

# Modeling the Formation and Dissolution of Social Ties in Virtual Reality: A Scalable Framework for Studying Social Dynamics of Small Groups

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### Background

#### **Objectives:**

- This paper forwards a framework for studying the temporal evolution of groups in virtual reality (VR). We demonstrate how network methods and newly available longitudinal interaction data from VR classrooms can be used to study social dynamics of small groups. Specifically, we examine *bridging/bonding* structures of "community" and the sense of presence.
- By bridging processes where actors link with popular partners to maximize their social reach and **bonding** processes where actors become friends with "friends of friends" and create closed networks, we aim to explore social structures in virtual space.

### Data / Measures

#### Data:

Collected in summer 2021, the dataset includes 86 university students in an 8-week course who were organized into 8 groups (10-15 persons per group) and invited to attend **8 weekly sessions** in VR classrooms for about 30 minutes while engaging in a variety of learning tasks.

#### Measures:

- The interpersonal distances in virtual space between each pair of students in each group session are calculated as the mode of their distances across all 1/3-meter bins and 1/30-second epochs of every 30-minute VR session.
- [1] Absence of social tie for each actor i with each other individual i in the group at time t



Self, social, and spatial presence were measured as the level of agreement with two items each (7-point Likert scale, 1 = strongly disagree to 7 = strongly agree) using weekly surveys:



- familiar individuals in the group prior to the course, and weekly ratings for identification to a group they belong to (e.g., club, sports; 7-point Likert). Dyadic relationship measure includes individual ratings of familiarity with
- every person in the group collected at the end of the course (7-point Likert)

### **Methods / Results**

### Methods:

#### Stochastic Actor-Oriented Model

. Week-to-week changes in social ties were modeled as a stochastic process where actors dissolve (or form) ties in a probabilistic way that is informed by the prior week's network structure and behavior. Per group, probability of tie dissolution is modeled as

$$\begin{split} & \ln P\left(\frac{AbsentTies(i,j,t)}{1-P(AbsentTies(i,j,t))}\right) \\ & = \beta_{OD}OD(i,t-1) + \beta_{GWESP}GWESP(i,\alpha,y,t-1) + \pmb{\beta_{Z}Z}(i,j,t-1) \end{split}$$

- where  $\mathbf{Z}$  denotes actor(*i*)- or dyad(*i*, *j*)-level covariates over time.
- The multi-group SAOM for undirected networks (Snijders & Pickup, 2017) was estimated using the "RSiena" package (Ripley et al., 2022).

#### Fig 1. Temporal Networks in Virtual Space (Group #8)



Note. 15 nodes (i.e., actors) are spatially located via multidimensional scaling (MDS) of distancebased group networks. Intensity and width of edges indicate relative closeness.

#### **Results:**

As depicted in Figure 2, there was a negative **out-degree** effect  $(\beta_{OD})$ 

= -1.52, p < .001), such that every disconnection to another person in the group reduced the likelihood of additional tie dissolution by 78.2%. In contrast, greater **GWESP** ( $\beta_{GWESP} = 1.01, p < .001$ ) was associated with a greater likelihood of social tie dissolution  $(\exp(\beta_{CWFSP}) = 2.74)$ .

#### Fig 2. Structural Effects on Tie Dissolution





likelihood of tie dissolution, but group identification obtained from in-person settings showed the opposite direction. Three types of presence display the conflicting effects of inter-/intra-individual differences in presence.

## **Discussion / Conclusion**

#### Discussion:

- Students were more likely to maintain ties when they interacted with smaller groups, and more likely to dissolve ties when their "cliquey" peers were not present. The results show that **bonding** (< bridging) structures manifest in VR classrooms.
- Increases in social/spatial presence over time reduced the likelihood of tie dissolution, implying that tracking psychological changes can contribute to facilitating in-VR communication.

Fig 4. Time-varying Effects of Presence on Tie Dissolution



#### Conclusion:

We analyzed longitudinal data from a university course taught in VR to demonstrate how SAOMs can be used to study social structures of VR classrooms. Pioneering integration of network theories with the traces of cutting-edge VR technologies opens new possibilities for group and interpersonal communication.

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