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Improving the visibility of minorities through network growth interventions

Keywords: network growth models, inequality, attributed networks, rankings, social networks

Extended Abstract

Historical disadvantages can result in the marginalisation of social groups. While there are many different mechanisms at play, research has shown that the network structure plays a vital role in the creation of structural inequalities and marginalisation[1, 2]. For example, the position of group members in a network determines their access to information [1], social capital [3], and their position in algorithmic rankings [4, 5]. However, as social networks are constantly evolving and growing, disadvantages can increase or decrease over time: as a result of institutional interventions, societal opportunities, or behavioural change, more people from disadvantaged backgrounds may enter certain social settings. For example, in STEM fields People of Color or women are historically underrepresented [6, 7] and there have been certain intervention measures, for example, scholarship programs, affirmative action and other support structures, to combat those historical disadvantages [7, 8]. Moreover, changes in behaviour can impact how new arriving individuals connect to the network as social attitudes and level of mixing between the groups may change over time [9].

However, previous research has shown that not all interventions are successful. Despite its importance, a rigorous and quantitative investigation of the interplay of different types of interventions on the marginalisation of minorities is still missing. While there are various dimensions of the impact that can be evaluated, we focus on marginalisation that emerges and exacerbated from the network structure.

In this work, we thus examine growth processes of social networks in order to identify how different network growth interventions impact the position of minority nodes in degree rankings over time. To this end, we construct a two-phase growth model as an extension of the *BA-Homophily* [4] model which itself is an extension of the well known Barabási-Albert (*BA*) preferential attachment model [10]. We thus consider networks in which both homophily and group-sizes are time-dependant and distinguish between two kinds of interventions: (i) *group size* interventions, such as introducing minority quotas that regulate the ratio of incoming minority and majority nodes and (ii) *behavioural* interventions, such as varying how homophilic groups interact and connect to each other. We find that even extreme group size interventions do not have a strong effect on the position of minorities in rankings if certain behavioural interventions do not manifest at the same time. For example, minority representation in rankings is not increased by quotas if the network does not additionally adopt homophilic behaviour. Therefore, the key finding of our research is that group size and behavioural interventions need to be coordinated. Moreover, their potential benefit is highly dependent on pre-intervention conditions in social networks. In a real-world case study, we explore the effectiveness of interventions to reach gender parity in academia. Our work lays a theoretical and computational foundation for a new generation of studies aiming to explore the effectiveness of interventions in growing networks.

References

[1] Paul DiMaggio and Filiz Garip. Network effects and social inequality. *Annual Review of Sociology*, 38(1):93–118, 2012.

[2] Fariba Karimi, Marcos Oliveira, and Markus Strohmaier. Minorities in networks and algorithms. *Preprint at https://arxiv.org/abs/2206.07113*, 2022.

[3] Frank Van Tubergen and Beate Volker. Inequality in access to social capital in the netherlands. *Sociology*, 49(3):521–538, 2015.

[4] Fariba Karimi, Mathieu Génois, Claudia Wagner, Philipp Singer, and Markus Strohmaier. Homophily influences ranking of minorities in social networks. *Scientific Reports*, 8(1):11077, July 2018.

[5] Lisette Espín-Noboa, Claudia Wagner, Markus Strohmaier, and Fariba Karimi. Inequality and inequity in network-based ranking and recommendation algorithms. *Scientific Reports*, 12(1):2012, February 2022.

[6] National Science Foundation, National Center for Science and Engineering Statistics. Women, Minorities, and Persons with Disabilities in Science and Engineering: Special Report NSF 15-311, 2015.

[7] Jacquelynne S. Eccles. Bringing Young Women to Math and Science. In Mary Crawford and Margaret Gentry, editors, *Gender and Thought: Psychological Perspectives*, pages 36–58. Springer, New York, NY, 1989.

[8] Mary A. Armstrong and Jasna Jovanovic. Starting at the crossroads: intersectional approaches to institutionally supporting underrepresented minority women stem faculty. *Journal of Women and Minorities in Science and Engineering*, 21(2), 2015.

[9] Steven M. Goodreau, James A. Kitts, and Martina Morris. Birds of a feather, or friend of a friend? using exponential random graph models to investigate adolescent social networks*. *Demography*, 46(1):103–125, February 2009.

[10] Albert-László Barabási and Réka Albert. Emergence of Scaling in Random Networks. *Science*, 286(5439):509–512, October 1999.

[11] Leonie Neuhäuser, Fariba Karimi, Jan Bachmann, Markus Strohmaier, and Michael T. Schaub. Improving the visibility of minorities through network growth interventions, 2022. arXiv:2208.03263.

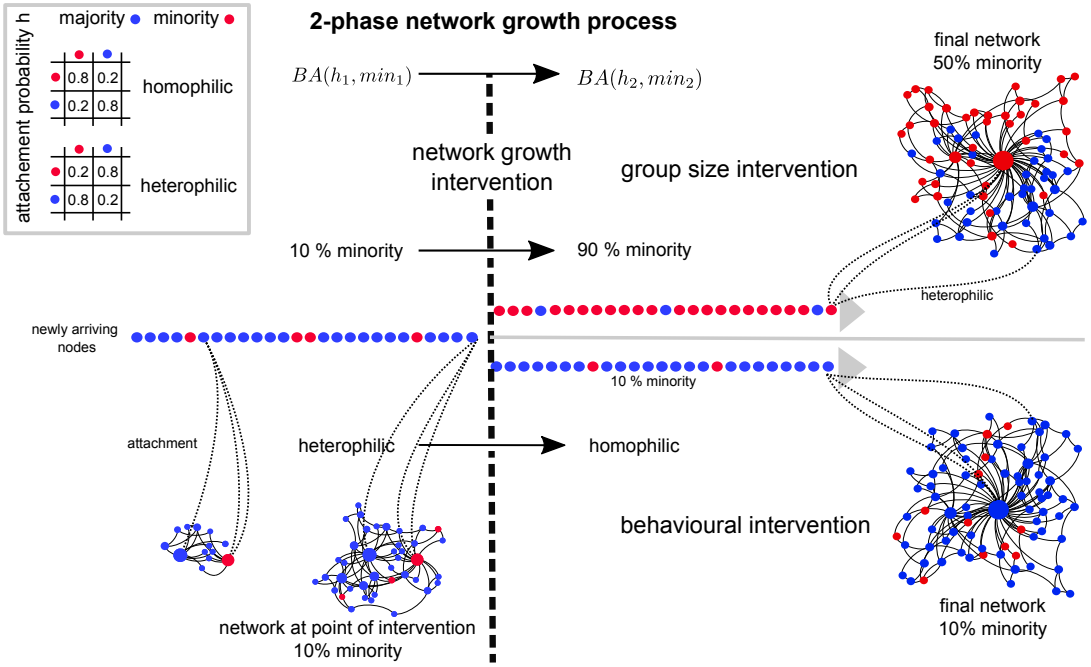

Figure 1: **Modelling interventions with a two-phase network growth model.** We consider attributed networks with two groups, a majority and a minority. The network growth process, $BA_h(h, min)$, is driven by preferential attachment, and a tunable homophily (h) and minority group size (min). Changing the two parameters at a certain intervention time point results in a two-phase process. The network growth in the pre-intervention phase happens according to $BA_h(h_1, min_1)$. The network growth in the second phase is determined by $BA_h(h_2, min_2)$, where we assume $min_2 \geq min_1$. For two growth phases with equal length, this results in a final network with a total minority size of $min_{total} = (min_2 + min_1)/2$. A network growth intervention is thus fully defined by $BA_h(h_1, min_1) \rightarrow BA_h(h_2, min_2)$. We can distinguish two different types of interventions. (i) We interpret the change in minority fraction in the incoming nodes as group size intervention, materialising in a quota for the newly arriving nodes. (ii) The switch in the homophily parameter, which determines if nodes like to attach to their kind, is interpreted as a behavioural intervention. Reproduced and adapted from [11].