Towards Happier Organisations: Understanding the Relationship between Communication and Productivity

Ailbhe N. Finnerty[1], Kyriaki Kalimeri[2], and Fabio Pianesi[1]

[1] FBK, via Sommarive 18, Povo, Trento, Italy
{finnerty,pianesi}@fbk.eu
[2] ISI Foundation, Via Alassio 11/c10126 Torino, Italy
{kalimeri}@ieee.org

Abstract. This work investigates in-depth the communication practices within a workplace to understand whether workers interact face to face or more indirectly with email. We analysed the interactions to understand how these changes affect our work (productivity, deadlines, interesting task) and our wellbeing (positive and negative affective states),by using a variety of data collection methods (sensors and surveys). Our analysis revealed that overall email was the most frequent medium of communication, but when taking into account just the communication within working hours (8am to 7pm), that face to face interactions were preffered. Correlation analysis revealed significant relationships between Affective States and Situational Factors while Longitudinal Analysis revealed an impact of communication features and measures of self reported Productivity and Creativity. These findings lead us to believe that different communication processes (synchronous and asynchronous) can impact Positive and Negative Affective States as well as how productive and creative you feel at work.

Keywords: Communication, Organisational Psychology, Multimodal Sensors, Growth Model.

1 Introduction

With constant developments in communication technology it has become important to examine the effects that this technology (smart phones, the virtual workplace), has on our everyday lives, at home and in the workplace. Within organizations, more and more workers are situated remotely from a designated office space, which is an increasing trend [4]. What is required is a way to enhance communication within an organization, due to the changing nature of its structure. A way to enhance communication is also necessary with the changes in how workers interact and collaborate and the effectiveness of working in teams [18]. Research into this particular area is important to determine whether technology helps or hinders our interactions with others. Within an organisation management needs to use an appropriate media when communicating with employees

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or to communicate work-related information throughout the organisation [12] in order to ensure worker productivity and satisfaction.

Previous research has focused on examining either email or face to face communication, but not on both within the same research population. What is necessary is to objectively examine the overall communication, face to face and email, as much of what has already been found is based on opinion and the attitudes of workers. This study will attempt to use a mixed methods approach utilising linear mixed models and growth models for a more complete understanding of how we communicate with others, also taking into consideration time varying phenomena. The type of communication available to us are the most common forms of interacting in a workplace, which are face to face interactions as well as internal company emails.

All media are not equally effective and although each type of media for communication has different characteristics, the reasons why managers choose one media over another are not clear, despite significant research. Four major theories have been developed to try to explain the reasons for different media choices for similar tasks [8], Media Richness Theory (MRT), Social presence theory, Social construction theory and Structuration theory [22]. We will focus on Media Richness Theory and a newer theory Media Synchronicity Theory which emerged from it [9]. These two theories, aim to explain how different media can have an impact, positive or negative, on communication, interactions and mood, due to their ability to create a shared context and convey the correct meaning, allowing for efficient communication practices, allowing us to better understand how to investigate communication.

Media Richness Theory (MRT) argues that productivity performance improves when team members use "richer" media for equivocal tasks [6]. This is central to the study as it is expected that using different media for communicating and collaborating, within and between groups, can have a positive or negative impact on the social interactions and mood of the participants. Media Synchronicity Theory (MST) develops upon MRT to focus on the capability of media to support synchronicity, such as, when individuals work together on the same activity at the same time i.e., having a common focus. The key to effective use of media is to match the media capabilities to the fundamental communication processes required to perform the task. Communication environments that support high immediacy of feedback and low parallelism encourage the synchronicity that is central to the convergence process, whereas communication environments that support low immediacy of feedback and high parallelism provide the low synchronicity that is central to the conveyance process. Because most work tasks require individuals to both convey information and converge on shared meanings, and media that excel at information conveyance are often not those that excel at convergence. Thus choosing one single medium for a task may prove less effective than choosing a medium or set of media for the task, which the group uses at different times in performing the task, depending on the current communication process (conveyance or convergence) [7].

MST can be applied to the data findings to understand why different media were used at different points of the study. This theoretical framework allows

for better interpretation of the results of the study. By understanding that the way we communicate changes due to the availability of the media to convey the message in the most appropriate manner. This in turn allows us to give meaning to the changing patterns of communication and the effect that they had on the individuals over the course of the study. Many other theories have been used in the past and developed to accommodate the changes that are occurring within communication practices, however we believe that our choice of theoretical framework best matches the aims of the project.

2 Related Research

Previous research has focused on examining either email or face to face communication, but not on both with the same research population. It has been found that face to face interactions are of great importance for developing trust relationships in the workplace which is beneficial for relationships among workers, and increasing trust in the workplace has positive effects on weak relationships [10], [16]. Factors of trust need to be taken into account to be able to communicate effectively [26]. With virtual communication, certain issues can become misunderstood and come across as blunt without a context or shared working environment. The context of an interaction is as important as the message itself and when possible face to face communication is preferred even if electronic communication is available [12]. In a study of communication and training of electronic engineers, the workers felt that face to face communication develops a sense of community and allows small problems to be discussed and fixed rapidly [28].

Studies of productivity in the workplace show that using extensive digital networks can increase productivity by 7%; however, employees with the most cohesive face to face networks were the most productive with an increased productivity of 30 % [25]. In terms of working in group collaborations, email has been researched extensively and along with all its advantages, there are many disadvantages. High levels of emails can be stressful to try and manage. Due to this, emails are becoming less used and wiki's and blogs are becoming more commonplace for collaborating on group projects [17], and minimising email can actually improve communication. Features of electronic communication can be used to informally discuss aspects of working life with a colleague, but while it is a quicker form of communication it also is much less rich than face to face contact [3]. A study using sociometric badges, combining quantitative and qualitative data, found that an elevated level of face to face interactions preceded the launch of a new product, suggesting that this was the most effective form of communication in this period [19]. It could be that more face to face interaction at a certain stage was preceded by a successful outcome, while using email at the same time resulted in less productivity, but at an earlier point in the project it was a more common and efficient form of communication. This suggests that different methods of communication are more beneficial for different stages of a project and observing both email and Sociometric badge data can provide a less biased understanding of inter-team collaboration patterns [19].

Using sociometric badges along with survey data, as has been done in previous research projects e.g. [23]; can be useful for investigating groups as they collaborate. Using a mixed methods approach we can better evaluate how effective different methods of communication can be for the output of the project, as it records personal (mood, personality state) as well as social (social interactions, location) aspects of a person's working day. The reason for investigating the different methods of communication within and between the groups involved in this study is that the dynamics of research groups are constantly changing. Different groups should use different methods based on what is necessary to get the work done and in the method which works best for them, as the most effective means of reaching a satisfactory outcome. Understanding when face to face communication is more beneficial to a team, to produce better results, can help improve group interactions and collaborations. This is becoming a more important issue with the increase of the virtual workplace where teams are distributed and have to use alternative forms of communication, not just email but wiki's, group websites and shared files and document resources etc. By understanding the type of communication that leads to a more positive outcome can help to increase the effectiveness of media used by groups. A first step is to understand the impact of communication on the individual and applying the knowledge gained in studies like this to future studies on collaborative work.

3 Motivation of the Study

The aim of this project is to investigate communication in the workplace by analysing first what media is preferred (email vs. face to face) and second whether it has an effect on the pattern of interactions and mood of the participants in the study, such as leading to more positive and happier workers. We hypothesise that there will be a relationship between increased face to face interaction and positive mood, which can lead to a better understanding of how different media are used in organisations and their effectiveness in contributing to a positive working environment and positive outcomes of work projects. In this study to differentiate between communication mediums we will refer to two types of communicating with others; a) synchronous (immediate, happening in real time, e.g., face to face interactions) and b) asynchronous (delayed, when there is a gap between sending and receiving a message, e.g., emails). The specific research questions that this study aims at addressing are:

Question 1. What are the effects that technology has on friendships and formal relationships in the workplace when communicating face to face, or when using email as a primary medium of interacting.

Question 2. What are the effects that features of communication have on our social relationships and how communication can have a positive or negative impact on our well being, creativity and productivity.

Based on these research questions we form the following hypotheses:

Hypothesis 1. There will be more asynchronous (email) communication rather than synchronous (face to face), reflecting the changes in how we interact and communicate with each other.

Hypothesis 2. There will be positive affect associated with synchronous communication rather than asynchronous communication, such that more face to face and close interactions will lead to reports of positive affect.

4 Dataset

The Sociometric Badge Corpus [21] collected data from fifty four (Female=6) employees of a research centre over a six week period. The data collected by the Sociometric badges [24] consists of face to face interactions (infra-red) and social co-location (Bluetooth) as well as speech and bodily activity features. Electronic communication (email) amongst participants was registered in terms of email traffic (no content was saved to assure privacy) while all information regarding the identity of the subjects was fully anonymised. Using Experiencing Sampling methods [5] the participants filled in an online survey three times daily if they were present at work (11am, 2pm and 5pm), the questions related to affective states, personality, interactions (e.g. I was continuously interacting with those around me) and situations (e.g. I had a deadline, What I was doing was freely chosen by me). Furthermore, organisational information was collected regarding the collaboration on projects and social ties of the participants. The subjects were recruited on a voluntary basis to participate in the study and signed an informed consent form approved by the Ethical Committee of Ca' Foscari, University of Venice. The data were fully anonymised and participants were assigned an identification number for anonymity. Logs of data on electronic communication from social media (smartphones, personal email accounts, etc.) could not be recorded, due to privacy concerns over the content of the data.

4.1 Experience Sampling Data

Participants were asked to fill in a 6-items shortened version of the Positive and Negative Affect Schedule (PANAS) [29] three times a day (excluding week-ends). The items that comprise the PANAS are the most general dimensions that describe affective experience. They are the components of the structure of affect most often described by English language mood terms, and also make reference to the "basic" emotions of anger, disgust, fear, happiness, sadness and surprise [11]). Positive Affect and Negative Affect are the affective, emotional components of psychological or subjective well-being [27]. Following Fleeson [14], they were asked to respond to five situational items that described the interactional context. These items were: 1) During the last 30 minutes, how many other people were present around you? ("0, 1-3, 4-6, 7-9, 10 or more"); 2) I was continuously interacting with the other people around me, 3) What I was doing was freely chosen by me, 4) The deadline for what I was doing was very near and 5) What I was doing was extremely interesting to me. Two items regarding their self perceived Creativity and Productivity were also assessed. Due to the difficulty of measuring productivity in research [2] we simply asked the participants how Productive or Creative they felt in the past 30 minutes. We rely on the individual's subjective experience, however we found that the self reported values

were within the normal range and no extreme within individual variation was found. All of the information from the participants relates to the 30 minutes before completing the survey. For full explanations of the dataset please see [21] and [20].

Friendship and Collaboration Social Network. In order to examine the communication by relationship the participants were divided into two groups; "friends" and "colleagues". The participants were asked to rate on a scale from 1-Strongly Disagree to 7- Strongly Agree their answer to the question "I consider this person a good friend of mine, someone I socialize with outside of work". Scores of 0 determined no relationship, scores of 1-3, "just colleagues", while neutral (4) and scores of 5-7 determined "friends". The relationships were then calculated as dyadic pairs. We collected a number of network measures that examined the participants relationships with each other. However we believe that the network on friendship was most applicable to our study on communication within the group.

4.2 Sociometric Badge Data

For this study, from the Sociometric Badges Corpus, we used the infra-red hits as a measure of face to face (synchronous) and email as a measure of electronic (asynchronous) communication. As well as the communication we used the data concerning, mood and context, which were recorded three times daily by means of Experience Sampling surveys. We examined the communication patterns of the participants as they went about their working day. The focus of the study is 1) in how they communicated with each other (face to face or by email). We were also interested 2) in whether their relationship with each other had an impact on how they interacted, such as having more face to face interactions with those who we consider friends. Then, 3) we wanted to understand whether the communication patterns had an impact on self reported measures of affect and 4) further if these changes depended on the context of the situation as defined by Fleeson [15].

Face-to-face Interaction - Infrared Sensor. The detection of another Infrared (IR) sensor can be used a good proxy for face-to-face interaction. For the IR sensor of one badge to be detected by the IR of another badge, the two individuals must have a direct line of sight and the receiving badge's IR must be within the transmitting badge's IR signal cone of height $h \leq 1$ meter and a radius of $r \leq htan\theta$, where $\theta = \pm 15^o$ degrees. Infrared transmission rate (TR_{ir}) was set to 1Hz. The amount of F2F interaction is defined as the total number of IR detections per minute divided by the IR transmission rate.

Proximity - Bluetooth Sensor. Bluetooth (BT), and in particular the radio signal strength indicator (RSSI), can be used as a coarse indicator of proximity

between devices, hence people. In particular, by analyzing our data we found that a BT hit with a RSSI value greater than, or equal to, -80 corresponded to a physical distance between the two sensors, hence the two subjects, of less than 3 meters ("strong signal"). Those BT hits can be taken as a good cue for small groups of people gathering at a conversational distance, as in meetings. We therefore distinguished between people being in *close* and in *intermediate* proximity, where the former corresponds to an RSSI range of $[-80, -60]$ (less than one meter, according to our data) and the latter to an RSSI range of $[-85, -80]$ (one to three meters).

While IR hits imply actual interaction between two people, the strict detection conditions (a direct line of sight and limited angles) mean that the device may fail to capture actual interaction in several situations such as group meetings (e.g., people sit around a big table) or when two interlocutors look at the same object (e.g., screen, whiteboard). In addition to IR, BT proximity can be used as a reliable method to sense face-to-face interaction with a low false negative rate. When using Bluetooth proximity data, the challenge is how to reduce its high false positive detection rate, which comes from its relatively long range compared to the face-to-face interaction. With these points in mind, we chose to combine both IR and BT data, for which we only keep BT hits with strong signal strength (high RSSI value). In order to reduce the false positive hits both from BT and IR, which were mostly due to the office arrangements. An office collocation map was created in the form of an adjacency matrix, based on the field knowledge regarding the institutes internal organisation.

Electronic Communication Data (E-Mail). The electronic communication from participant to participant, was registered; the emails with multiple recipients were treated as multiple one-to-one communications in order to be able to consider each exchange as similar to an one-to-one interaction in person. The emails between each pair of participants were totalled to have a measure of the strength of their (electronic) relationship.

5 Automatic Feature Extraction

In this work we move from the traditional static approaches in analysing communication patterns to concrete behavioral cues automatically extracted from wearable sensing devices. The sociometric and the e-mail data described previously provide the behavioral sequences that are aligned to the ground truth for affective states and situational factors. In the following paragraphs, we discuss the features we identified to represent those behavioral sequences, clustering them according to the sensor type they are based on. All the behavioral features, Infra-red hits, bluetooth and emails were then normalised in order to compare them to each other. All values representing the relationships between the pairs of participants were divided by the maximum value. This gave the communication a value between "0" and "1" for both infra-red and email, "1" being the maximum value, "0" being no interaction between the pair of participants.

Face-to-face Interaction - Infrared Sensor. For each subject and for each time window, we extracted: the number of people F2F interacting with the subject; the mean duration of the interactions; the number of friends the participant F2F interacted with; the amount of time spent with them; the overall level of the F2F interactions, computed as the fraction of friends over the total number of people the subject had F2F interacted with, the level of global formality of a given situation/window, computed as the fraction of collaborators who were present over the total number of present people.

Proximity - Bluetooth Sensor. For each time window and for each subject, we extracted: the number of people in close proximity based on the RSSI; the mean physical distance from other subjects. Besides measuring co-location and proximity between people, we also addressed spatial localization by means of 17 badges placed at fixed locations of common interest such as the organization's bar, cafeteria and meeting rooms. All Sociometric Badges, including base stations, broadcast their ID every five seconds using a 2.4 GHz transceiver (TR_{radio} = 12 transmissions per minute). Combining this information with the signal's strength, we extracted the amount of time spent at the canteen, at the the bar, and at meetings. Moreover, exploiting information subjects had provided in the initial survey about their acquaintances and friends, for each participant and for each window we extracted: the number of friends each participant interacted with; the amount of time spent with them; the level of global friendship of a given situation/window, computed as the fraction of friends who were present over the total number of present people. Similarly from the information subjects had provided regarding their collaboration with the other participants in terms of specific projects, for each participant and for each window we extracted: the number of collaborators each participant interacted with; the amount of time spent with them; the level of global formality of a given situation/window, computed as the fraction of collaborators who were present over the total number of people present.

Electronic Communication Data (E-Mail). For each subject and for each time window, the following features were extracted: the number of e-mails they received; the number of people they contacted; the consistency of the communication, defined as the average number of the emails sent per recipient; the standardized mean length of the sent e-mails measured by the number of characters used in the body of text; the mean number of recipients. Respectively, the same features were calculated for the emails received by each of the participants: the number of e-mails they received; the consistency of the communication, defined as the average number of the emails received per recipient; the mean length of the received e-mails measured by the number of characters used in the body of text; the mean number of senders.

6 Methodology

6.1 Linear Mixed Model Analysis

Multilevel models are fundamentally about modelling the non independence that occurs when the individual responses are affected by group membership which is further complicated with longitudinal analysis [13].

A linear mixed model can be represented as:

$$y = X\beta + Zu + \epsilon, \tag{1}$$

where, y is a vector of observations, with mean $E(y) = X\beta$, β is a vector of fixed effects, u is a vector of random effects with mean $E(u) = 0$ and variance-covariance matrix $var(u) = G$, ϵ is a vector of IID random error terms with mean $E(\epsilon) = 0$ and variance $var(\epsilon) = R$, X and Z are matrices of regressors relating the observations y to β and u, respectively.

We have a typical multilevel dataset with repeated measures Dependent Variable being the Communication features extracted from the data and the Independent Variables being the Affective States and the Situations. After comparing the communication types through Spearman correlations (Table 1), Linear Mixed Models analysis was used to investigate if the communication patterns over time had any effect on the self reported measures from the questionnaire data.

6.2 Growth Model Analysis

To further examine changes of communication and to compare it to Affective States the data was analysed as a Growth Model [1]. We used this measure to understand the relationship between the communication used by the participants, how it changed over the six week data collection period and what variables were associated with the fluctuations in patterns. We assume that over the course of the study there will be naturally occurring changes in the data and we are interested in whether these changes are as a result of external factors such as the context of the situation. We hypothesised that with changes in communication there would be associated changes in Affective States allowing us to draw conclusions on the effect of communication practices within the organisation. The type of analysis used is autoregressive correlation, which is a covariance structure used in multilevel models in which the relationship between scores changes in a systematic way. The notation AR("p") indicates an autoregressive model of order "p". The AR("p") model is defined as:

$$X_t = c + \sum_{i=1}^{p} \varphi_i X_{t-i} + \varepsilon_t \ , \tag{2}$$

where $\varphi_1, \ldots, \varphi_p$ are the parameters of the model, c is a constant, and ε_t is a white noise process with zero mean and constant variance σ_ε^2.

We used Time as a repeated measure for this study and was calculated as the number of the survey out of the total possible number of surveys (n=90) taken during the study. When the participants were absent from the workplace they were not able to take part in the surveys, which lead to some missing data.

7 Experimental Results and Discussion

7.1 Analysis of Variance (ANOVA)

Taking the total number of normalised hits and emails, and for both "friends" and "colleagues" groups we ran a series of Analysis of Variance (ANOVA) tests on the data to determine whether there were significant differences between the communication types and then communication types by relationship. An experimental design of 2 (Communication; Email, IR) x2 (Relationship; Colleagues, Friends) Analysis of Variance (ANOVA) was carried out on the data with the independent variable "Relationship" (Colleagues, Friends) and the dependent variable "communication" measured as a score of the interactions (email and IR) between the participants. The data considered all infra red hits and emails between the participants for the study.

The analysis revealed a main effect of Communication $F(51,1)=25.70$, $p < .001$, with more email than infra-red (3.15 vs. 2.00) and a main effect of Relationship $F(51,1)=50.81$, $p < .001$, with more interactions between friends than colleagues (3.68 vs. 1.47). The analysis also revealed a significant interaction between Communication and Relationship $F(51,1)=6.31$, $p < .05$ Fig. 1. The interaction revealed that even though there was more email communication between the participants that the difference in the type of communication used between colleagues was very large, email was used as a form of communication much more than IR (2.26 vs. .65) while for friends the difference between the type of communication was much smaller difference indicating that friends interacted face to face nearly as much as they emailed (3.34 vs. 4.03).

As a second step we calculated the communication that was directly related to the Experience Sampling data, aggregated into thirty minute segments. This time frame was chosen as it was the time the participants were asked to consider when filling in the questionnaire (e.g. in the last thirty minutes "What I have been doing was freely chosen by me").

A second 2x2 ANOVA was carried out on the data. This analysis resulted in a significant main effect for Relationship $F(51,1)=67.65$, $p < .001$ with significantly more communication between friends ($M = 2.56$, $SD = 0.23$) than colleagues ($M = 0.45$, $SD = 0.10$). The analysis also revealed a significant interaction between Communication and Relationship $F(51,1)= 10.67$, $p < .05$ Fig. 2, where there was more communication between friends than colleagues, with a slightly greater value of face to face interaction than interaction via email for the friends group (3.0 vs. 2.17), while for colleagues it was found that there was a smaller proportion of face to face communication than email communication (0.13 vs. 0.77).

This difference in results could be due to the fact that infra-red data could only be measured during working hours, while the email data collected could have been taken at any time, during or outside of working hours. This could explain why email was marginally larger than infra red hits in our first ANOVA, while the second analysis supported our hypothesis that there would be more face to face interactions between friends than colleagues.

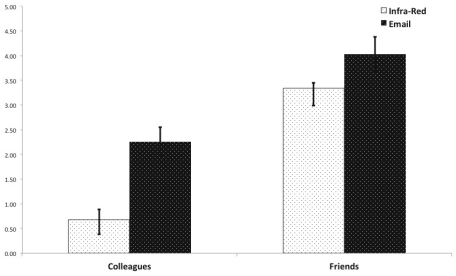

Fig. 1. Experimental design of 2 (Communication; Email, IR) x2 (Relationship; Colleagues, Friends) Analysis of Variance (ANOVA)

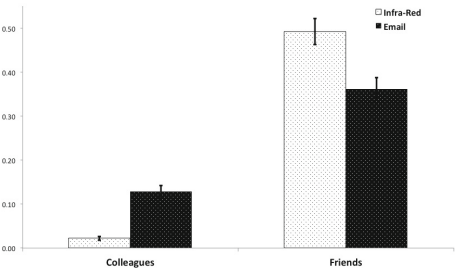

Fig. 2. Experimental design of 2 (Communication; Email, IR) x2 (Relationship; Colleagues, Friends) Analysis of Variance (ANOVA) on 30 minute segments

Table 1. Spearman Correlations between the communication, affective states and the situations. Note that * is significant at value $p < .000$ while all others are significant at $p < .05$

	HPA	HNA	LPA	LNA	Lonely	Discrete	Product	Create	Interact	FreeC	Interest
HPA				.697*		-.304	.778*	.838*	.416	.570*	.691*
HNA			.748*	-.476*	.577*	.878*				-.287	-.347
LPA					.755*	.720*					-.303
LNA						-.491*	.500*	.496*	.300	.482*	.490*
Lonely						.571*			-.369		
Discrete							-.319		-.305	-.373	-.392
Product								.770*	.427	.309	.582*
Create									.509*	.417	.633*
Interact										.355	.357
FreeC											.640*
Interest											

Using the data as formatted for the second ANOVA (in 30 minute segments prior to the survey) we ran a series of Spearman correlations on the communication data with the Affective States and Situations. We found that the communication had little impact on any of the variables ($sig > 0.05$). However we did find many significant correlations between the affective states and the situations (Table 1). While there were no significant correlations for communication (IR or Email) there were for the context of constantly Interacting with others, such as, High Positive Affect rs[0.416], Productivity rs[0.427] and Creativity rs[0.509]. We believe that this could be due to fluctuations in communication patterns over time, which could have accounted for a larger within subjects and between groups variance and the non significant results. We decided to continue our analysis using a method appropriate for longitudinal data analysis.

Taking the communication features as described in detail in Section 5 we ran an analysis using Linear Mixed Models in SPSS. This analysis expands the general linear model and allows the data to exhibit non consistent variability and adjusts for correlation due to repeated observations. This was done to examine the effect of communication patterns on the self reported questionnaire data and whether there were changing patterns over time.

7.2 Linear Mixed Model Analysis

We found that the number of infra red hits (synchronous interactions) between a larger number of friends explained variances in Productivity [F(1, 317.80)= -3.09, $p < 0.05$] and Creativity [F(1, 1421.02)= -3.03, $p < 0.05$]. While email sent and received (asynchronous interactions) between friends were related to the situational context, if you considered what you were doing as Interesting (email sent [F(1, 265.45)= 2.35]; email received F(1, 2112.18)= 3.283]) ($ps < .05$).

We did not find as many significant results for the Mixed Models analysis as expected. This could simply be due to the fact that the software used is not the most appropriate for the task. SPSS is not the best program for multilevel modelling [13] and more specialised software such as R and SAS are commonly used for this type of analysis. As the analysis here was inconclusive we decided to use growth models using R software to further examine the data as a time series. While we did not find the expected relationship between communication features and Affective States and did not support our second hypothesis, what was interesting were the significant relationships between the communication features and self reported measures of Productivity and Creativity. This could mean that the way that we interact with each other does affect us and that our interactions with those around us can make us feel more or less productive or creative.

7.3 Growth Model Analysis

It is assumed that the correlation between scores gets smaller over time and variances are assumed to be homogeneous. A benefit of using Growth Models is to be able to better understand the patterns of the communication and whether

the variances over the course of the study can be accounted for by Time or the other variables present (Affective States, Situations).

For this, features extracted from infra-red and emails were used, as well as Bluetooth (a measure of co-location).

IR. The results found that interacting closely with more people face to face [$F(1, 3161)=2.78$, $p < 0.05$] was related to higher Positive Affect especially when your task was interesting [$F(1, 3161)=2.109$, $p < 0.05$], but also that higher number of face to face interactions with friends was negatively related to self reported measures of Productivity [$F(1, 3161)= -5.32$, $p < 0.001$] and Creativity [$F(3161)= -4.65$, $p < 0.001$].

BT. The same trend was found when considering co-location with others through BT signals, that being co located with friends [$F(1, 3157) =2.93$, $p < 0.05$] was related to higher reports of Positive Affect. It was also found that higher number of interactions, with more people in the canteen [$F(1, 3157= -4.99$; $F(1, 3158)= -3.95$] and when having coffee [$F(1, 3157= -6.11$; $F(1, 3158)= -3.10$] were found to negatively impact the reported levels of Productivity ($ps < .001$) and Creativity ($ps < .001$) respectively.

However for the BT features it was found that more time interacting [$F(1, 3157)= 2.53$, $p < 0.05$] and being co located with friends [$F(1, 3157)= 4.41$, $p < 0.001$] had a positive effect on Productivity but not Creativity, whereas being surrounded by more people [$F(1, 3158)= 3.92$,$p < 0.001$] regardless of relationship led to higher reports of Creativity.

EMAIL. Average email length was the only feature to have any impact on task status, if what you were doing was Interesting [$F(1, 3161)= 1.99$, $p < 0.05$] or if there was a Deadline [$F(1, 3162)= -1.98$, $p < 0.05$].

What we can draw from the Growth Model findings are that we found partial evidence to support our second hypothesis that more face to face interactions had an impact on feelings of positive affect and more importantly on self reported creativity and productivity, while email communication was only relevant when the participants were engaged in an interesting task or had a deadline to meet. Being co located with others differently impacted the productivity and creativity, in that when surrounded by those that are considered friends more productivity was reported but not creativity, while when around more people in general higher levels of creativity were reported. The findings here can have implications on future research on satisfaction and motivation in the workplace and also in studies attempting to understand how to improve productivity.

8 Conclusion

From the first analyses, our second ANOVA, evidence was found to support our first hypothesis, that there would be more asynchronous than synchronous communication between the participants. By analysing the data as a time series we found partial support for our second hypothesis, as over the course of the study different patterns emerged where the communication impacted the Affective States and self reported measure of the participant's Productivity and

Creativity. Interacting with "friends" face to face had an impact on Positive Affective state but a negative effect on self reported Productivity and Creativity, especially during lunch or coffee breaks. Co location just with friends found higher levels of self reported Productivity only, while being co located with more people in general was found to have a greater impact on self reported Creativity. Email was found to have minimal impact on any of the self reported variables.

Our findings were much more evident when it came to the positive effect of communicating and the link to productivity and creativity, which we believe can also be classified as positive states. We believe that by improving communication practices in the workplace can lead to more positive environments and boost worker morale, making it a happier place to be.

We focused on communication practices, mood and affective states, as this is an area that is changing with new working practices and means of communicating. This study extends the state of the art in the communication studies in organisational management, providing useful deep insights on the communication channels and attitudes of workers. These insights can be an important steppingstone for creating teams that are not only more productive, but more importantly engaged with their mission.

Future extension of this research includes not only development of predictive models that can accurately capture and explain the behavioural cues but also inclusion of other means of communications, such as virtual (online) communication, Skype, instant messaging as well as workers smartphones that are also becoming tools for communicating within the workplace. We aim not just to focus on improving productivity in the workplace, but on how it can be affected by our social interactions and our mood, exploiting simple broadly used productivity strategies and last but not least the effect of personality and individual characteristics on the communicational behaviours and preferences. The aim of future studies should focus on making this work generalisable to organisations and any collaborative situations.

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