Predicting Social Networks and Psychological Outcomes through Mobile Phone Sensing

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Problem Statement

Our study seeks to explore:

1) How language usage affects students' social ties, through friendship, co-location, and call partnership

2) How longitudinal changes in adaptation to college are related to academic outcomes.

Research Methods

Participants were asked to use Android smartphones preinstalled with our software that could record and send phone usage data and colocation information to our server located in the university. The software application ran on any android mobile phone, and would mandatorily start at bootup. We used the WiFi fingerprinting method for indoor localization, which achieved an accuracy of 5-7 meters in our study. We used the periodic Bluetooth scanning to discover co-located participants. This study followed participants for one academic year.

Participants were also asked to complete self-reported questionnaires on language use, friendship tie-strength, and adaptation to college life, once each term (~every 13 weeks).
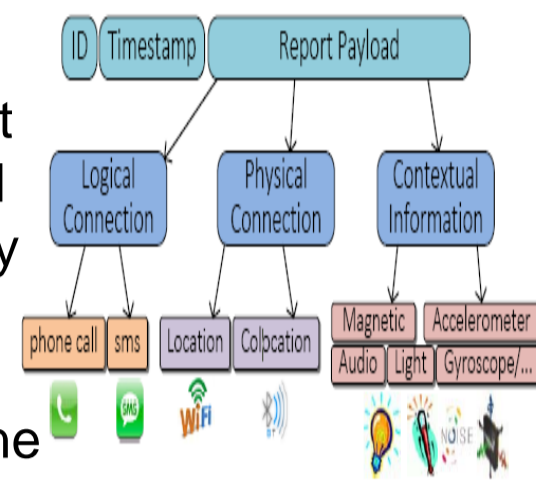
Psychological Measures

- **Language Background and Code-switching Questionnaire** – self-reports on proficiency and usage of the language(s) and code-switching in the past week under different contexts (e.g., face-to-face communication, text messaging, academic setting, casual setting, etc.). In addition, participants received automatic code-switching questions biweekly to submit their responses via the phones.
- **Friendship Tie-strength Questionnaire** – self-reports on participants' tie-strength (friendship) with each other.
- **Student Adaptation to College Questionnaire (SACQ)** - measures college adjustment.

Analysis Techniques

For question one, the three network types (call, friendship tie and co-location) were analyzed for each year. We used a stochastic, actor-driven model, through Rsiena. For each model, we measured three effects: ego (incoming), actor (outgoing) and homophily (similarity) effects. These effects describe the changes in the different types of ties, as predicted by the independent variable (e.g. language use). We also measured how similar the participants became over time with respect to language use, but did not find any significant results in any of the six networks.

For question two, two structural equation models were fitted to the data using Mplus. We used multiple-least squares imputation. There was no missing data for this model.
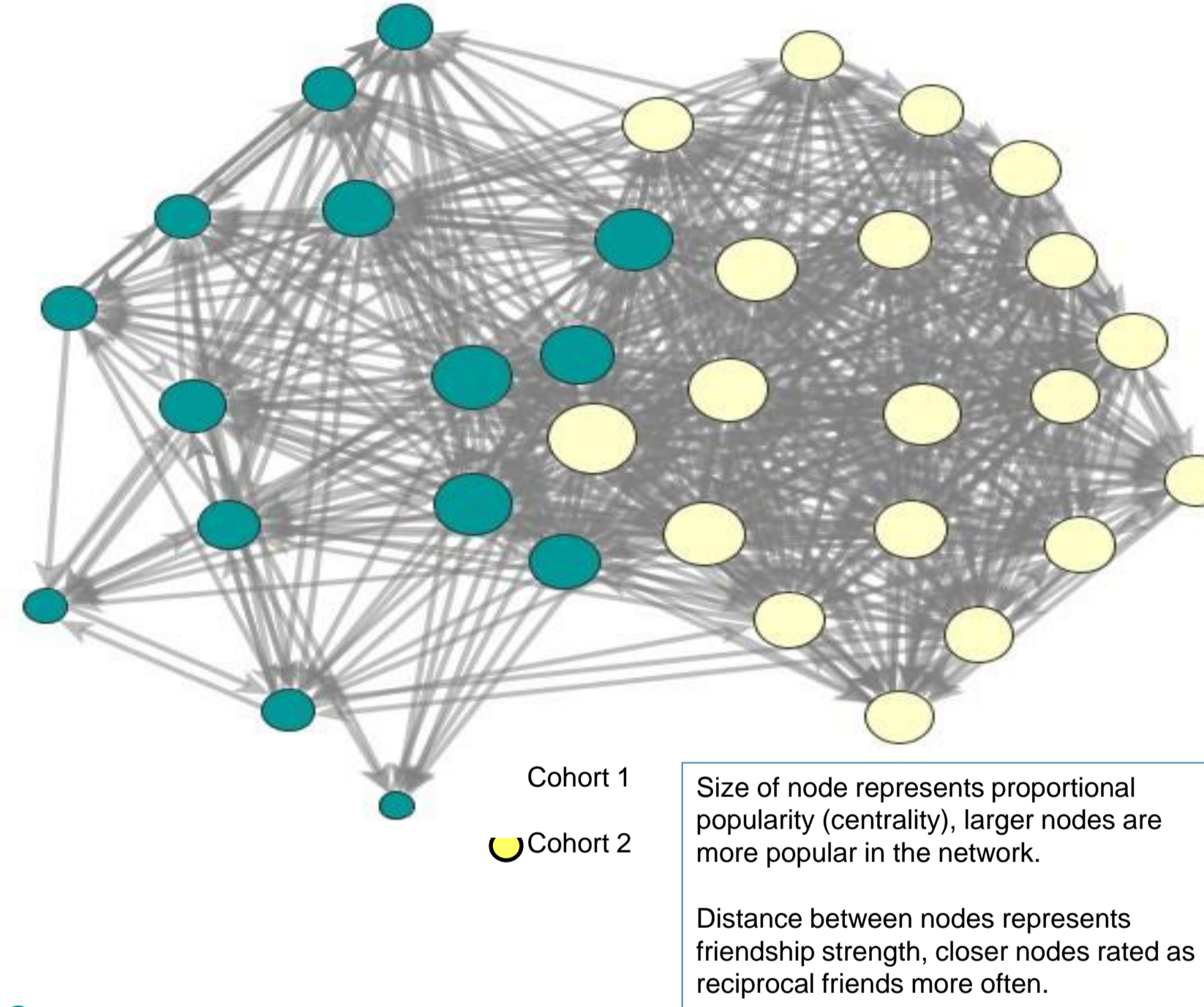
Sample results are presented in the tables and figures below; full results are then discussed respectively.

Results

Table 1
Summary of Demographics for Mobile Phone Study

	First-year Count (n)	First-year Percentage	Second-year Count (n)	Second-year Percentage
Cohort 1	15	42.9	13	35.1
Cohort 2	19	57.1	10	27
Cohort 3	-	-	14	37.8
Male	19	54.3	19	51.4
Female	15	45.7	18	48.6
Singaporean	21	62.9	20	54.1
Chinese	5	14.3	9	24.3
Indonesian	-	-	2	5.4
Indian	2	5.7	-	-
Malaysian	4	11.4	3	8.1
Vietnamese	2	5.7	-	-
Other (Asian)	-	-	3	8.1

Figure 3
First Year Friendship Network Model

Cohort 1
Cohort 2

Size of node represents proportional popularity (centrality), larger nodes are more popular in the network.

Distance between nodes represents friendship strength, closer nodes rated as reciprocal friends more often.

Social Networks

The homophily effects of language behavior on social network showed differential effects that varied depending on the number of years already in college. For the first-year students, who had just transitioned into a new environment, we found a strong language effect on co-location network. These first-year students tended to be around those who share similar degree of language balance in proficiency, and those who code-switch in similar amounts. This evidence suggests shared language behavior facilitates the proximal contact between the students' first year in college.

The effect of language proficiency on friendship network is dependent on how much the students code-switch. For the effect of language proficiency on the first-year call network, no homophily effects were found. Instead, only alter and ego effects were found.

In contrast, we found significant homophily effects of language proficiency with the second-year students in the co-location and call networks, and ego effects of language proficiency in the friendship network. In the co-location network, the second-year students tended to be around those who share similar balance in proficiency in both languages. However, the code-switching homophily for the second-year students was negative, where students tended to co-locate with those who code-switch in different amounts from them.

Longitudinal Changes

The results from the longitudinal analysis demonstrate that adaptation appears to have a snowball effect, especially for academic adjustment, personal-emotional adjustment and the full scale SACQ scores. In general, only the T3 SACQ scores had a direct effect on cumulative GPA. None of the T1 SACQ scores had a direct effect on GPA, nor were they correlated to T1 GPA. It appears that feelings of adaptation may take time to impact GPA. When the results from both studies are taken together, it appears that the first term GPA has a direct, and lasting impact on future feelings of adaptation, while feelings of adaptation may take some time to manifest in a student's GPA.

Figure 1
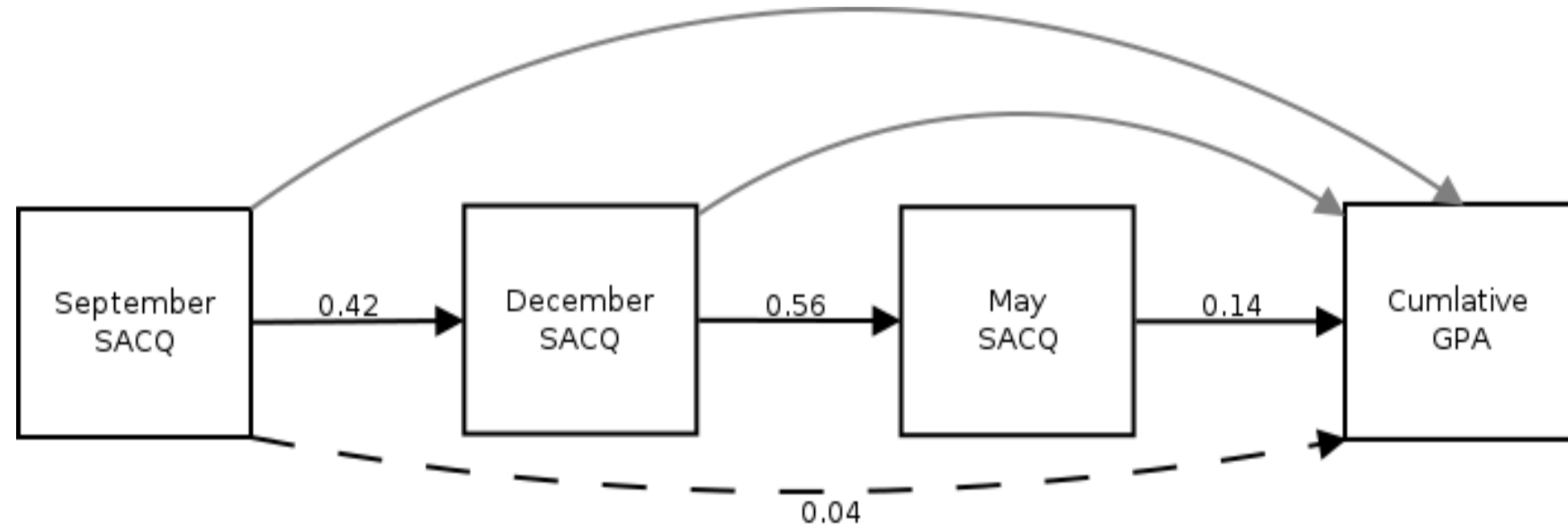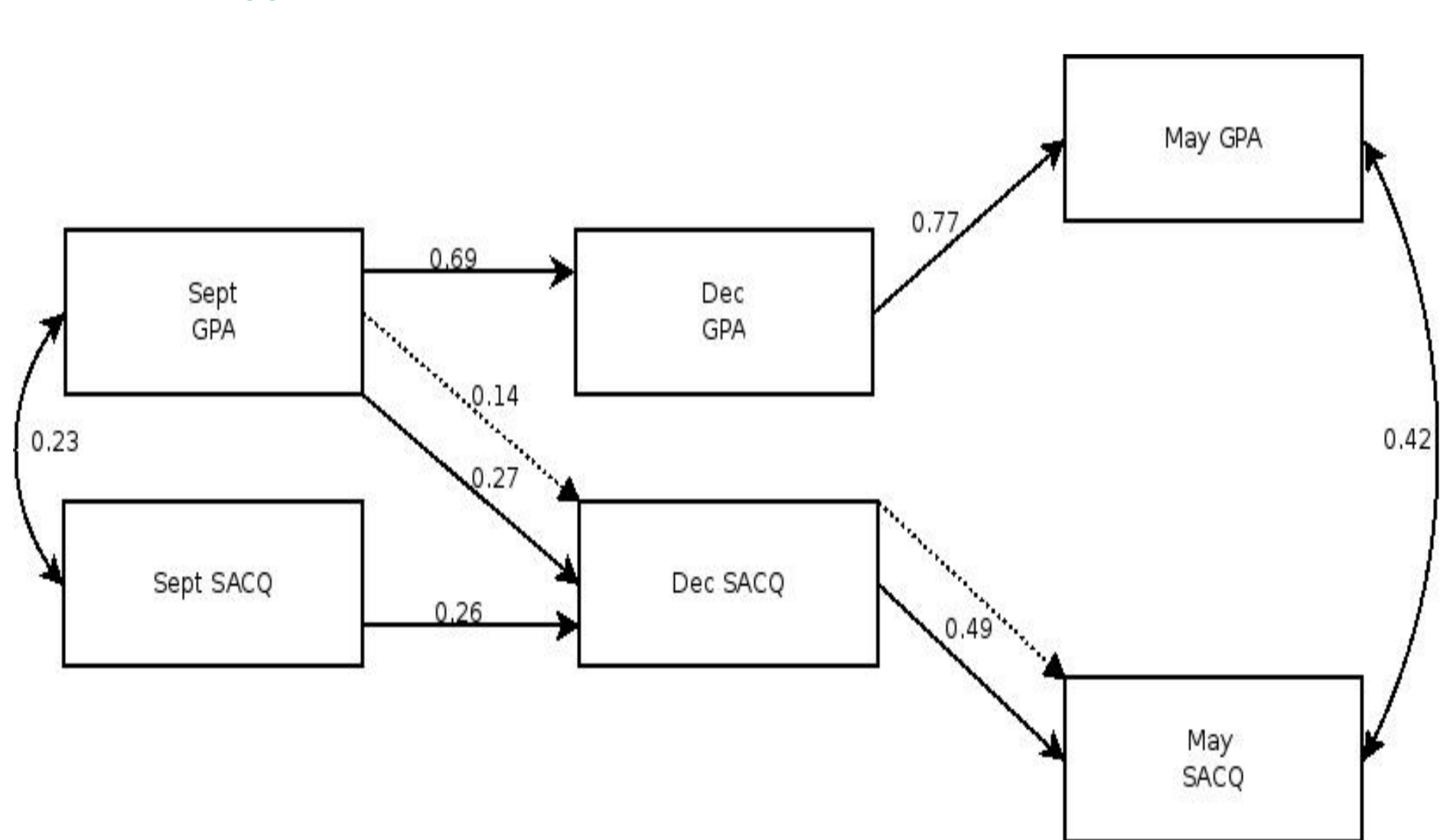*Full Scale SACQ to Cumulative GPA Results*

Figure 2
Cross-lagged model of GPA and Adaptation

Note: All effects reported in all figures are standardized and significant at p < 0.05. Dashed line indicates indirect path. Greyed lines indicate non-significant paths.

Table 2
First-year Friendship Network

Effect	b	SE
Outdegree (density)	--0.961***	-0.076
Reciprocity	0.670***	-0.087
Local Status alter	0.075	-0.084
Local Status ego	--0.327***	-0.097
Local Status homophily	0.208**	-0.073
Cohort homophily	1.012***	-0.077
Eng-Mand Balance alter	0.061	-0.056
Eng-Mand Balance ego	--0.180**	-0.065
Eng-Mand Balance homophily	0.1	-0.105
Code-Switching alter	0.003	-0.046
Code-Switching ego	0.089†	-0.052
Code-Switching homophily	0.376†	-0.198
Eng-Mand Balance ego x Code-Switching ego	0.237***	-0.061
Code-switching assimilation (not included)	0.294	0.181

† p < .1; * p < .05; ** p < .01; *** p < .001;

Figure 4
Interaction of Code-Switching Ego and EMB Ego Effects for First-Year Friendship

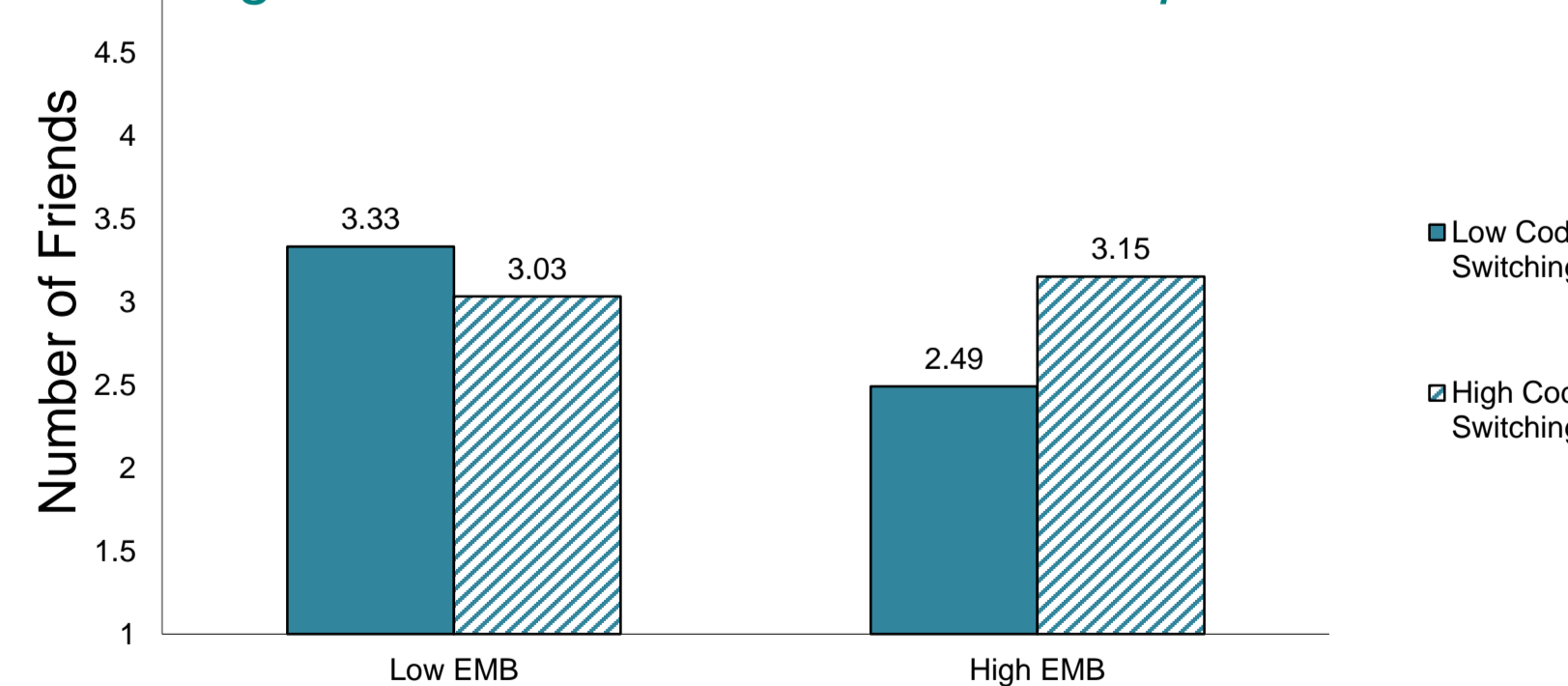
Low Code-Switching
High Code-Switching

Table 4
Second-year Friendship Network

Effect	b	SE
Outdegree (density)	--0.451***	-0.077
Reciprocity	0.573***	-0.089
Local Status alter	0.03	-0.092
Local Status ego	0.117	-0.107
Local Status homophily	0.181*	-0.085
Cohort homophily	0.312***	-0.091
Eng-Mand Balance alter	0.007	-0.038
Eng-Mand Balance ego	0.122**	-0.041
Eng-Mand Balance homophily	0.102	-0.176
Code-Switching alter	0.007	-0.009
Code-Switching ego	0.003	-0.01
Code-Switching homophily	0.036	-0.217
Code-switching assimilation (not included)	0.307	4.355

† p < .1; * p < .05; ** p < .01; *** p < .001;

Discussion

We also investigated the longitudinal psychological measures in this study. The results from this section suggest that the effect of adaptation levels may take time to manifest in a student's GPA, especially for academic adjustment, personal-emotional adjustment and the full-scale SACQ scores. Furthermore, the first term GPA appears to have the most impact on subsequent levels of academic adaptation, above and beyond baseline academic adaptation. Adaptation and GPA appear to have a reciprocal relationship. Previous research has found that low SACQ scores may serve as a warning signal to administrators of potential early leavers (Krotseng, 1992). Over a long period of time, students with low first term GPAs may be at risk for a negative feedback cycle, in which their low first term GPA leads to decreased feelings of adaptation, which leads to a subsequent low cumulative GPA.

Using advanced technology and stochastic actor-driven modeling techniques, we were able to investigate the dynamic nature of social networks in both the selection and the influence processes of the formation of social and friendship networks in college students. We found the way first-year students form social networks is different from the second-year students. There are more testing of relationships in the initial year of college life. Despite certain limitations, this study provides emerging evidence of how language, an important feature of human communication, plays a critical role in social network formation in college students transitioning from secondary school.

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