"Who run the world?" Gender and the social network of R&B/hip hop collaboration from 2012 to 2020

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Abstract

Part of the reason women are disadvantaged in the labor market is because gender inequalities define social networks of the workplace. In the current project, I consider how gender shapes professional networks by focusing on the R&B/hip hop industry as an empirical case study. By conceptualizing the collaboration patterns between performers of popular R&B/hip hop songs from 2012 to 2020 as a network, I apply exponential random graph models (ERGMs) and find that women tend to occupy marginalized positions when compared to their male peers. Then, I adopt a social exchange framework to argue that critical acclaim is a resource that is associated with higher odds of collaborating for all artists, though gender differences define this process. For instance, the largest gender gaps in collaboration are present among artists who have either won Grammy awards or never received nominations for such honors. These findings suggest that female artists with lower status are often excluded from collaboration opportunities. Once women acquire enough prestige to "make up" for their gender, they may avoid collaborations because gender stereotypes challenge their decision-making power within these interactions.

Keywords: Gender, R&B/hip hop, Collaboration networks, Workplace inequality, Social exchange theory, Exponential random graph models

Introduction

Despite progress made in the past century, gender inequalities continue to define the American labor market. When compared to their male peers, women receive fewer call backs for high-paying positions (Quadlin 2018; Rivera and Tilcsik 2016), make lower wages for performing equivalent work (Blau and Kahn 2007), and are more likely to be passed over for promotions (Ibarra et al. 2010). These disparities are further magnified by overlapping identities of race, sexuality, and socio-economic status (Crenshaw 1989). For instance, Black women make an average of 19% less than White women across all education levels (Budig et al. 2021). Part of the reason women, and particularly women of color, continue to face these disadvantages in the workplace is because they rarely can access the same professional network connections as their male colleagues (Forret and Dougherty 2004; Kanter 1977). In the current project, I reconsider women's

disadvantage in the workplace by examining the collaboration networks of high-profile R&B/hip hop performers, a unique, yet informative case study for understanding how social connections shape gender dynamics in the labor market.

Like other high paying, prestigious job sectors, the R&B/hip hop industry is heavily male-dominated (Rebollo-Gil and Moras 2012; Rose 2008). Although there has been an influx of female R&B/hip hop artists over the past several decades (Emerson 2002), female performers continue to face specific challenges when they vie for prominence in the industry. For instance, the genre has been critiqued for reproducing hegemonic masculinity and stereotypic images of women, especially Black women (Herd 2015; Ling and Dipolog-Ubanan 2017; Rose 2008; Weitzer and Kubrin 2009). Forming social ties with influential peers represents a viable strategy for women to navigate male-dominated workplaces (Ibarra 1997; van den Brink and Benschop 2013), including the R&B/hip hop industry (Emerson 2002). Gender homogenous ties, in particular, are understood to be a valuable resource for women as they navigate systems of career advancement (Gorman 2005). Thus, by considering the gendered patterns of professional ties, we can better understand whether the social networks of male-dominated workforces further reproduce gender inequality or attempt to challenge these disparities.

To disentangle how professional connections can promote and inhibit women's rise to the highest levels of power in the workforce, I further argue that there is value in applying social exchange theory to examine the collaboration patterns of the R&B/hip hop industry. Social exchange theory posits that interactions are "two-sided, mutually contingent, and mutually rewarding processes" that revolve around the trading of either tangible or intangible goods (Emerson 1976: 336). Given that R&B/hip hop artists often write and perform songs together (Smith 2006), the logic of social exchange theory can be applied to illuminate how artistic content is created and disseminated within the field. However, social exchanges, including R&B/hip hop collaborations, occur within heavily gendered social structures where men and women occupy substantially different positions (Cook et al. 2013; Ridgeway and Correll 2004; Risman 1998). For instance, gender-based discrimination and harassment make it extremely difficult for female artists to acquire the resources necessary to establish their careers, such as successful marketing campaigns and connections to important people in the music industry (Rebollo-Gil and Moras 2012). Furthermore, in male-dominated fields, like the R&B/hip hop industry, gender itself can be understood as a valuable resource. While male collaborators often lend cultural legitimacy to a hip hop song, featuring a female artist can directly challenge this authenticity, especially if she does not adhere to stereotypical, highly sexualized gender roles.

In the current study, I use data on popular R&B/hip hop songs from 2012 to 2020 to analyze how gender structures patterns of collaboration. In addition to being the most widely consumed music genre in the United States (Nielsen Music 2017), R&B/hip hop artists frequently collaborate when writing and performing music by featuring one another on their songs or working together to produce albums (Emerson 2002; Smith 2006). As a result, I model the process of collaboration as a social network in which individual R&B/hip hop artists/groups are actors and edges indicate that a pair of artists performed a song together. In one of the first applications of statistical network analysis to a musical field, I consider whether women's systematic disadvantage in the R&B/hip

hop industry is reflected in the structure of the collaboration network. Then, I apply a social exchange framework to test whether there are gender differences in the association between critical acclaim and collaboration patterns. I argue that the implications of my results can inform our understanding of how gender shapes male-dominated institutions, cultures, and workplaces, more broadly.

Why study collaboration networks?

To understand how we create cultural products, it is crucial to move beyond studying individual actors and widen our focus to the complex web of social relations in which they are embedded (Becker 1974; Bourdieu 1983; DellaPosta et al. 2012; DiMaggio 2016). While scholarship on cultural production has long considered how this process is embedded in a system of industrial conditions and legal structures, another line of work draws specific attention to how social interactions between individuals can both promote group conformity and encourage innovation. For instance, the redundancy of social connections can encourage agreement on the norms that govern a creative field and enable it to flourish (Becker 1974). In Leschziner's (2007) research on high cuisine chefs, she argues that new ingredients and flavor combinations quickly diffuse throughout the community because chefs frequently dine in one another's restaurants. High levels of connectedness are not without their limitations, however. In Uzzi and Spiro's (2005) analysis of collaboration among Broadway artists and producers, they find that connectedness is associated with greater financial and critical success of Broadway musicals, but only up to a certain threshold. When the collaboration network was extremely interlinked, there was a significantly higher risk for Broadway shows to experience financial and artistic failure. This pattern likely reflects the fact that highly cohesive networks lack bridges, or weak ties that connect disparate groups and encourage the exchange of novel ideas (Adler 2012; Burt 2004; Granovetter 1973).

Even within the same network, actors often experience different degrees of success and recognition because of the unique structural positions that they occupy (Durkheim 1984; Simmel 1950). For instance, Rossman et al. (2010) find that actors who report many ties in the network of film co-appearances are more likely to receive nominations for Academy Awards. While well-connected actors tend to be more successful, certain collaborations are particularly beneficial for the actors they connect. Crossley's (2009) work, for example, highlights the importance of brokerage in the network of musicians and non-musicians involved in Manchester's punk music scene during the late 1970s. Those individuals who bridged structural holes, or gaps, in the punk music network had the unique ability to introduce players who were previously unconnected, resulting in new collaboration opportunities.

Like other art forms, individual R&B/hip hop artists do not write or perform music in a social vacuum (Roy and Dowd 2010). Instead, the genre's proliferation is heavily embedded in both informal and formal networks of support, rivalry, and collaboration. R&B/hip hop artists often "sample" short fragments of other artists' performances in their recorded songs and these practices are associated with the development of group identities (Lena 2004). At the same time, the industry has witnessed many feuds between pairs of rap artists, which often culminate in rap battles or "diss songs." Through the adoption of a network perspective, recent work finds that when low status rappers target

higher status peers with "diss songs," the performer tends to experience a boost in their future record sales (Halgin et al. 2020).

More formally, R&B/hip hop artists from different groups and music labels frequently work together to write and produce songs, resulting in an explicit network of artistic collaboration. In these cooperative ventures, R&B/hip hop artists often feature fellow peers on their records by having them perform a verse or sing the hook for one of their songs (Smith 2006). While collaboration has become increasingly common in several popular music genres, it holds historical importance in R&B/hip hop (Collins 1991; Emerson 2002) and is associated with the prestige and economic success of R&B/hip hop artists. New artists are more likely to collaborate than performers who are more established (Smith 2006), suggesting that collaboration may be necessary for jumpstarting one's career and rising to commercial prominence. As a result, the structural patterns of R&B/hip hop collaboration should provide insight into how the genre produces creative innovation, perpetuates norms, and privileges certain actors while disadvantaging others.

Collaboration, gender, and intersectional identities

While network location shapes one's individual behaviors and outcomes, actor-level characteristics, such as gender, also determine one's position in the broader structure of relationships (McMillan et al. 2018; McPherson et al. 2001). Since resources are unequally allotted to men and women, gender often patterns our relationships and social institutions (Ridgeway and Smith-Lovin 1999). Gender itself can be conceptualized as a social structure. Even when individuals reject gender norms and stereotypes, institutional pressures and social costs often force individuals to continue to adopt gendered behavior in their social interactions (Ridgeway and Correll 2004; Risman 1998).

Individuals, however, are not solely defined by their gender. We all occupy multiple social statuses that interact in complex ways and lead individuals to report non-uniform experiences with discrimination and privilege (Crenshaw 1989, 1990). Discrimination that targets Black women, for example, is uniquely distinct from both the racism that Black men experience, as well as the sexism White women face (Hooks 1992). In fact, many intersectionality theorists point to examples from the R&B/hip hop industry to illustrate the tenants of their arguments (e.g., Crenshaw 1990; Collins 1991). These case studies demonstrate that the marginalization experienced by Black women artists and consumers does not originate from a single status, but instead the overlap of multiple identities (Berggren 2016). Gender and its interaction with other individual characteristics can systematically grant or forbid access to opportunities, in addition to carrying implications for ones' network position (Felmlee et al. 2018; Jackson et al. 2018). As a result, such inequalities are apt to be reflected in the hierarchical patterns that define R&B/hip hop collaboration networks.

Previous work finds that the social networks of other professional workplaces tend to reflect broader systems of inequality (Durbin 2011). In academia, for example, scholars of all genders are more likely to collaborate on academic journal articles with male colleagues (Fahmy and Young 2017) and co-authorship is more likely to result in elite publications for men than it is for women (Light 2013). Similar to these professional fields, women and other disadvantaged actors may occupy less optimal positions in the R&B/hip hop collaboration network, resulting in negative consequences for their success,

career path, and the size of their fan base. Even though there has been a noticeable increase in female hip hop artists over the past few decades, the genre continues to be male-dominated and is often associated with hyper-masculine themes, such as violence and drug use (Rebollo-Gil and Moras 2012; Rose 2008). As a result, when hip hop producers and artists are considering potential collaboration partners, they may be more inclined to overlook female artists who do not fit the stereotypes of what a hip hop artist should look like.

At the same time, unique genre conventions may create opportunities for female artists to collaborate with their peers. For instance, a male artist who is interested in writing a love duet is likely to seek out a female collaborator. Despite these potential opportunities, hip hop culture has received harsh critiques from academics and non-academics alike for upholding strong misogynistic views (Hooks 1992; Ling and Dipolog-Ubanan 2017; Morgan 1999; Rebollo-Gil and Moras 2012; Rose 2008). Because women are highly underrepresented in the hip hop industry, they are likely relegated to play the role of "tokens" and treated as symbolic representations of their minority group, rather than individuals (Kanter 1977). In R&B/hip hop, Black women in particular are often reduced to stereotypes such as the hypersexualized Jezebel, gold digger, or baby momma (Collins 1991; Stephens and Phillips 2003; Stokes 2007).

To avoid tokenization, female hip hop artists may actively avoid collaborating with their male peers and instead seek out collaboration opportunities with other female artists. Male-dominated workforces tend to be characterized by stronger in-group preferences among women, including greater tendencies for women to hire female peers (Gorman 2005). In the R&B/hip hop industry, specifically, qualitative work has posited that collaborations between female artists can further combat male hegemony by emphasizing mutual support and sisterhood, as well as help female artists navigate the male-dominated field (Emerson 2002). As a result of these benefits, women hip hop artists may seek out collaborations with other women in the industry, leading to high levels of gender homogeneity.

Since R&B/hip hop collaboration is expected to play a crucial role in helping artists reach the top levels of their field, I first test whether men and women tend to occupy significantly different positions in the collaboration network (Research Question 1). Additionally, I consider whether there is a tendency towards gender homogeneity in the collaboration patterns of highly successful R&B/hip hop artists (Research Question 2). By studying how gendered processes shape the R&B/hip hop collaboration network, we can better understand whether the industry's professional networks reproduce or challenge systems of inequality.

Social exchange theory applied to R&B/hip hop collaborations

The primary focus of social exchange theory is on the interactions that connect pairs of individuals (Emerson 1976; Homans 1958; Thibaut and Kelley 1959). When deciding whether to partake in a social interaction, individuals are assumed to deliberately weigh the costs and benefits, and only initiate relationships when they expect to profit from the exchange (Homans 1958). Gains from the exchange do not need to be material but can also include intangible rewards such as respect and approval (Blau 1964). By focusing on the interaction itself, social exchange theory pays keen attention to the relational nature

of power. In a pair, the partner who is the least dependent on the exchange has the most power since they have less to lose if the relationship dissolves (Cook et al. 2013; Homans 1974).

We can intuitively conceptualize R&B/hip hop collaborations as social exchanges; artists enter into partnerships voluntarily and have specific interests to collaborate with peers who can bring multiple rewards, such as financial success or an increased fan base. Artists with greater prestige should make more desirable collaboration partners because the songs that result from these efforts are likely to be more popular and lucrative. However, since social exchange theory asserts that pairs will only form mutually beneficial relationships (Blau 1964; Emerson 1976), high-prestige artists will not collaborate with everyone. Instead, they will tend to collaborate with other acclaimed artists, or those who are expected to bring them further rewards. Once collaborative partnerships are formed, members of a pair are unlikely to share equal degrees of power and dependence. Within each collaboration, the actor with more outside resources (e.g., greater financial success) will have greater influence over the products that result from the collaboration (following Bittman et al. 2003). Such products include the substance of a song's lyrics, allocation of each artist's performance time, and the content of music videos.

There are theoretical reasons to believe that gender also plays a crucial role in determining the costs and benefits of our interactions. Recent perspectives on social exchange theory underlie the importance of macro-level structures in shaping interactions. Because one's access to material and immaterial goods is directly influenced by their social position, actors develop a need to initiate exchanges in order to obtain resources that would otherwise be inaccessible (Cook et al. 2013). Due to the structural nature of gender (Risman 1998), men and women come into relationships with different access to resources, and as a result, power and dependence in exchange relations can be understood as gendered processes.

Following this perspective, social exchange theory can help explain the gendered patterns of R&B/hip hop collaboration. In male-dominated career fields, the aptitude of women is rarely evaluated according to the same standards as their male peers (Kanter 1977; Williams et al. 2016). For example, Ong (2005) finds that, regardless of exam performance or grades, physics students who identified as women and/or racial minorities were consistently evaluated as being less competent than their White male peers because they impugn stereotypical images of what scientists look like. Female hip hop artists also challenge the standard appearance of rappers, and this is likely to shape how their peers evaluate their musical talents and commercial success. In order for female artists to be considered as potential collaboration partners, they likely must "make up" for their gender by bringing particularly high levels of critical acclaim and prestige to their collaborative relationships. At the same time, collaborative efforts may receive higher levels of success and prestige when they exclude female artists who challenge stereotypical perceptions of who a rapper is supposed to be.

Women may also only see collaborations as beneficial for their careers if they are able to enter these relationships with a certain degree of power. Gender norms often leave women disadvantaged in decision making processes, particularly when these interactions are embedded in male-dominated domains, such as sexual relations (Wolff et al. 2000) and financial budgeting (Fonesca et al. 2012). Thus, women R&B/hip hop artists

may prefer to avoid collaborations if they lack the necessary power to bargain out of playing stereotypical roles and producing misogynist content. Thus, collaboration opportunities may only be attractive to women with access to large amounts of tangible and intangible resources that can bolster their power and authority.

To gauge the critical acclaim and success of the R&B/hip hop artists in my sample, I consider whether they were recognized by the Recording Academy with a Grammy Award or nomination, both of which represent acclaimed honors in the music industry (following Anand and Watson 2004; Rossman et al. 2010). I apply social exchange theory to test whether receiving Grammy awards and nominations is associated with higher odds of participating in collaborative ventures for all R&B/hip hop artists (Research Question 3). Furthermore, I consider whether this association varies in its magnitude for men and women (Research Question 4). High levels of prestige may be particularly necessary for female artists since they can use this esteem to "make up" for their femininity and gain bargaining power.

Methods

Collaboration data

To construct collaboration networks, I analyzed data from *Billboard*'s year-end "hot 100" R&B/hip hop charts (following Lena 2004; Ling and Dipolog-Ubanan 2017). *Billboard* was one of the original players in the commercial music industry and has been collecting and disseminating information on musical artists since the turn of the twentieth century. Starting in 1958, the company began formulating a list of the current week's "hot 100" songs by integrating information from multiple sources, such as record sales and jukebox airtime (Anand and Peterson 2000). *Billboard* continues to publish this information, and during the past couple decades, rankings started incorporating additional data on radio airplay, sales, and online streaming (Billboard 2021). Additionally, *Billboard* publishes genre-specific year-end lists of each calendar year's most popular songs, including a "hot 100" R&B/hip hop chart that has been released every year since 2002.

For the current study, I consider collaboration between artists who performed together on songs ranked in *Billboard*'s year-end "hot 100" R&B/hip hop charts from 2012 to 2020.[1] I focus on this time period because throughout the twenty-first century, women became increasingly prominent in the hip hop/R&B industry, with several female performers and groups receiving high levels of acclaim and popularity. Furthermore, starting in 2012, Billboard made wide changes to their algorithm for ranking songs by incorporating data on online sales and streaming (Billboard 2021), making it difficult compare year-end charts before and after this change. While this sample represents a particularly elite group of R&B/hip hop artists, it is still informative to study the experiences of these high-achieving women. First, previous work suggests that professional connections and exclusion from "old boys'" networks are particularly salient to women who already accumulated high levels of professional success and are vying for the top positions in their field (Durbin 2011; Ibarra 1997). Second, these elite R&B/hip hop performers are the most visible to consumers, giving them disproportionate influence over

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[1] For 2012–2014 and 2016–2020, Billboard released the top 100 R&B/hip hop for each year, but in 2015 only the top 25 R&B/hip hop songs were released since the weekly R&B/hip hop charts for 2015 were scaled back to a 50 position chart.

the genre. Finally, since power differentials tend to be amplified in precarious situations, I argue that focusing on the experiences of women in this highly successful group of artists represents a particularly stringent test of my research questions about gender inequality. Taken together, the collaboration patterns of these popular artists are apt to have the broadest impacts on the R&B/hip hop industry and the labor market, in general.

Although the data I collected represent a two-mode network where artists can only be tied to one another through having collaborated on the same song, I projected this network into a one-mode graph where each node represents an individual artist. Previous work shows that techniques from one-mode network analysis are appropriate for such projections (Everett and Borgatti 2013). More specifically, I reshaped the data into a binary matrix with a row and column for each artist who had at least one collaborative song ranked on the year-end "hot 100" R&B/hip hop chart during 2012–2020. Each (i, j) cell of the symmetric matrix was coded as a 1 if artist i and artist j collaborated on at least one "hot 100" song during the time of the study and 0 if no collaboration occurred.[2] Since it is possible for the same song to be ranked on multiple year-end "hot 100" charts, there were a total of 733 unique songs from 2012 to 2020. Of the 733 songs, 53.75% ($n = 339$) were performed by at least two collaborators. The maximum number of collaborators per song observed in my sample is seven artists.

Additional data were collected for each artist. By examining the pronouns used on *Billboard*'s artist biographies, I recorded the gender of each artist (Billboard 2021). I determined whether artists/groups won or were nominated for any Grammy awards before or during the time period of interest (i.e., all years including and prior to 2020), as well as the year that each artist became active in the music industry (Recording Academy 2021). While collaboration was overwhelmingly common in my sample of R&B/hip hop artists, there were 64 artists who only had sole-authored songs recognized on the year-end "hot 100" charts during the period of interest. Since these artists did not participate in any collaborations that made the "hot 100" charts, they are not included in my final analysis.[3] Although the non-collaborating artists were less likely to receive Grammy nominations (without winning the award), the group was not statistically significantly different from the collaborative artists on the other variables of interests (see Additional file 1).

Of the 286 artists involved in the collaboration network, some represented bands or musical groups. The members of all groups were gender homogenous and coded accordingly, except for one band, The Cults, which included both male and female artists. The Cults is a rock band that only collaborated on one song in my sample; they were featured in J. Cole's "She Knows," along with Amber Coffman. Due to the gender heterogeneity of The Cults, the group and their ties to J. Cole and Amber Coffman are omitted from the final analysis. Additionally, Michael Jackson and Justin Timberlake's "Love Never Felt So Good," made the "hot 100" chart in 2014. However, the collaborative version of the song was both produced and released after Michael Jackson's death in 2009 and, as a result,

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[2] It is important to note that it would also be possible to model collaboration as a directed relationship (e.g., $(i, j) = 1$ indicates that artist i invited artist j to perform on their song). In the current project, I conceptualized collaboration as an undirected relationship because of my interest in how these collective endeavors can introduce either member of a dyad to various tangible and intangible resources necessary for career advancement.

[3] Additionally, the statistical models I estimated experienced convergence issues when the non-collaborating artists were included in the analysis.

Michael Jackson and his tie to Justin Timberlake were excluded from the final analysis. My final sample includes 284 artists and 605 symmetric, collaborative ties.

Analytic approach

I statistically modeled patterns in the collaboration network through the application of exponential random graph models (ERGMs). Previous work applies ERGMs to analyze how the structures of professional relationships can perpetuate gender inequality in other workplace environments, such as networks of co-authorship in academia (Fahmy and Young 2017) and job mobility patterns across the distribution centers of a large US firm (Wilcox et al. 2022). ERGMs represent a multivariate statistical method that can measure how various types of actor-level, dyadic, and structural processes simultaneously shape relational tie patterns by comparing the observed network to a series of randomly simulated graphs. As a result, ERGMs enable the researcher to determine whether observed network processes are significantly different from what would be expected to occur by chance, controlling for all other parameters included in the model. Unlike traditional statistical models, ERGMs enable one to analyze data at the level of the dyad, rather than the individual, without violating dependence assumptions. ERGM coefficients can be exponentiated and interpreted as the log odds that a one unit change for a given indicator will shape tie patterns between actor pairs, while controlling for all other parameters in the model. For more details on the statistical properties that underlie the ERGM, see Robins et al. (2007).

Parameters

The ERGMs estimated here included two types of parameters: the first relate to structural processes endogenous to the network and the second relate to the exogenous attributes of individual actors or actor pairs. Three parameters were included to account for structural processes. First, the *edges* parameter measures the base log-odds that two artists will collaborate with one another and serves a similar role as the intercept in traditional statistical models. The coefficient for this parameter tends to be negative in all but the densest networks, reflecting the time and labor costs of tie formation. Second, all models included the *geometrically weighted degree (GWD)* parameter to account for degree skew, or the tendency for most actors to report few relational ties, while a small minority are highly connected. Finally, I included *geometrically weighted edgewise shared partner (GWESP)* terms to account for structures of transitivity in the collaboration network. Transitivity—or the tendency for actor *a* to be connected to actor *c* if actor *a* is tied to *b* and actor *b* is tied to *c*—defines various genres of social networks (Felmlee et al. 2021). The GWESP term measures tendencies towards the formation of these patterns, while also taking the nesting of shared partners into account (Hunter 2007).[4]

The second set of parameters I included test for differences in collaboration patterns based on the individual-level characteristics of artists. To explore how gender structures the network, I first included an individual-level parameter to test whether an artist's

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[4] I used a weight of 0.25 for all terms that require a decay parameter. I included the GWESP triad parameter, but not the geometrically weighted dyadwise shared partner term, because I encountered convergence issues when both terms were incorporated. While this is a possible limitation of the current study and the GWESP term should be interpreted with caution (Hunter 2007), the omission of the GWDSP parameter is unlikely to substantively bias the conclusions presented here since transitivity is not of primary interest to the current study.

Table 1 Descriptive statistics by artist ($n = 284$)

	Proportion/mean	S.D.	Minimum	Maximum
Women	20.07%			
Grammy winners	27.11%			
Grammy nominees (with no wins)	28.87%			
Years active	13.82	(8.54)	0	63
Degree centrality	4.26	(5.66)	1	38
Eigenvector centrality	0.03	(0.05)	0	0.30
Betweenness centrality	297.56	(730.04)	0	6106.79

S.D. refers to standard deviation

gender is associated with their odds of reporting collaboration ties (1 = artist identifies as a woman). Negative values of this coefficient suggest that women are less likely to have ties in the collaboration network. I also included a set of dyad-level parameters to test for *gender homophily*, or whether men are more likely to collaborate with other men and whether women are more likely to collaborate with other women. Positive values of these coefficients imply that collaborations are more likely to connect actors who share the same gender, than those who do not.

Additionally, I created a categorical variable for Grammy recognition such that artists were characterized as having: (1) won a Grammy, (2) received a nomination for a Grammy, but not been awarded the honor, or (3) never received a nomination (reference group). I constructed two individual-level ERGM parameters to capture the associations between Grammy recognition and collaboration odds using data on all Grammy awards and nominations before the end of 2020. One parameter considered whether *Grammy winners* were more likely to collaborate and the other considered whether *Grammy nominees* were more likely to participate in these ventures. For both variables, collaboration odds were compared to those of artists who had not received recognition from the Recording Academy.

Finally, since previous work finds that prior experience in the music industry is associated with participation in collaboration (Smith 2006), I included an individual-level ERGM parameter to control for the number of *years active in the industry*. I also included a quadratic version of this parameter to account for any curvilinear relationships between industry experience and collaboration odds. All ERGMs presented here produced adequate goodness of fit measures and convergence diagnostics (see Additional file 1).

Results

Descriptive statistics

The 2012–2020 R&B/hip hop collaboration network is overwhelmingly male-dominated with almost four male artists for every one female artists (see Table 1). More than half of the performers in my sample were either Grammy winners or nominees prior to the

Table 2 Descriptive statistics by artists' gender

	Men		Women	
Grammy winners	25.99%		31.58%	
Grammy nominees (with no wins)	35.09%		35.09%	
Years active	13.65	(8.76)	14.53	(7.65)
Degree centrality	4.60	(5.88)	2.91	(4.45)*
Eigenvector centrality	0.03	(0.05)	0.02	(0.04)
Betweenness centrality	333.00	(768.89)	156.42	(531.13)*

*Significant difference between men and women using a two sample t-test at *p* < 0.05. Standard deviations are in parentheticals

end of 2020, which is unsurprising given that my sample represents an elite and well-established group of R&B/hip hop artists. Average centrality measures highlight the connectedness of the collaboration network. For instance, the mean degree centrality for each artist was 4.26, indicating that during the time period of interest, the average artist collaborated with slightly more than four of their peers.

When men and women are considered separately, however, it becomes clear that men tended to be situated in more central locations in the network (see Table 2). As confirmed by a two-sample *t*-test, male artists reported significantly higher average measures of degree and betweenness centrality when compared to their female peers. Not only did male artists report an average of almost two more collaboration ties than female artists, men also played a more important role in bridging the greater network. For example, the average betweenness centrality for male artists (333.00) was more than twice the size of the average betweenness centrality for women (156.42). Men reported average measures of eigenvector centrality that were slightly higher than women, however, the difference is not statistically significant.[5] There are no statistically significant gender differences in the proportion of Grammy winners and Grammy nominees. In fact, a slightly higher proportion of women in my sample were recognized with these honors.

Visualizing the network further suggests that male artists tended to occupy more central positions in the network (see Fig. 1). The center of the network, which was characterized by a greater density of collaborative ties, was predominated by men. While there were a handful of highly central female artists embedded in the network's core (e.g. Nicki Minaj), far more women were located on the peripheries of the network. Even women who were relatively well-connected when compared to their female peers (e.g., Rihanna) occupied peripheral positions.

Exponential random graph models

The first ERGM presented in Table 3 provides statistical evidence that female artists were less likely to collaborate on R&B/hip hop songs when compared to their

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[5] Degree centrality refers to the number of ties each artist has to other artists in the network. Eigenvector centrality expands upon the concept of degree by considering both the number of collaboration ties reported by each individual artist, as well as the popularity of their collaboration partners. Finally, betweenness centrality measures how much of a role each actor plays in connecting the disparate parts of the network (Wasserman and Faust 1994).
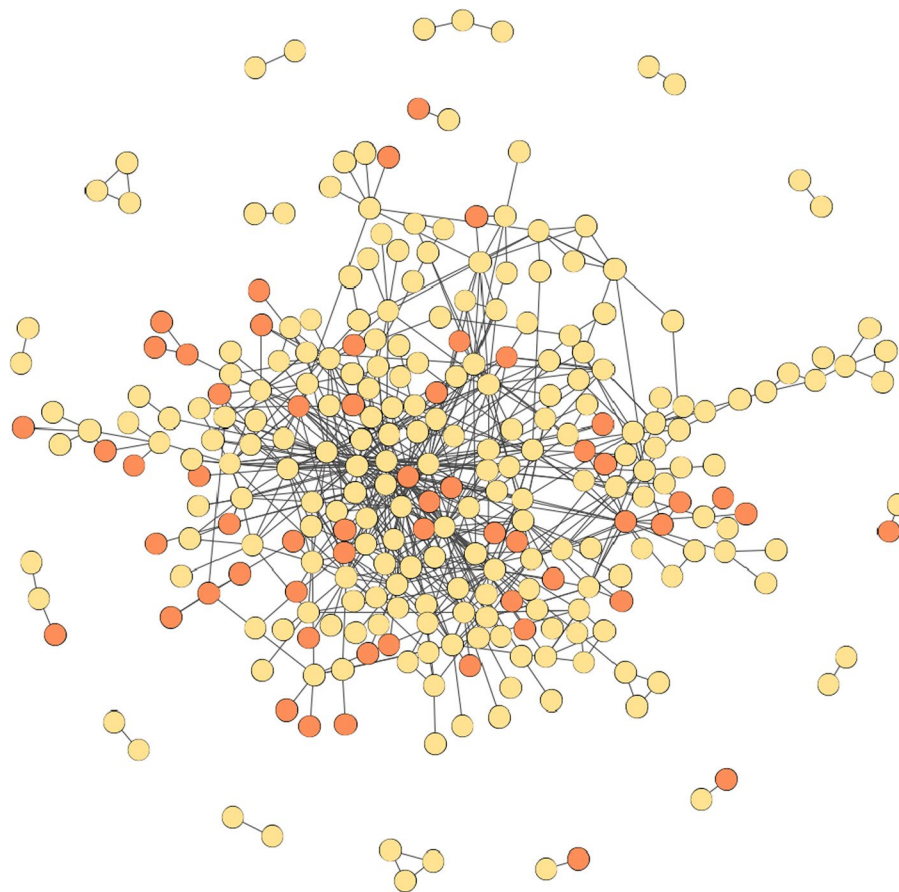
Fig. 1 R&B/hip hop collaboration network 2012–2020. Men are represented by yellow circles and women are orange circles. Edges indicate that the two artists collaborated on a hip hop/R&B song that was featured on a Billboard Hot 100 year-end lists from 2012 to 2020

male peers. Controlling for all other included variables, a female hip hop artist was roughly 28% less likely to participate in a collaboration when compared to male artists ($b = -0.323$, $p < 0.001$). In other words, even after accounting for the gender distribution of the observed network, female artists participated in far fewer collaborations than would be expected by random chance. As demonstrated in Model 2, part of the reason women were marginalized in the collaboration network was because of a strong tendency for men to collaborate with other men. Male artists were roughly 48% more likely to collaborate with other male artists than female artists ($b = 0.389$, $p < 0.001$). Despite the potential benefits of same-gender collaborations, female artists were not significantly more likely to collaborate with female versus male colleagues ($b = 0.050$, $p = 0.182$).

As predicted by social exchange theory, winning Grammy awards or being nominated for these honors prior to the end of 2020 was associated with greater odds of collaboration during the period of interest. For instance, Grammy winners were 62% more likely ($b = 0.480$, $p < 0.001$) and nominees were 63% more likely ($b = 0.486$, $p < 0.001$) to collaborate with other artists in the network when compared to their peers who did not receive these accolades. After including gender interactions with both the Grammy winner and Grammy nominee variables, I find additional evidence that gender moderated

Table 3 ERGM results for 2012–2020 R&B/hip hop collaboration network

|	Model 1		Model 2		Model 3	
	Coef.	**SE**	**Coef.**	**SE**	**Coef.**	**SE**
Structural attributes						
Edges	− 7.263	(0.146)***	− 7.631	(0.134)***	− 7.244	(0.146)***
GW degree	1.725	(0.092)***	1.731	(0.100)***	1.803	(0.098)***
GWESP	2.061	(0.085)***	2.064	(0.084)***	2.063	(0.086)***
Individual attributes						
Woman	− 0.323	(0.068)***			− 0.465	(0.056)***
Grammy winner	0.480	(0.068)***	0.476	(0.067)***	0.499	(0.067)***
Winner × woman					− 0.103	(0.096)
Grammy nominee	0.486	(0.062)***	0.484	(0.062)***	0.465	(0.063)***
Nominee × woman					0.303	(0.076)***
Years active	0.041	(0.010)***	0.041	(0.009)***	0.040	(0.010)***
Years active squared	− 0.001	(0.000)***	− 0.001	(0.000)***	− 0.001	(0.000)***
Dyadic attributes						
Both men			0.389	(0.072)***		
Both women			0.050	(0.037)		
AIC		5169		5170		5165
BIC		5238		5247		5251

SE refers to standard error

***$p < 0.001$

the relationship between prestige and collaboration (see Table 3, Model 3). Though artists of both genders tended to participate in more collaborations if they were nominated for Grammy awards before or during 2020, nominations mattered even more for female performers ($b = 0.303$, $p < 0.001$). Grammy nominations were associated with 59% greater odds of collaborating for male artists, while they were associated with a 116% increase in a woman's odds of collaborating. The interaction between Grammy winner and gender is not significant, however, suggesting that there were no gender differences in the association between being a Grammy winner and the formation of collaboration ties.

However, no level of Grammy recognition enabled female performers to entirely close the gender gap in the collaboration process (see Fig. 2). When compared to their equally-decorated male peers, women were consistently less likely to form collaborative ties. Among artists who did not receive Grammy nominations, men were almost twice as likely to collaborate than their female peers. While Grammy nominations reduced this gender gap, female nominees continued to be disadvantaged. A female nominee's odds of collaborating were only 85% the size of a male nominee's odds. Interestingly, the gender gap in collaboration odds widens for artists who won Grammy awards. Similar to those artists who were not nominated, a female Grammy winner's odds of collaborating were about half the size of their male peers' odds.

Finally, coefficients for control variables expose interesting patterns in the collaboration network. The edges coefficient is both negative and significant ($b = -7.244$, $p < 0.001$), reflecting the relative sparsity of the collaboration network and tendency for artists to collaborate with only a small proportion of their peers. The coefficient for geometrically weighted degree is positive and significant ($b = 2.063$, $p < 0.001$), suggesting
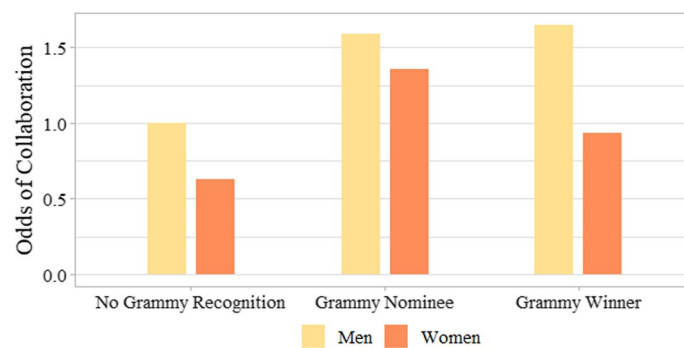
Fig. 2 Odds of collaboration by gender and Grammy recognition

that the distribution of collaborative ties was more even than would otherwise be expected. The GWESP coefficient is also positive and significant ($b = 2.063$, $p < 0.001$), which provides evidence that the R&B/hip hop collaboration network was defined by transitivity. Additionally, the variables included to control for the number of years each artist was active in the music industry are significant, implying that there was a curvilinear relationship between industry experience and collaboration probability in my sample. Those artists who were just starting their musical careers and those who had been involved in the industry for decades were less likely to collaborate than mid-career artists.

Supplemental analyses

Given that my sample covers a sizeable period, I also estimated supplemental ERGMs that begin to unpack whether these gender-related network processes varied across time. In these supplemental analyses, I estimated the same set of ERGMs presented in the manuscript on two distinct panels of the R&B/hip hop collaboration network, 2012–2016 and 2017–2020. I considered these specific time frames given their relevance to the rise of the #MeToo movement, an international social movement that focused on sexual and gender-based harassment in the workplace. Although Tarana Burke originally used the phrase "Me Too" in this context in a 2006 MySpace post, the #MeToo movement received widespread coverage in 2017 when Alyssa Milano used the phrase as a hashtag on Twitter in the wake of Harvey Weinstein's sexual abuse allegations (Brockes 2018). As a result, I argue that the first panel represents a period of time before the #MeToo movement received large-scale, international attention, while the second panel occurred after the movement gained momentum.

  Findings from the supplemental ERGMs suggest that gender and prestige structured the collaboration networks of highly successful hip hop/R&B artists in distinct ways across the two time periods (see Additional file 1). During the first time period, or before the rise of the #MeToo movement, the collaboration network was defined by network processes that were largely similar to those uncovered in the full sample. Women were significantly less likely to collaborate than men (Additional file 1: Table S2, Model 1: *Woman*: $b = -0.515$, $p < 0.001$), and the association between Grammy recognition and reporting collegial ties varied by gender (e.g., Additional file 1: Table S2, Model 3: *Woman × Nominee*: $b = 0.390$, $p < 0.01$). During the second panel of data, however, I

found no evidence that gender significantly shapes the structural patterns of the R&B/hip hop network. After the rise of the #MeToo movement, female artists had similar odds of collaborating as their male peers (Additional file 1: Table S3, Model 1: *Woman*: $b = -0.031$, $p = 0.728$), and the collaboration patterns did not vary for men and women when they were recognized by the Recording Academy (e.g., Additional file 1: Table S3, Model 3: *Woman × Nominee*: $b = 0.199$, $p = 0.534$). Although my analytical design does not enable one to conclude that there was a causal effect of the #MeToo movement on the structures of R&B/hip hop collaboration, these supplemental analyses suggest that there is potential for network processes to evolve in ways that challenge gender inequalities.

Discussion

By considering the relational patterns and social structures that underlie the workplace and other professional settings, we can gain unique insight into why inequality continues to define the American labor market. Here, I take this approach by examining how gender structures the collaboration network of popular R&B/hip hop artists. The R&B/hip hop industry represents an informative case study for untangling processes of gender inequality in the workforce because the male-dominated industry is uniquely defined by an explicit and readily observable network of professional relationships. In one of the first studies to apply statistical network analysis to patterns of musical collaboration, I found that the organization of the 2012–2020 R&B/hip hop collaboration network promoted the continued success of male performers, while impeding female artists' career advancement. Female performers tended to be marginalized in the collaboration network, both reflecting and perpetuating their systematic disadvantage in the R&B/hip hop industry and the labor market, more generally.

In my sample of R&B/hip hop artists, female performers reported relatively few collaborative ties and rarely bridged structural holes in the broader network. Even after accounting for a variety of network processes and attribute-based controls, women continued to find themselves in less favorable positions when compared to their male peers. The disadvantage that female artists experience in the R&B/hip hop collaboration network is likely to have detrimental consequences for both their career advancement and influence over the broader industry. Previous work argues that forming connections to well-established performers is essential for aspiring artists in hyper-competitive creative industries since these ties can provide them with the necessary financial resources and social capital to achieve success (Emerson 2002; Rossman et al. 2010; Smith 2006). Additionally, social network theories highlight the individual-level benefits associated with bridging the disconnected parts of a graph (Burt 2004; Granovetter 1973). If female artists want to challenge norms of misogyny in the R&B/hip hop industry, for instance, bridging structural holes in the collaboration network may be necessary for inspiring institutional change and innovation. In supplemental analyses, I found evidence that gender differences in collaboration patterns decreased in the past decade. However, across the full period of R&B/hip hop collaboration analyzed here, few female artists occupied highly central positions in the network. Instead, most women were situated on the graph's periphery.

Part of the reason female artists occupy decentralized positions is because there exists a strong tendency for male artists to collaborate with other male artists. This propensity towards gender homogenous collaboration results in dense clusters of old boys' networks, or tight-knit, powerful male-dominated networks that prevent women from gaining status and shaping organizational norms (Durbin 2011; Kanter 1977). While old boys' networks make it difficult for women to navigate workplaces predominated by men, maintaining gender homogenous ties can provide female employees with the support needed to overcome these obstacles (Emerson 2002; Goodall 1994; van den Brink and Benschop 2013). Despite these potential benefits, I found no evidence that the female R&B/hip hop artists in my sample were more likely to report collaboration ties with fellow women from 2012 to 2020. These findings complement those of other studies on gender homophily in workplace networks. For instance, in the male-dominated academic field of criminology, female scholars are significantly more likely to co-author peer-reviewed articles with male colleagues than their female peers (Fahmy and Young 2017). Such gender heterophily may impede women's abilities to challenge systems of gender inequality in the R&B/hip hop industry, as well as the workplace, more broadly.

Following the tenants of social exchange theory, I suspect that two simultaneous processes shape female R&B/hip hop artists' experiences in the collaboration network. First, it is likely that R&B/hip hop artists (often with the guidance of their producers) pass over opportunities to collaborate with their female peers because they perceive such exchanges as being associated with fewer financial and professional rewards. Second, female artists may prefer to avoid entering collaborations because they lack the necessary power to derive worthwhile benefits from these ventures. For instance, even though receiving a Grammy nomination was associated with an increase in the collaboration probability for all artists, this recognition resulted in an additional boost for women performers. This finding implies that for collaborative exchanges with female artists to appear rewarding to other artists, women may need to "make up" for their gender by obtaining particularly high levels of prestige. It is important to note that given the study's analytical design, it is not possible to determine whether Grammy recognition causes more collaboration, or whether collaborative artists are more likely to receive these acclaims than their non-collaborating peers. Regardless of the causal order, my findings suggest that accounting for Grammy recognition does not entirely omit the gender gap in collaboration, particularly in the earlier years of the period considered. Even when female artists are critically recognized by their male colleagues or member of the Recording academy, gender stereotypes are apt to limit their bargaining power in collaborative relationships and reduce their ability to reap rewards from their professional accomplishments.

I also found that female artists who won Grammy awards did not experience a boost in their odds of collaborating. Instead, the gender gaps in collaboration among Grammy award winners and among those who had never been recognized by the Recording Academy are substantively similar in their size. I speculate that this pattern reflects the fact that after female artists reach a particularly high level of prestige, they may avoid undesirable collaborations since they need not rely on these exchanges for career advancement. These highly successful female artists may pass up collaboration opportunities where they are tokenized according to their gender (Kanter 1977; Stephens and Phillips

2003; Stokes 2007). Instead, these women can be more selective when deciding who to work with and opt out of collaborations that demean their artistic accomplishments.

While the current study provides unique insight into the gendered structures of R&B/ hip hop collaboration networks, there are also limitations that should be addressed. First, although I estimated supplemental analyses that begin to unpack how gender-related processes changed over time in the collaboration network, additional work is needed to analyze the coevolution of collegial ties and individual characteristics. In my full sample, I found that there are gender differences in the association between Grammy recognition and collaboration that highlight female artists' disadvantage, regardless of the causal order. However, future work is needed to disentangle the social processes that inform this gender disparity. Qualitative analyses of media interviews with R&B/hip hop artists, for example, could further distinguish whether women view partnerships with men as crucial for achieving high levels of professional acclaim, or if such collaboration opportunities are only accessible after being legitimized by the Recording Academy and other industry insiders.

Second, the current study only considered official, credited collaborative relationships that connect R&B/hip hop artists. The individuals in my sample were also socially connected through less formal relationships, such as friendship, mentorship, and advice giving. Since previous work finds that women in male-dominated workplaces tend to report fewer informal social connections (Durbin 2011), I suspect that female artists are similarly disadvantaged in other relational networks that characterize the R&B/hip hop industry. Third, the R&B/hip hop industry is racially heterogeneous and, as predicted by theories of intersectionality (e.g., Crenshaw 1989), I expect that the collaborative experiences of all artists are further shaped by their race and ethnicity. For instance, previous work shows that the skills and abilities of both Black men and women tend to be evaluated according to stricter standards than their White, male peers (Ong 2005; Williams et al. 2016). However, due to the challenges of acquiring accurate, self-reported data on artists' racial identities, I leave questions about how race shapes the collaboration network open to future research. Finally, it remains unclear whether the structural patterns of inequality that define twenty-first century R&B/hip hop collaborations apply to all sectors of the labor market. Future work should continue to apply the methodological techniques discussed here to evaluate other workplace networks, including those of academic co-authorship and professional advice seeking.

Despite these limitations, the current study builds on our understanding of how the collaboration network of R&B/hip hop artists reflects gender inequalities, and these patterns have broader implications for women's experiences in male-dominated workforces. Even at the highest levels of critical acclaim, women are absent from key structural positions in the R&B/hip hop collaboration network, and this is apt to limit their authority to change the industry's norms (Uzzi and Spiro 2005). By studying how women are marginalized in their professional networks, researchers can shed light on why issues such as gender discrimination and sexual harassment define a variety of male-dominated workplaces (Stainback et al. 2011). My results also suggest that even those female performers who reach the highest levels of prestige in the R&B/hip hop industry are often excluded from the collaboration network. As a result, aspiring female artists will have limited access to quality mentors from whom they can acquire support and encouragement

(Ibarra et al. 2010). Fortunately, like many other male-dominated workplaces, female representation in the R&B/hip hop industry continues to be on the rise (Emerson 2002; Rose 2008) and there is evidenced that gender disparities are on the decline. While Beyoncé may have been premature in her assertion that it is "girls" who run the world, there is hope that opportunities for women's advancement in the R&B/hip hop industry—and the broader labor market—will improve as women continue to enter professions that were historically dominated by men.

Abbreviations
ERGMs   Exponential random graph models
GWD   Geometrically weighted degree
GWESP   Geometrically weighted edgewise shared partner

Supplementary Information
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> **Additional file 1.** Supplemental Materials.

Declarations

Ethics approval and consent to participate
I used secondary data sources for my analyses and complied with the terms of service for all websites and databases from which I collected the data.

Competing interests
The author declares that they have no competing interests.

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