Low status rappers with dissing ties to high status rappers show enhanced record sales. This is a result of the prismatic effect of these negative ties, which elevate the status of low status rappers through their association with high status rappers.

Van der Ploeg et al.'s (2019) study shows that both positive and negative node-level consequences can come to actors as a result of sending negative ties. As mentioned, younger school children tend to punish bullies by refusing to award them status, while older school children tend to reward bullies for their negative ties, by attributing to them higher status. In this case, third parties - other students in the class - are the deliverer of the consequences, with

the bullying acting like a prism through which third parties make judgements about the social status of senders of negative ties.

Neal's (2019) paper on polarisation can also be conceptualised as a study of the consequences of negative ties and signed graphs for group level outcomes. He shows that at the group level - the U.S. Congress as a whole - there is increasing polarisation which is leading to the body's inability to effectively legislate for the nation as a whole. He shows this is a result of the emergence of more (+ - -) triads, with positive ties between congress people of the same party who share negative ties to congresspeople of the opposing party. By embedding negative ties more firmly in positive ties, the conflict between the two parties grows worse, making collaboration even more unlikely.

6. Future Directions/Conclusion

Owing to the relative dearth of social network research on negative ties and signed graphs, there are far more future directions that would be fruitful compared to the space we have to elucidate them; however, we would like to highlight some topics that have come up in various conversations at conferences that seem to be of interest to network researchers.

6.1 Challenges in temporal modeling

One crucial future direction involves further developing the notion of temporal dynamics and relational trajectories into signed graph research, particularly with respect to the consequences of these dynamics for actors (e.g., Lopez-Kidwell, et al, 2018). While theories such as structural balance have always considered that negative ties can be transformed into positive ties and vice versa to achieve balance within a triad, and there is a considerable literature on the longitudinal modeling of bullying networks (e.g., Huitsing, et al 2014), there remains considerable space for further research that develops (1) an understanding how these dynamics affect the individuals and their outcomes; and (2) non-linear and non-incremental effects of long-term relationships (which violate Markov chain assumptions underlying most existing longitudinal models). For example, if two individuals have had a strong, positive relationship for many years, embedded within a dense clique of ties created over time, and there is suddenly a betrayal between the two (cf., Jones & Burdette, 1994; Hilmar, 2019), this might create an extremely strong negative tie. This type of "super-toxic" negative tie might be much more likely to have

purely detrimental outcomes (e.g., health outcomes, demonization of the other, retaliation) as compared to more typical negative ties; it might also have a higher propensity to draw in other individuals through the process of triangulation (Smith, 1989), which can generate severe conflict escalation and the creation of opposing camps within the network. On the other side, it is possible, but much less likely, that two individuals be engaged in a negative tie for many years and eventually come to develop a positive relationship through mutual trust building and relationship repair (e.g. at a societal level, we can think of the resolution of long-term civil wars). Note that while the transition from a positive to a negative tie can be precipitous and begin drawing in third parties quickly, the reverse journey from a negative to positive tie might be one that takes a long time and might need to be shielded from other parties that might wish to see the negative tie continue. This suggests the need to study the coevolution of positive and negative ties over time (Huitsing et al., 2014), the need to relax Markov chain assumptions (of the current ties only being dependent on the previous time point), and to focus in on how the transformations of relationships are impacted on by third parties and sub-groups.

One concern with taking this path of studying co-evolution is that positive and negative ties might be so different fundamentally that the assumptions underlying certain analyses are violated. For example, some statistical models might require a moderate amount of change in network ties between time periods (e.g., a SIENA model requiring a Jaccard coefficient that is neither too high, reflecting no change in ties between time periods, nor too low, reflecting little network stability); while positive ties might fit this requirement for moderate amounts of change, it has been our experience in real-world networks that negative ties exhibit little stability on the whole (i.e., have generally low Jaccard coefficients). In our opinion, negative ties are inherently subject to greater instability than positive ties; for example, negative ties can motivate exit from the network entirely, and they can motivate individuals to rewire the network to avoid interacting with a person. As a result the negative ties - while highly influential on network structure - are transient as they fade away with exit or avoidance (e.g., Lopez-Kidwell et al., 2018, Harrigan and Yap, 2017). If this is true, how will our analyses and modeling approaches hold up when including both positive ties that are more stable, in models that also involve negative ties that might be inherently more unstable? More fundamentally, this high churn rate, coupled with a low base rate for negative ties to begin with, and difficulty in collecting these accurately to begin with, is often used by journal reviewers as an excuse to dismiss negative tie research when it is put forward, and for researchers to avoid trying to collect such data in the first place. We believe this is an erroneous approach; a single negative

tie can have greater impact than a comparable positive tie on all manner of outcomes, and we believe investing in developing the proper theoretical, methodological, and analytical tools to study signed graphs will have long term rewards for researchers and the scientific community.

6.2 Typologies and taxonomies

We also feel that typologies and taxonomies are important to pursue. It's quite clear that there are many types of negative ties, and their antecedents, consequences, and relational dynamics might all be quite different. For example, we have mentioned here the theoretically-driven tripartite model of interpersonal attitudes involving affect (e.g., hatred), behavior (e.g., violence), and cognition (e.g., incompetent) as one typology to distinguish different types of negative ties that might behave quite differently and might fruitfully be investigated in combination (Casciaro & Lobo, 2008). Similarly, researchers might wish to employ a more inductive taxonomic approach to eliciting different negative ties in specific contexts (De Lange et al., 2004, Vörös and Snijders, 2017, Harrigan, et al., 2018). Either approach allows us to acknowledge the diversity in types of negative ties without falling victim to pursuing dozens of different negative ties in an *ad hoc* fashion that keeps us from accumulating knowledge across different contexts, such as schools and work organizations, which previous research has suggested share a lot of similarities in how their negative ties operate in spite of the obvious differences in these contexts.

6.3 Context

Understanding the role that context plays with regard to the prevalence and intensity of negative ties continues to be of great interest. For example, Labianca and Brass (2006) noted that in contexts lacking interdependence among individuals, the prevalence of negative ties might be greater than in contexts where individuals depend on each other to achieve some outcome because there is greater autonomy to both perceive a negative tie and act accordingly. In general, we see that the base rate of negative tie expression is higher in classrooms, where there is little interdependence outside of some project teams, as compared to work organizations, where there are often high levels of workflow interdependence. Yet, we would also expect that negative ties in non-interdependent contexts would tend not to intensify because that same autonomy of action and lack of interdependence makes it easier to simply avoid interacting with the individuals with whom one has a negative tie. This might create something of a self-

limiting factor to negative ties where the intensity doesn't increase, and where there might be less likelihood to wish to draw in third party bystanders through structural balancing mechanisms. It is in contexts where there is great constraint on individuals' actions, including situations involving heightened interdependence, where we expect that negative ties will be less prevalent, more likely to involve ambivalence (i.e., holding positive and negative ties with the same individual at the same time), and where negative ties are likely to become both more intense and draw in third parties; similar arguments have been made with regard to role-based relations, such as kinship, that also constrain individuals' actions and force interaction even when negative ties exist (Offer & Fischer, 2018). Even within two interdependent contexts, such as work organizations and families mired in poverty, we might expect that because it is easier to exit the work organization and take a job elsewhere as compared to exiting interaction with one's family, we will see greater relational ambivalence and flare-ups of negative ties and their escalations in families as compared to work organizations. Beyond interdependence, there might be a host of contextual elements that have been studied in the conflict literature (e.g., Pruitt & Rubin, 1986; Rubin, Pruitt, & Kim, 2004) that might affect the broader set of negative ties we study in social networks, including (but not limited to) whether structures have been set up to encourage competition between two individuals; whether there are trusted institutions in place within a context to mediate disputes (e.g., formal and informal courts) and to provide restorative justice, rather than furthering growing mutual acts of revenge; whether there are time and resource deficits that affect interaction; whether the context is promoting a negative tie that is between two individuals that are similar or dissimilar (e.g., in terms of age, gender, ethnicity); and the influence of third parties either in mediating or exacerbating differences between individuals. Thus, we view pursuing greater understanding of the prevalence, intensity, and likelihood of escalation for negative ties based on the context in which they emerge as an important future research endeavor.

6.4 Ambivalence

We also welcome the increasing interest being exhibited in examining relational ambivalence -- the co-existence of both positive and negative ties within the same dyad (e.g., Methot, et al, 2017; Fingerman, et al., 2004). Much of the early social network literature relied on a unidimensional, continuum approach to designating relationships between two individuals as either positive or negative, but not both at the same time. While it is generally true that most relationships are unidimensional and that behavior directed toward others tends to correlate

with a continuum approach to characterizing the dyad (Labianca & Brass, 2006), there are certainly many contexts where an orthogonal approach to considering the positive and negative aspects of ties within a dyad make sense theoretically and would likely have strong impact on the individuals involved. Crossing some of this work with a network typology might be of interest as well; for example, holding an ambivalent tie where the negative tie is cognitive (e.g., incompetence) while the positive tie is affective (e.g., liking) might generate different behavioral outcomes than where the negative tie is affective (e.g., disliking) and the positive tie is cognitive (e.g., competent) (e.g., Casciaro & Lobo 2008, 2014). Similarly, holding a positive advice seeking tie to someone while exhibiting a negative behavioral tie toward that person (e.g., some form of harming behavior, such as undermining) might result in very different outcomes than a negative affective tie that is less visibly apparent to the other party (e.g., dislike).

7. Conclusion

We are excited to bring these papers, all of which make a significant contribution to the study of negative ties and signed graphs, to the social network research community's attention. While this type of research is clearly more difficult to conduct than research on positive or neutral ties, we are heartened to see that it is now growing at a faster pace than the overall growth rate of social network research. The field has clearly recognized that if we are to make greater leaps in understanding the antecedents, evolution, and consequences of social networks, we cannot continue to focus only on the associative forces that bring together actors in networks, but also need to incorporate the dissociative forces that push apart the actors. We are eager to see where future research on signed networks takes the field and hope that this special issue plays some part in stimulating researchers to take on this worthy pursuit.

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