Social networks and positive and negative affect

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Abstract

We followed 100 university students in the UK for one week, instructing them to record all face-to-face, phone and digital contacts during the day as well as their positive and negative affect. We wanted to see how positive and negative affect spread around a social network while taking into account participants' socio-demographic data, personality, general health and gratitude scores. We focused on the participants' connections with those in their class; excluding friends and family outside this group. The data was analysed using actor-based models implemented in SIENA. Results show differences between positive and negative affect dynamics in this environment and an influence of personality traits on the average number and rate of communication.

Keywords: Positive and negative affect ; short-term network dynamics ; social networks; big five personality traits; gratitude; SIENA; Actor-based models;

1. Introduction

Recently, research using longitudinal data from the Framingham heart study (Fowler & Christakis, 2008), has suggested happiness is influenced by the happiness of others up to three degrees of separation (one's friend's friend's friend). It has also been shown that how others respond to an individual's good fortune impacts on that individual's well-being (Gable, Reis, Impett, & Asher, 2004), and that we can experience positive emotions by basking in the happiness of others (Royzman & Rozin, 2006). Similarly, there is a work showing that negative emotions are contagious (Rozin & Royzman, 2001), (Rosenquist, Fowler, & Christakis, 2010).

Although there is some evidence that happiness spreads through a social network, causal mechanisms by which this happens and the short term dynamics of happiness have not been investigated. In this work we concentrate on transitory affect, described in terms of moment-to-moment changes in positive and negative affect. As well as transitory measures we consider traits which are habitual patterns of behavior, thought or emotion, that are relatively stable over time and differ between individuals.

Transitory positive and negative affect are frequently measured by PANAS (the positive affect negative affect schedule) scale (Watson, Clark, & Tellegen, 1988) which has 10 descriptors for positive affect [PA], e.g. attentive, interested, active, and 10 descriptors for negative affect [NA], e.g. distressed, upset, hostile, angry. Recently, a

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shortened 5-item with internationally recognisable words in each category has been developed and is being used more commonly.

It has been shown that PA and NA are independent constructs (Watson & Clark, 1984) and relate to mood/well-being and level of anxiety (Tellegen, 1985). For example, PA relates to social activity and the frequency of pleasant events (Tellegen, 1985; Watson & Clark, 1984). The high energy and engagement, optimism, and social interest characteristic of individuals with high-PA also makes them more likely to be satisfied with their life. In (DeNeve & Cooper, 1998), PA and NA and life satisfaction are seen as indicators of the broader construct of subjective well-being, based on their content similarity.

Another construct related to well-being is gratitude. It has been suggested (Wood, Froh, & Geraghty, 2010) that at the dispositional level, gratitude is part of a wider life orientation towards noticing and appreciating the positive in the world. In order to encourage a more positive perspective, gratitude interventions have been developed and typically ask people to reflect on their day and identify positive events for which they can be grateful. In (Emmons & McCullough, 2003a), it has been shown that a gratitude intervention can increase daily PA and decrease daily NA. In the current study, we measured trait gratitude scores of participants at the beginning of the study and included them in our model.

When looking at a social network of individuals, it is normally easier to identify correlations between constructs, but it is more difficult to pinpoint the causality of different constructs and their interplay with underlying network. However, in recent years, development of methods based on stochastic actor-based models for network dynamics implemented in SIENA, Simulation Investigation for Empirical Network Analysis, (Snijders, Steglich, & Van de Bunt, 2010; Snijders T. A., 2005) enabled a simultaneous study of the co-evolution of networks and behaviour of its members. Based on longitudinal data of individuals' behaviour and their social connections, SIENA allows the user to differentiate between two types of processes: selection and influence. Selection processes focus on criteria for actors to choose other actors, based on their assigned attributes, with whom to make or break a link with. Influence processes focus on dynamics of actors' observed qualities or attributes (which can be behaviour, attitude, or another measurable state) and its influence on individuals to whom actors are directly or indirectly connected.

We investigate the dynamics of PA and NA to explore the role that selection and influence effects play and to highlight potential mechanisms underlying the observed affect network dynamics. We also explore how the big-five personality traits[1] are related to behaviour in a social network, and if they are related to transitory PA and NA.

Establishing which variables influence the short-term dynamics of PA and NA might help in the future design of well-being interventions to be delivered via a social network. Previous studies in health-behaviour settings have shown that social network interventions are cost-effective, easy-to-implement and the effects are more sustainable (Kelly, et al., 2006) (Stock, et al., 2007). In the next section, we refer to the work that explores the convergence of PA and NA in work-groups, connections of PA and NA to some health-related behaviours and how personality traits might be related to social network dynamics.

2. Previous work

Here is an overview of several articles related to our study that explore connections between social networks and happiness, PA and NA, and personality traits.

2.1. Happiness and social network

(Fowler & Christakis, 2008) completed longitudinal social network analysis on the Framingham Heart Study social network data from 4739 individuals followed from 1983 to 2003 in which happiness was measured with a validated four item scale.[2] Results showed that clusters of happy and unhappy people were visible in the network, and the effects reached to three degrees of separation (the friends of someone's friends' friends). People who were surrounded by many happy people and those who were central in the network were more likely to become happy in the future. The analysis suggested that clusters were created by influence and not by selection processes such as

[1] Big-five personality traits are five broad domains or factors of personality: Agreeableness, Conscientiousness, Emotional Stability, Extroversion, and Openness.

[2] To measure happiness, four items from the Center for Epidemiological Studies depression scale CES-D were used in which people were asked how often they experienced certain feelings during the previous week, e.g."I felt hopeful about the future".

homophily (a tendency to associate with similar individuals). For example, having a friend who lives close-by and who becomes happy significantly increased the probability of becoming happier yourself. Similar effects were seen in co-resident spouses and next door neighbours, but not between coworkers. The effect decayed with time and with geographical distance.

2.2. Positive and negative affect and social network

In (Cohen & Lemay, 2007) the authors examined the relation between social integration, affect, and smoking and alcohol consumption. Social network and psychological questionnaires were administered to participants, and they were interviewed for 14 consecutive days about their daily social interactions, affect, and smoking and alcohol consumption. Social integration refers to participation in a broad range of social relationships. Although there is no standard measure for social integration, in most cases the number of recognised social roles or identities is assessed. This study found that people high in social integration (with more diverse social networks) interacted with more people and smoked and drank less, but social integration was not associated with affect. People with high social integration reported high PA irrespective of the number of people with whom they interacted and their smoking and drinking behaviours were less influenced by number of contacts. However, for people low in social integration, increased number of contacts resulted with greater PA, drinking and smoking on that day.

The relationship between organizational networks and employees' affect was examined in (Totterdell, Wall, Holmand, Diamond, & Epitropaki, 2004). In two studies PA and NA were shown to spread within work interaction groups and were shaped by them. It was found that similarity of affect between employees depended on the presence of work ties and structural equivalence. Affect was also related to the size and density of employees' work networks. In the second study, which examined a merger of two organizational groups, it was found that negative changes in employees' affect were related to having fewer cross-divisional ties and to experiencing greater reductions in network density.

2.3. Personality traits and social network

Big five personality traits and their effect on social network formation among freshmen were explored in (Selfhout, Burk, Branje, Denissen, Aken, & Meeus, 2010). Sociometric nominations and self-ratings on personality traits were gathered from 205 late adolescents (mean age 19 years) at 5 time points during the first year of university. SIENA (Snijders, Steglich, & Van de Bunt, 2010) was used to examine effects of the Big Five traits on friendship selection. Results showed that individuals with higher Extraversion scores tended to select more friends than those low on this trait, while individuals with higher Agreeableness scores tended to be selected more as friends. In addition, individuals tended to select friends with similar levels of Agreeableness, Extraversion, and Openness.

In an earlier piece of work on the effects of personality differences, including big five personality traits on network structures, the authors examined egocentric networks of strong and weak ties of 125 students using a new triad census method (Kalish & Robins, 2006). Three principal components of triad census, describing central aspects of strength-of-weak ties and structural holes theories were used. Psychological predispositions explained a significant proportion of the variance in each of these components. Here we focus only on the big-five personality traits aspect of their approach, whose results suggested that people who seek to keep their strong tie partners apart, and thus bridge structural holes, tend to have lower levels of emotional stability. People with strong network closure and weak structural holes (as with the strength of weak ties) tend to be more extraverted.

In the current study, we are using a social network approach to explore mechanisms of PA and NA spread in a group of students. We also investigate the influence of big-five personality traits and gratitude scores on the dynamics of students' communication and their PA and NA during a week. In this way we contribute to the knowledge of PA and NA dynamics within a group which might be helpful in the future design of well-being interventions delivered through a social network.

3. Study design

Our study examined the relationship between daily interactions with colleagues inside an existing social network and levels of PA and NA in university students.

3.1. Aims

The main aim of the study was to investigate the short term dynamics of PA and NA through existing social networks and to identify main effects of selection and influence processes. Also, we were interested if there was a difference in the dynamics of PA and NA, given that they are independently defined constructs.

The secondary aim of the study was to investigate if the big-five personality traits, gratitude scores and general health scores of individuals influence the dynamics of their interactions' network and of PA and NA levels.

3.2. Participants

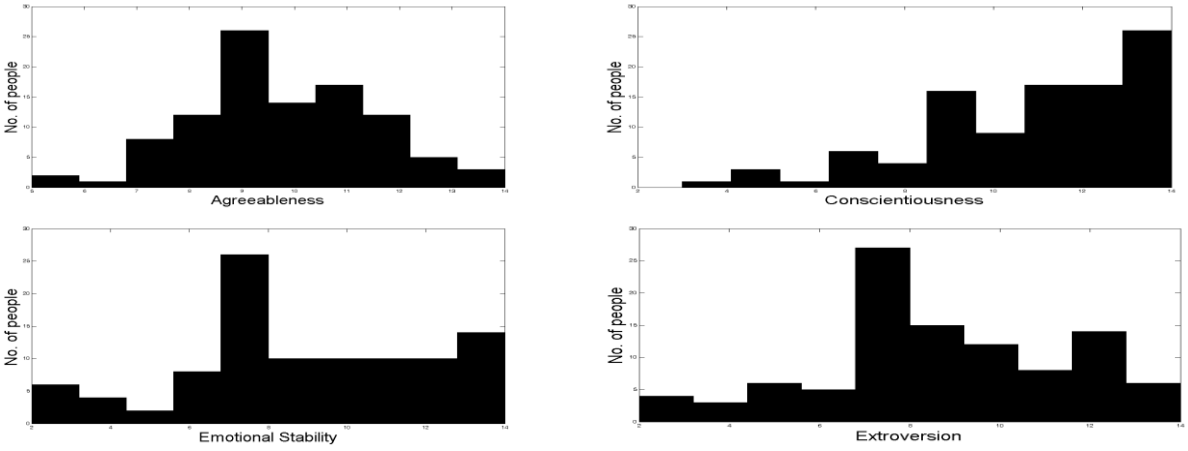
Participants were 100 students enrolled in a second year university course in the United Kingdom. They completed baseline and post-study measures as well as daily measures explained below for 7 days, these are explained below. Participants provided informed consent and were paid for their participation, given the intense requirements of the study. Approval was obtained from the University's ethical committee.

3.3. Baseline Measures

All baseline measures were taken at the beginning of the study. We recorded gender, age and ethnicity of participants. Participants then completed a series of questionnaires. Personality variables were assessed by the Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003). Trait gratitude was assessed using 6 questions gratitude questionnaire (Emmons & McCullough, 2003b; McCullough, Emmons, & Tsang, 2002). The histograms obtained from the population of 100 participants can be seen in Figure 1.

3.4. Daily Measures

Daily frequency of interaction with others in their network was collected, which assessed how frequently and how much time people spent interacting with others in their network. All participants completed a daily contacts diary. This included recording the name and a short description (friend, family, colleague, etc.) of a contacted person, if the contacted person belonged to the study group or not, a type of interaction: face-to-face, phone or digital (SMS, email, online) contact, and the duration of interaction in minutes. Then, they recorded daily levels of PA and NA via the shortened version of 20-item positive affect negative affect scale PANAS (Watson, Clark, & Tellegen, 1988) to assess positive and negative affect, based on how the respondent had been feeling that day. General health was self-reported using a scale from 1 to 5.



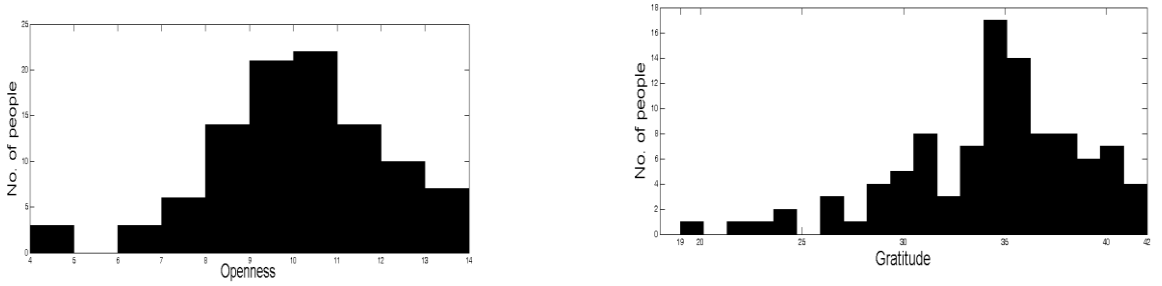


Figure 1: Histograms of participants' big five personality traits and trait gratitude scores

4. Results

4.1. Analysis

For the analysis, we used stochastic actor-based models for network dynamics implemented in SIENA, (Snijders, Steglich, & Van de Bunt, 2010) (Snijders T. A., 2005). We used 2000 iterations for updating parameters, which appeared sufficient as t-ratios showed good convergence for all our models.

As one of the main assumptions of SIENA models is that the network is a Markov chain (i.e. stochastic process where the probability distribution of future states depends only on current state and not on the past states), we aggregated communications during the day so that ties represented relations connected to daily well-being and not disconnected ephemeral events.

4.2. Constant actor covariates

Constant covariates represent actor attributes that are independent and do not change during the time when the network is observed. We used age, gender and ethnicity as constant covariates. The minimum age was 18 and maximum was 43 with a mean of 19.32. There were 90 female and 10 male participants, coming from 7 different ethnical backgrounds. We also used scores obtained on big-five personality domains, and gratitude scores as constant covariates, assuming that those scores are relatively stable at least in the short-term, and thus they should not change during the 7 days of the study.

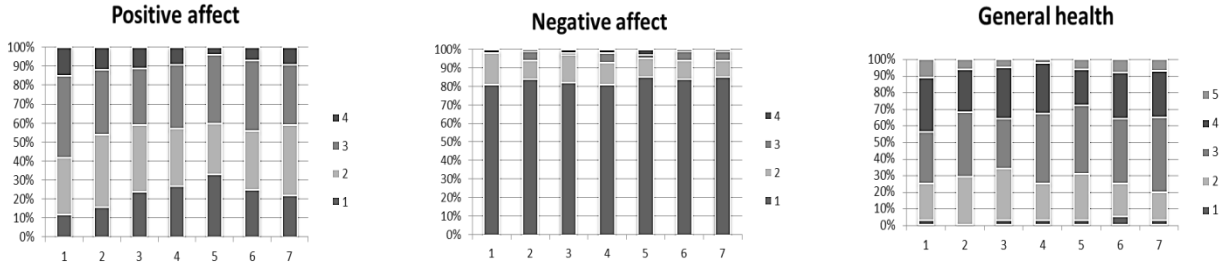


Figure 2: Percentage of participants in different categories of measured attributes(1-4 for PA and NA and 1-5 for GH) on each day

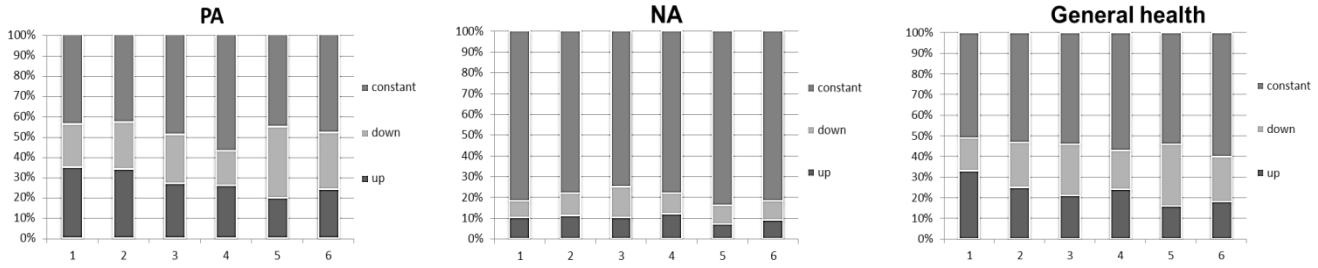


Figure 3: Percentage of participants going up, down or having constant value of PA, NA and GH between each two days

4.3. Changing actor covariates

Changing covariates represent actors' attributes that do change during time. Positive and negative affect and general health were self-reported each day at the end of the day. Positive and negative affect were measured using the shortened 10 item PANAS scale, and scores were normalised to scale 1-4 by transforming original range 5-25 to 1-4 in the following way: all values between 5 to 10 were assigned 1, 11 to 15 were assigned 2, 16 to 20 were assigned 3 and 21 to 25 were assigned 4. General health scores had values from 1 to 5. Figure 2 above shows marginal distributions of these scores for each day. Figure 3 above shows the changes between each two consecutive days (how many people went up, down and stayed at the same level of a measured attribute). We found a clear difference between PA and NA. Fluctuations in (self-perceived) general health were much bigger than we expected.

4.4. Selection processes

Several structural effects regarded as relevant for network dynamics were included in the proposed model:

- as representatives of network structure functions: outdegree (a number of initiated communications), reciprocity (a number of reciprocated communications) and transitive ties (a number of communications between any two people contacted by the same person;)
- to control for constant covariates: age, gender, ethnicity, big-five personality traits, and gratitude;
- and the following effects to test for selection based on dependent covariates: PA, NA, and general health.

Effects were tested using t-ratios (estimates divided by standard error, with an approximate standard normal null distribution).

Results showed that negative outdegree and positive transitive ties effect were significant at the 0.05 significance level, which suggests that participants preferred not to communicate with arbitrary colleagues, but to communicate with friends' friends. Reciprocity is by default included in communication networks, but a significant effect with positive values just confirmed that recall was acceptable, as data was self-reported in a diary of contacts. The detailed results can be seen in the Table 1.

The covariate-similarity effect was significant only in the case of the Openness score. The positive parameter for Openness implies that individuals prefer ties to others who scored similarly on Openness. This is known as homophily – a tendency to associate with similar others (McPherson, Smith-Lovin, & Cook, 2001; de Klepper, Sleebos, van de Bunt, & Agneessens, 2010).

The several other significant effects on the actor's activity are in a group of covariate-ego effects. A positive parameter for ego effect suggests a tendency for actors with higher values on this covariate to increase their out-degrees more rapidly. For example, the actors with higher general health scores initiated communication more rapidly which might be caused by having (self-perceived) higher energy levels which allow them to initiate more contacts. Also, individuals with higher negative affect initiated communication more rapidly. This is in line with (Totterdell, Wall, Holmand, Diamond, & Epitropaki, 2004) who found that "low and high negative affect states such as calm and anxiety, are more easily shared through network ties than are low and high positive states" and with (Agneessens & Wittek, 2008) who found that "satisfaction spillover" actually works in the opposite direction – people with a low level of job satisfaction tended to create more trust ties with the others than people with a high level of job satisfaction. This insight might help in the development of social network based interventions to decrease negative affect. The impact of PA on participants' activity was not significant. Also, the negative value for

the gender variable parameter implied that male participants were initiating contacts more rapidly than females. However, there was only 10 males and 90 females in the study.

When a multi-parameter score-test was applied to test goodness-of-fit of restricted model, ego effects of gender, negative affect and general health yielded p value less than 0.0001, with 3 d.f. and when tested separately with values of p equal to 0.0004, 0.014, and 0.004 respectively, so they were all significant.

As expected, the covariate-ego effect was significant for Openness and Extroversion, but surprisingly for Extroversion it has a slight negative parameter value, although this might be because highly extrovert persons initiated more communications out of the cohort (the university class) that we did not capture.

Table 1: Structural effects of network dynamics

Parameter name	Estimate	S.E.
Network effects		
Outdegree	-4.538*	0.1596
Reciprocity	2.1536*	0.2981
Transitive Ties	2.7891*	0.3625
Ego effects		
Gender(1=m, 2=f)	-1.2906*	0.4573
Age	-0.0203	0.0597
Ethnicity(1-7)	0.2061	0.1147
Gratitude	0.0078	0.03
Agreeableness	0.1124	0.0752
Conscientiousness	0.1188	0.0644
Emotional stability	-0.0634	0.0464
Extroversion	-0.1275*	0.0564
Openness	0.1514*	0.0712
PA	-0.0823	0.1907
NA	0.5908*	0.2904
General health	0.5182*	0.2014
Alter Effects		
Gender(1=m, 2=f)	0.1099	0.3271
Age	0.0005	0.0501
Ethnicity(1-7)	0.1784	0.1073
Gratitude	-0.0262	0.0194
Agreeableness	0.0392	0.0447
Conscientiousness	0.0426	0.0332
Emotional stability	-0.0332	0.0314
Extroversion	0.0053	0.0321
Openness	-0.0085	0.0451
PA	-0.0557	0.1416
NA	0.2740	0.2226
General health	0.1011	0.1302
Similarity Effects		
Gender(1=m, 2=f)	0.3829	0.3285
Age	0.0145	1.3368
Ethnicity(1-7)	-0.7865	0.6370
Gratitude	0.2793	0.5140
Agreeableness	-0.2958	0.4213
Conscientiousness	0.0352	0.4602
Emotional stability	0.2216	0.3792
Extroversion	0.4249	0.4588
Openness	1.4465*	0.5282
PA	0.2787	0.5896
NA	0.7989	0.8081
General health	0.1922	0.7120

(* significant at 0.05 level)

4.5. Influence processes

A key result was the difference between PA and NA dynamics with respect to their shape parameters (Snijders, Steglich, & Van de Bunt, 2010). Shape parameters estimate a function depending on the actor's own behaviour z_i (in our case level of PA and NA on 1-4 scale) as the relative preference for the specific value z_i of a behaviour. We estimated linear and quadratic coefficients of that function. They were both significant for both PA and NA (one-sided score test for a goodness-of-fit yielded $p<0.0016$ and $p<0.0001$ respectively), and while for PA, both the linear and quadratic coefficients were negative and close to zero (-0.14 and -0.15), for negative affect the quadratic coefficient was positive (see the Table 2). Our interpretation of these results is that in the case of PA, there is a push toward the midpoint of the range (between 2 and 3) and there is a negative feedback relationship - so that when PA level increases, the further push toward a higher level is smaller and when the level decreases, the push toward a lower level is smaller. On the other hand, the level of negative affect tended to be drawn to the extremes, with participants already low on negative affect being drawn to low values and participants on high levels being drawn to high values. However, we did not find any significant effects that differentiated participants by their position in the networks and their neighbourhood's behaviour. None of the similarity effects (total similarity, average similarity, indegree and outdegree effects) was significant, which shows that there is no evidence of the PA nor NA influence through the social network.

Table 2 : Effects caused by dynamics of PA and NA and general health

Parameter name	Estimate	S.E.
Linear shape effects		
PA	-0.1475*	0.0500
NA	-2.2772*	0.1611
General health	-0.0281	0.0601
Quadratic shape effects		
PA	-0.1543*	0.0529
NA	0.6360*	0.0804
General health	-0.3405*	0.0432
Average Similarity effects		
PA	0.2065	1.0112
NA	-0.3768	1.845
General health	-1.7465	1.6591
Indegree effects		
PA	0.008	0.0851
NA	0.1106	0.1288
General health	-0.0243	0.1007
Outdegree effects		
PA	-0.0154	0.0742
NA	0.0433	0.1147
General health	0.0243	0.0813

(* significant at 0.05 level)

4.6. Effects of big-five personality traits and gratitude on PA and NA dynamics

When looking at the effects of constant covariates on rates of PA and NA and on PA and NA themselves, we found that the emotional stability effect on NA was significant and had a negative value, which means that people higher on emotional stability had lower NA. Extroversion had a positive effect on PA, as expected. There was a slight but significant positive value for an effect of gratitude on NA rate wherein individuals with higher gratitude scores change levels of NA more rapidly.

Results are given in Table 3.

Table 3: Effects of personality traits and gratitude on PA and NA

Parameter name	Estimate	S.E.
Effects on PA, NA rates		

Effect from gratitude on NA rate	0.0890*	0.0429
Effect from emotional stability on NA rate	-0.1907*	0.0824
Effects on PA and NA		
Effect on PA from extroversion	0.0660*	0.0208
Effect on NA from emotional stability	-0.0748*	0.0319

(* significant at 0.05 level)

5. Conclusions

We looked at the dynamics of PA and NA through the communication network of 100 university students for a week. The students kept diaries of their daily contact and recorded daily PA and NA. Before the study their big-five personality and gratitude traits were measured. We used actor-based models implemented in SIENA for the analysis. We found that better general health and greater negative affect in an individual related to the initiation of communications more rapidly inside the group, while there was no significant effect regarding PA. A negative value for gender variable implied that male participants were initiating contacts more rapidly than females. For the big-five personality traits, we found that individuals prefer ties to others who scored similarly on Openness, and also individuals with higher values of Openness initiated communications more rapidly. Individuals with higher values of extroversion initiated communications more slowly, perhaps because they had more contacts outside the group. As expected, Extroversion had a positive effect on PA and individuals high on Emotional stability had lower NA. Emotional stability also had a negative effect on NA rate. Surprisingly, higher gratitude scores had a slight positive effect on NA rate.

We found no evidence for the contagion of PA or NA through the social network. The dynamics of PA and NA differed, which was in a way expected as they are independent constructs. For PA, there was a tendency toward the midpoint of the range and a negative feedback relationship - so that when the level of PA increases, the tendency to move toward a higher rating level is smaller and when the level decreases, the tendency to move towards a lower level is smaller.

On the other hand, the level of negative affect tends to be drawn to the extremes, with participants already low on negative affect being attracted to low values and participants on high levels being drawn to high values. It would be of practical interest to explore these different PA and NA relationships further as there might be different mechanisms that can help push behaviour change interventions from two different perspectives, e.g. to reduce NA and to increase PA.

In our study design, we relied on self-report and paper-based measures. Although there is evidence that daily contact diaries are a reliable tool to collect personal networks data, and the PANAS questionnaire is a standard method of collecting PA and NA, further studies are needed with more direct measures. For example, variables could be monitored via wrist-worn digital interfaces as a type of EMA (Ecological Momentary Assessment). This would allow us to capture participants' mood and social interactions in real time. An EMA approach might also help the accuracy of data by reducing reliance on retrospective assessment and thus, recall bias. The robustness of the network mechanisms reported here could also be tested through the application of more sensitive methods of data collection.

While we concentrated on the intra-cohort communications, and did not use the data on the frequency, mode and the duration of communications, with the development of SIENA methods for weighted networks, an analysis of such extended data-set is becoming feasible.

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