Personality and Mental Health Assessment

A sensor-based approach to estimate personality and mental health

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Abstract - **The purpose of this study was to estimate personality and mental health through behavior data measured by acceleration and voice intensity sensors. Traditionally measuring methodologies require huge amount of time and resources for its operation. Techniques that attempt to classify and measure psychological states require acknowledgment of its dynamic behavior, and the issues intrinsic to the use of self report inventories. This research conducted experiments in real-life settings, minimizing intrusiveness to participants. A methodology for estimating personality and mental health in the work place was proposed. Sensor-based behavior analysis provided an unobtrusive and time-efficient mechanism to estimate psychological states through measurement of a selected set of behaviors. This methodology's objective was to demonstrate existing correlations between estimated behavior and assessed personality and mental health. The results showed significant correlations between behavior and all personality and mental health states studied except for openness. This research provides insights into the analysis of personality and mental health states in the working settings. More broadly, the methodology proposed in this research provides implications for the development of recognition systems that will facilitate the attainment of personal and collective goals, which proves highly useful in today's increasingly *technicized* societies.**

Keywords - human behavior; sensory technology; mental health; personality

I. INTRODUCTION

The wide study of personality theory and mental health has opened new research directions through the use of sensorial technology to better understand personnel psychology [1]. Companies are increasingly aiming to develop their human workforce performance by studying their employees' individual characteristics. Robbins [2] identified four individual-level variables, i.e. biographical characteristics, ability, personality, and learning, which have effects on employee performance and satisfaction.

Since the use of questionnaire-based objective tests for both personality and mental health has been widely established [3], the time required for employers and employees to carry out such questionnaires has increasingly become wasteful and troublesome. On the other hand, recent technology enables to visualize office workers' interactions [4], identify human behavior within organizational situations and obtain associated tacit knowledge [5][6] without privacy intrusion or major burden.

The purpose of this study was to propose a sensor-based methodology to estimate behavior, and to further demonstrate existing correlations between employee's estimated behavior and mental health and personality traits. Building on the aforementioned findings, this study provides conclusions involving personality traits and mental health in the working setting with a minimum required burden from both employers and employees.

This paper is organized as follows. Section II contains an overview of related personality and mental health studies in the workplace. In Section III, it is proposed a methodology to estimate behavior based on sensory data, which was used in Section IV to analyze the relationship with personality and mental health. Section V includes some discussion points, and finally, Section VI presents conclusions, a summary of the paper, and future work.

II. RESEARCH ON PERSONALITY AND MENTAL HEALTH

Personality has been defined as the characteristic manner in which one thinks, feels, behaves, and relates to others [7]. Robbins [2] claimed that all our behavior is at some extent explained by our personalities and experiences. Traits in personality psychology have been used to describe consistent inter-correlated behavior patterns [8]. The study of personality traits has increased the understanding of the differences between people's behavior in order to explain how certain personality traits better adapt for certain job types [2][9], how personality relates to the effective performance of teams [9][10][11], and how personality is a component of motivation [12].

With similar attention, mental health in the workplace has also been studied. A study has concluded that adverse psychosocial work conditions are predictors of depression worsening [13]. This result was independent from personality traits analyses, and demonstrated the importance of the study of mental health alone. Also, the impact of job stress and working conditions on mental health problems

[14], and the relation between job satisfaction and the Five Factor model [15][16] has been studied.

A. Personality traits in this study

Although there is a general consensus over the Big Five being a general framework for assessing personality traits, this study has included in addition to those in the Big Five, the Locus of Causality, the General Causality Orientation, the Self Monitoring, and the Type A traits in order to present a more comprehensive assessment of personality.

The Five Factor Model (FFM) is a taxonomy, or descriptive model of personality traits organized at the broadest level of abstraction in five factors or dimensions named: extraversion or surgency, agreeableness, conscientiousness, emotional stability versus neuroticism, and intellect or openness [8]. These traits became eventually known as the Big Five [17]. Extraversion describes traits relating energy, dominance, sociability, and positive emotions. Agreeableness includes traits such as altruism, tender-mindness, trust and modesty, defining a prosocial orientation towards others. Conscientiousness summarizes traits which facilitate goal-directed behavior. Neuroticism describes anxiety, sadness or irritability, contrasting emotional stability. Finally, openness describes the depth of an individual's mental and experiential life [18].

Locus of Causality traits are related to the motivation factor of an individual and it examines the source of the motivation when engaging on an activity. Locus of Causality's intrinsic motivation refers to doing something because it is inherently interesting, fun, or enjoyable. On the other hand, extrinsic motivation refers to doing something because it leads to a separable outcome, or because it responds to external demands. Each motivation trait has two secondary scales. Secondary scales for intrinsic motivation are enjoyment and challenge. Challenge orientation is related to problem-solving, while enjoyment orientation is related to writing and art involvement. Secondary scales for extrinsic motivation are outward and compensation scales. Outward motivation entails personal endorsement and a feeling of choice. Compensation, on the other hand, merely involves compliance with an external control [19][20].

General Causality Orientation is referred as the individual differences that can be characterized in terms of people's understanding of the nature of causation of behavior [21]. In other words, these traits characterize the degree to which human behaviors are volitional or self-determined. There are three causality orientations, namely, autonomy, control, and impersonal orientation. Autonomy orientation trait involves a high degree of experienced choice related to the initiation and regulation of one's own behavior. Control orientation trait involves people's behavior following controls either in the environment or inside themselves. Impersonal orientation trait involves people experiencing their behavior as being beyond their intentional control [21].

Self-Monitoring people are described as showing considerable adaptability and behavior flexibility to external factors, being capable of behave differently in different situations [2].

Type A personality is the trait describing people which is aggressively involved to achieve more in less time. Highly rated Type A people are highly competitive, cannot cope with leisure time, and are continuously measuring their success [2].

B. Mental health in this study

The mental health states considered for this study were depression and happiness. Although these states could be related to a general happiness scale, in this study the term mental health was used to describe each of them. The viewpoint from which these traits were analyzed was to relate depression, and stress, against job satisfaction characterized by happiness in the workplace.

C. Personality and mental health measurement

Objective tests have been firmly established as the preferred personality measuring method [3], and it has also been used to assess mental health. However, it has been pointed out that several issues relating to this method may jeopardize its efficacy. Measuring methods have failed to accurately reflect the dynamics of personality and mental health [22][23]. As individuals' behavior is not constant from situation to situation, the associated personality and mental health will also be continuously shaped by experiences. Another concern is the increasing number of inventories and scales offered, for which a huge amount of time and effort would be required for its completion [8].

On the other hand, recent technology enables to make inferences about office workers' interactions [4], and obtain associated tacit knowledge [5][6], without privacy intrusion or major burden. The use of these approaches may be a mechanism to cope with issues regarding the use of objective tests [8][22][24] in the assessment of mental health and personality traits.

III. STUDY 1: ESTIMATION OF BEHAVIOR BASED ON SENSORY DATA

This first study proposed a methodology to estimate human behavior at the workplace based on objective data measured by sensors. An experiment was done in order to investigate the possibility of identifying certain human behavioral expressions based on sensory data.

A. Participants

Two male participants volunteered for this experiment. Participants were aged 25 and 44, and were all capable of moving freely.

B. Apparatus

Business Microscope (BM) [6] developed by Hitachi Corporation was used in this experiment. BM, shown in Figure 1 being worn as a name tag, records data from the

user's acceleration, face-to-face (IR), temperature, and voice intensity sensors.

Figure 1. Hitachi's Business Microscope.

C. Procedure

Each participant wore a BM device and acted out different behaviors switching them from one to another for 2 hours as if they were engaging in daily office working activities. The characterized behavior categories were desk working, talking, walking, and not-working related behaviors like sleeping, eating-drinking, or simply being unoccupied. These last were grouped into a single category hereafter referred as idle.

D. Measurements

For the purpose of this study, this experiment only used acceleration and voice intensity sensory raw data with a sampling frequency of 50 Hz. Due to privacy concerns and to a limitation of energy consumption, each datum was observed for 2s long and was acquired once every 10s. The data captured by the device was wirelessly transferred to a server where it was stored for later use.

While acting out behavior categories, participants marked the time, the location, the posture, and the behavior being acted.

E. Results

Sensor data chosen from each behavior category was plotted for analysis to reveal distinctive characteristics representing each acted behavior. This information served to build a method with which behavior was estimated. The estimated behavior was compared with the participants' actual behavior by finding out hit and false alarm rates. A hit was defined by corresponding predicted and actual behaviors. False alarm on the contrary was defined by a mismatch between them.

A graphic method, the Receiver Operating Characteristic (ROC), was used to evaluate and compare the performances of signal-noise discrimination [25]. ROC was used to portray the optimal criteria to detect behaviors and to select the most effective prediction thresholds.

1) Behavior detection criteria

For the walking category, the amplitude and the frequency of the oscillations of acceleration data were calculated. The amplitude of the curve was calculated by subtracting the curve's minimum data value from the maximum data value. As for the number of oscillations of the curve, it was used the zero crossing method. The zero cross line was determined as the data's average line. The number of times the curve crossed the zero-crossing line were added up to obtain the curve's frequency.

Sound intensity curve was represented by temporal changes of sound volume. The data's mean and the standard deviation were calculated and used to obtain thresholds for data characterized by sound representing a talking behavior.

For desk working behavior, back and forth acceleration data was investigated. It was found that the mean of acceleration data at time t, and the mean of acceleration data at time $t-10s$, tended to be comparable. As differences in mean values of these succeeding two time points were limited in range, it was assumed that such behavior corresponded to small posture changes as those displayed by desk working behavior. Upper and lower limits were calculated, and data found within this range was regarded as describing desk working behavior category.

As for the idle behavior category, the acceleration data's frequency of vibration was analyzed. The most suitable data for analysis was found along the vertical direction; therefore

the zero crossing number was used to calculate this behavior's data frequency along that axis.

2) Sequential detection method

The hit rates and false alarm rates for each behavior category are shown in Table I. Also, ROC curves for each behavior category are shown in Figure 2. The variance of dots in each graph represents the performance of criteria using various threshold combinations. The results showed that the best detection performance (represented by a red dot) was found in the following order: walking behavior category, followed by talking, desk working, and idle behavior. Consequently, it was considered a sequential detection order through which the sensitivity of each detection method was set as the detection order priority [25].

Thus, walking behavior was the first category to be detected from the entire sensor data set. From the remaining data, talking behavior was detected, then desk working, and finally idle behavior category.

TABLE I. HIT AND FALSE ALARM RATES FOR BEHAVIOR DETECTION

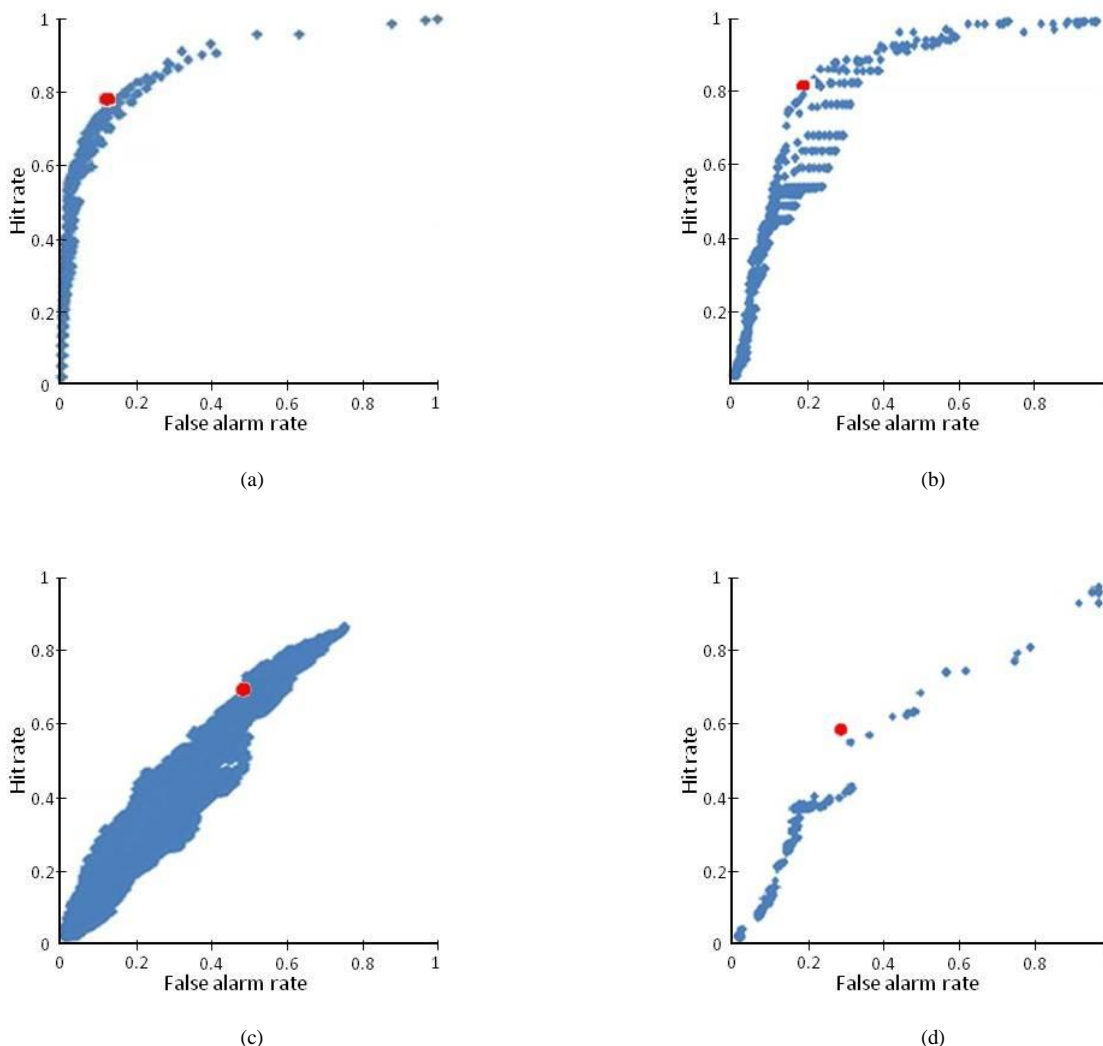| Behavior category	hit rate	false alarm rate
Walking	0.78	0.12
Speaking	0.82	0.19
Desk working	0.69	0.48
Idle	0.59	0.28

(a)

(b)

(c)

(d)

Figure 2. ROC curve: (a) walking detection, (b) talking detection, (c) desk working detection, (d) idle detection.

IV.   STUDY 2: STUDY OF PERSONALITY AND MENTAL HEALTH BASED ON BEHAVIOR DATA

The purpose of this study was to analyze the relationships among behavior estimated through the method proposed in Section III, and personality and mental health. An experiment was conducted, and a correlation analysis was done in order to validate that sensory data can be used to assess personality and mental health.

A. *Participants*

Ninety two Japanese participants, 77 males and 15 females, ranging between 21 and 61 years old (M = 35.93, SD = 8.50), who worked as software developers at a certain company volunteered for the experiment. They were all capable of moving freely and perform routine office activities. The participants of this experiment were not familiar with what kind of measurements were being executed, and further agreed to provide individual psychological states information.

B. *Apparatus*

The apparatus for this study were the same as those used in study one. Refer to Section III.

C. *Procedure*

Participants wore individual BM devices every working day for 71 days, time in which they engaged in normal daily working activities. Participants' behavior was detected according to the procedure explained in Section III. Also participants conducted 8 sets of questionnaires, 5 relating personality, and 3 more relating mental health.

D. *Measurements*

To assess the big five personality, the Big Five Inventory [18], which consisted of 44 items, was used. The Work Preference Inventory (WPI) which consists of 30 items was used to assess Locus of Causality [20]. The 12-item General Causality Orientation Scale Questionnaire (GCOS) was used to assess General Causality Orientation [21]. It was also used the Self-Monitoring trait questionnaire developed by Lennox and Wolfe [26], and the Type A questionnaire developed by Bortner [27].

As for mental health, two scales for depression and one for happiness were used. The Center for Epidemiology Studies Depression Scale (CES-D) was developed by Radloff [28], and consisted of 20 items. Also the Beck Depression Inventory Second Edition (BDI-II) was used. The BDI-II is a 21 items self-administered questionnaire assessing the severity of depression in adults and adolescents [29]. The last mental health state studied was satisfaction. The Oxford Happiness Questionnaire (OHQ) was used to assess this state [30].

E. *Results*

This study considered unitary behavior samples and behavior events as measurement units. A behavior sample was defined as each datum in a set of data corresponding to an estimated behavior category (one sample per *10s*). A behavior event was defined as the sequential group of two or more samples under the same behavior category. A chronological summary showing the time series of estimated behavior samples and events was prepared for each participant. This summary indicated what type of behavior category a participant engaged in and for how long.

1) Detected behavior

Basic statistics of the behavior data collected are shown in Table II. After analyzing the number of behavior samples of the 92 participants, three outlier participants were excluded as they provided significantly less number of samples ($< M - 2 \times SD$) due to their absence in the experimentation settings.

TABLE II. BEHAVIOR SAMPLES AND EVENTS DETECTED PER PARTICIPANT

	Average	Standard Deviation	Median	Minimum	Maximum	Sum
Total samples	147031.63	33345.42	152837	50633	203825	13085815
Behavior Samples (number of samples)						
Walking	41229.87	18198.27	37405	6538	94410	3669458
Talking	22147.24	9796.56	20431	6469	51626	1971104
Desk working	44192.09	13258.58	43589	13845	75012	3933096
Idle	31643.84	9933.78	30054	9989	63565	2816302
Behavior events (number of events)						
Walking	9129.35	2854.07	9186	1527	15844	812512
Talking	7996.57	2749.70	7576	2662	15795	711695
Desk working	11446.83	2861.78	11457	3457	17209	1018768
Idle	13471.34	3707.78	13750	3769	21119	1198949

The results hereafter report data from the remaining 89 participants, 74 males and 15 females ($M = 36.07$, $SD = 8.56$). From the total number of detected samples, 28% were detected as walking, 15% as talking, 30% as desk working, and 21% were detected as idle behavior. There was a 5% of samples which could not be detected as any of the proposed behaviors.

2) Personality and mental health results

The results presented in Table III show the participants scores obtained through personality and mental health questionnaires.

3) Behavior characteristic variables

Characteristic variables were obtained for the behavior samples and events of individual participants. The behavior characteristic variables (BCVs) were represented by letters triplets and are summarized in Table IV. The first letter of each triplet represented the behavior categories. This is W, T, D, and I represented walking, talking, desk working, and idle behaviors, respectively. The second letters in a triplet were A, T, E, and D, and represented time instances. A as a triplet's second letter represented the entire time span. T as a triplet's second letter represented the time ratio per day.

This ratio was obtained by dividing a given behavior total time over the total time in a day. The letter E as a triplet's second letter represented the number of events per day. The letter D as the second letter in a triplet represented the behavior events duration. If the second letter of the triplet was A, the third letters of a triplet were T or E. In this case T represented the time ratio, and E represented an event. However if the second letter of the triplet was T, E, or D, the third letter of a triplet could be A, D, or M, which stood for average, standard deviation, and median.

Personalities like intrinsic or extrinsic motivation are estimated to be related to the variation of behavior. In order to assess this variation, the percentage of behavior-engaged time over all the experiment's time span and the number of events per day was calculated. It was also calculated the average, standard deviation and median of behavior-engaged time (time ratio T and number of events E) per day.

TABLE III. PERSONALITY AND MENTAL HEALTH SCORES

	Average	Standard Deviation	Median	Minimum	Maximum
Big Five					
Extraversion	22.88	4.98	23.00	10.00	37.00
Agreeableness	28.81	3.70	28.00	20.00	37.00
Neuroticism	26.82	4.62	27.00	10.00	38.00
Conscientiousness	26.94	4.27	27.00	15.00	40.00
Openness	30.78	4.42	31.00	21.00	42.00
Locus of Causality					
Intrinsic M	39.02	6.05	39.00	24.00	52.00
Enjoyment	20.93	3.59	21.00	13.00	29.00
Challenge	18.94	2.94	19.00	10.00	27.00
Extrinsic M	35.46	5.31	35.00	24.00	51.00
Outward	18.52	3.89	18.00	9.00	30.00
Compensation	11.94	2.47	12.00	6.00	19.00
General Causality Orientation					
Autonomy	56.77	10.65	56.00	36.00	83.00
Control	37.12	8.47	37.00	17.00	61.00
Impersonal	43.87	11.54	44.00	23.00	84.00
Additional traits					
Type A	9.35	3.10	9.00	3.00	18.00
Self-Monitoring	7.39	3.37	7.00	0.00	15.00
Mental health					
CES-D	9.33	8.14	7.00	0.00	43.00
BDI-II	21.11	9.90	20.00	3.00	51.00
OHQ	100.29	23.16	102.00	24.00	147.00

TABLE IV. BEHAVIOR CHARACTERISTIC VARIABLES USED IN STUDY 2

Variable	Definition
WAT, TAT, DAT, IAT	percent of walking (W), talking (T), desk working (D), and idle (I) time (T) over all investigation time (A)
WAE, TAE, DAE, IAE	percent of walking (W), talking (T), desk working (D), and idle (I) events (E) over all investigation time (A)
WTA-WTD-WTM, TTA-TTD-TTM, DTA-DTD-DTM, ITA-ITD-ITM	average (A), standard deviation (D) and median (M) of the percent of daily walking (W), talking (T), desk working (D) and idle (I) time (T)
WEA-WED-WEM, TEA-TED-TEM, DEA-DED-DEM, IEA-IED-IEM	average (A), standard deviation (D) and median (M) of the percent of daily walking (W), talking (T), desk working (D) and idle (I) events (E)
WDA-WDD-WDM, TDA-TDD-TDM, DDA-DDD-DDM, IDA-IDD-IDM	average (A), standard deviation (D) and median (M) of walking (W), talking (T), desk working (D) and idle (I) events duration (D)

The concept of absorption is important for some personality traits and it is considered to be strongly related with uninterrupted behavior engagement. Therefore the average, standard deviation and median of the time continuance of each behavior were also calculated (triplets with "D" as the second letter).

4) Correlation among personality traits, mental health, and BCVs

a) Big Five personality scores

Big Five personality scores and BCVs combinations whose correlations were significant are shown in Table V.

Extraversion showed positive correlation with walking behavior variables. It was also found negatively correlated with talking events (TEA, TEM) and desk working related variables (DAE, DAT, DEA, DTA, DTM). These results suggested that people who often walk, and often spent their time away from their desks were likely to be extraverted.

b) Locus of Causality and subscales personality scores

Intrinsic and extrinsic Locus of Causality personality scores and BCVs combinations whose correlations were significant are shown in Table VI and Table VII, respectively.

TABLE V. PEARSON'S CORRELATION BETWEEN BIG FIVE PERSONALITY SCORES AND BCVs

	Extraversion	Agreeableness	Conscientiousness	Neuroticism	Openness
WAT	0.212 *	0.082	-0.142	0.006	0.076
WED	0.235 *	0.089	-0.109	0.118	0.147
WTA	0.216 *	0.091	-0.141	0.009	0.078
WTD	0.255 *	0.221 *	0.015	-0.010	0.181
WTM	0.239 *	0.096	-0.130	0.010	0.081
WDA	0.238 *	0.120	-0.081	-0.102	0.059
WDM	0.226 *	0.128	-0.089	-0.039	0.104
TEA	-0.216 *	-0.164	0.032	0.129	0.018
TEM	-0.213 *	-0.140	0.043	0.110	0.027
TDD	-0.131	0.064	0.209 *	-0.041	-0.071
DAE	-0.298 **	-0.029	-0.111	0.184	-0.002
DAT	-0.285 **	0.000	-0.039	0.058	-0.142
DEA	-0.210 *	0.048	-0.132	0.216 *	0.077
DEM	-0.204	0.099	-0.118	0.233 *	0.078
DTA	-0.284 **	-0.008	-0.036	0.059	-0.158
DTM	-0.273 **	-0.007	-0.039	0.056	-0.154
n=89; **p<.01; *p<.05					

Locus of Causality variables were both positively and negatively correlated with BCVs. Talking related variables were negatively correlated with intrinsic Locus of Causality, and both of its subscales, enjoyment and challenge. It can be argued that intrinsically motivated people have a strong preference for working individually without talking or interacting with people around. However, as it is shown in Table VI, idle behavior variables were found positively correlated with challenge subscale alone. It might be argued

that the nature of intrinsic Locus of Causality and challenge orientation, motivate these people to find time to think and reflect about their own initiatives.

Intrinsic Locus of Causality and the challenge subscale correlated positively with idle BCVs IAT, ITA, ITD, ITM, IDA. It may be argued that the nature of intrinsic Locus of Causality and challenge-motivated people drives them to find time to think and reflect about their own initiatives.

TABLE VI. PEARSON'S CORRELATION BETWEEN INTRINSIC LOCUS OF CAUSALITY AND SUBSCALES PERSONALITY SCORES AND BCVS

	Intrinsic	Enjoyment	Challenge
WTD	0.203	0.126	0.209 *
TEA	-0.254 *	-0.216*	-0.230 *
TEM	-0.220 *	-0.174	-0.214 *
TTA	-0.211 *	-0.210*	-0.173
TTM	-0.212 *	-0.222*	-0.166
TDM	-0.226 *	-0.231*	-0.174
DEA	-0.217 *	-0.048	-0.283 **
DEM	-0.168	0.005	-0.246 *
IAT	0.280 **	0.157	0.298 **
ITA	0.285 **	0.169	0.298 **
ITD	0.209 *	0.136	0.225 *
ITM	0.264 *	0.151	0.272 *
IDA	0.239 *	0.119	0.277 **

n=89; **p<.01; *p<.05

TABLE VII. PEARSON'S CORRELATION BETWEEN EXTRINSIC LOCUS OF CAUSALITY AND SUBSCALES PERSONALITY SCORES AND BCVS

	Extrinsic	Outward	Compensation
WED	0.275**	0.217*	0.250*
DAT	-0.221*	-0.148	-0.241*
DTA	-0.213*	-0.136	-0.243*
DTM	-0.237*	-0.144	-0.282**
DDA	-0.223*	-0.174	-0.205
DDM	-0.249*	-0.186	-0.242*
IEM	0.179	0.232*	0.019
ITD	0.209*	0.183	0.161

n=89; **p<.01; *p<.05

The variation of the percentage of daily walking events (WED) showed a positive correlation with extrinsic personalities, and both of its subscales (extrinsic, r=.275, p<.01; outward, r=.217, p<.05; compensation, r=.250, p<.01). Also, walking variable WTD which referred to the variation of walking time in a day, correlated with challenge subscale. Building from these findings, it can be argued that intrinsic motivated participants walked longer by their challenging determination; however, although extrinsic participants walked more times, they tend to do it for shorter periods.

Other results showed that extrinsic motivated people did not tend to stay in their desks or focus on their work for long periods as desk working related variables (DAT, DTA, DTM, DDM) were all negatively correlated with extrinsic Locus of Causality and compensation subscale.

c) General Causality Orientation personality scores

General Causality Orientation personality scores and BCVs combinations whose correlations were significant are shown in Table VIII. Talking related variables correlated negatively with the autonomy trait. On the other hand, impersonal trait correlated positively with desk working and idle behavior related variables. It can be argued that people

who do not actively engage or face external circumstances tend to spend more time at their desks.

TABLE VIII. PEARSON'S CORRELATION BETWEEN GENERAL CAUSALITY ORIENTATION PERSONALITY SCORES AND BCVS

	Autonomy	Control	Impersonal
WED	0.163	0.233*	0.085
WTD	0.231*	0.133	-0.041
WDA	0.175	-0.120	-0.240*
WDD	0.148	-0.244*	-0.182
TAE	-0.238*	0.000	0.101
TAT	-0.273**	-0.016	0.065
TTA	-0.278**	-0.029	0.060
TTD	-0.305**	-0.034	0.054
TTM	-0.254*	-0.032	0.051
TDA	-0.216*	-0.029	0.009
TDM	-0.292**	-0.096	0.034
DAE	-0.016	0.059	0.304**
DEA	0.041	0.054	0.331**
DEM	0.083	0.087	0.323**
IEA	0.077	0.117	0.296**
IED	0.148	0.222*	0.165
IEM	0.100	0.147	0.301**

n=89; **p<.01; *p<.05

These results implied that people with high impersonal score, whose behavior is marked by decisions beyond their control, tend to follow directions as they are told. In other words, these people might not leave their desks or stop working. These findings are comparable to idle behavior variables being positively correlated with impersonal trait. It can be argued that as these people tend to stay at their desks, they might be able to loosen up, even in front of their desks.

d) Self-Monitoring and Type A personality scores

Self-Monitoring and Type A personality scores and BCVs combinations whose correlation were significant are shown in Table IX. Self-Monitoring personality was positively correlated with walking related variables (WAT, WTA, WTM, WDA, WDM). This suggested that people with high sociability skills, or those rating high in Self-Monitoring, engage for longer periods in walking behavior. High Self-Monitoring rated people are able to show striking contradictions between their public persona and their private self [2]. Thus, by the fact that Self-Monitoring correlated negatively with talking related variables (TEA, TEM) it can be argued that even though these people regulate their behavior by walking or interacting with others, they might be reluctant to show their opinions by an apprehension of social disapproval.

Type A trait correlated positively with the number of walking events per day (WEM). This suggested that people who tended to walk more often are likely to be competitive or involved in achieving more in less time. It might be argued that these people are often walking around, looking for self-improving opportunities.

TABLE IX. PEARSON'S CORRELATION BETWEEN SELF-MONITORING AND TYPE A PERSONALITY SCORES AND BCVS

	Self-Monitoring	Type A
WAT	0.271*	0.055
WEM	0.080	0.236*
WTA	0.268*	0.060
WTM	0.281**	0.069
WDA	0.266*	-0.031
WDM	0.225*	-0.003
TEA	-0.232*	0.013
TEM	-0.221*	0.009
*n=89; **p<.01; *p<.05*		

e) Mental health scores

Mental health scores and BCVs combinations whose correlations were significant are shown in Table X. Both depression scales utilized in this study presented similar results which highlighted positive correlation with talking, desk working, and idle behavior related variables (TEA, TEM, DAE, DEA, DEM, IEA). These results suggested that people who more often engaged in talking, desk working, and idle behaviors present higher depression or stress scores. Given that BDI-II depression scale positively correlated with walking idle events related variables (WEA, IEM) it can be argued that both, unoccupied behavior people or persistently walking people, might display high work depression or stress.

TABLE X. PEARSON'S CORRELATION BETWEEN MENTAL HEALTH SCORES AND BCVS

	CES-D	BDI-II	OHQ
WEA	0.103	0.221*	-0.083
WDA	-0.174	-0.139	0.237*
TAE	0.204	0.144	-0.215*
TAT	0.191	0.166	-0.235*
TEA	0.282**	0.267*	-0.287**
TEM	0.250*	0.271*	-0.267*
TTA	0.188	0.158	-0.228*
TTM	0.176	0.151	-0.211*
TDM	0.072	0.152	-0.270*
DAE	0.239*	0.254*	-0.255*
DEA	0.283**	0.371**	-0.283**
DEM	0.211*	0.355**	-0.255*
IEA	0.223*	0.264*	-0.156
IEM	0.173	0.246*	-0.119
*n=89; **p<.01; *p<.05*			

The OHQ results showed that participants who highly engaged in walking behavior rated high in satisfaction (WDA). On the contrary, results also showed that high talking, and desk working behavior people often showed frustration or discontent (TAE, TAT, TEA, TEM, TTA, TTM, TDM, DAE, DEA, DEM). It can be argued that people who talked for longer periods, would be able to cope with dissatisfaction.

V. DISCUSSION

Personality information is important for managers as they can make more educated decisions on how to conform teams, based on their members' characteristics. This research provided a methodology that provides up-to-date personality information. This is most important since the evaluation of such teams can be tracked along time. Until now, this was only possible through a pervasive policy of personality assessment that would demand great effort and time for both employers and employees.

Mental health information is also of great importance for managers as provides a clear sight of the mental condition of their workforce. The methodology proposed in this study presented a real-time assessment of mental health which is most important for immediate actions can be taken in order to prevent the worsening of the condition, and the potential dissemination to nearby environments.

This study used the personality and mental health questionnaires as the affect ascertaining method. As it has been discussed, the use of questionnaires describes a number of concerns. Nevertheless, what has been argued as a benefit of the use of questionnaires (greater choice) is a major weakness; the use of questionnaires allows for questionnaire items' omission or misrepresentation, thus affecting the overall effectiveness and goals of the assessment. This limitation affects the informant him/herself who is the ultimate beneficiary of the research efforts. In addition, the subjective nature of these questionnaires impedes the elucidation of an individual's self perception of personality, as opposed to the external perception of an individual's personality. The improvement of the methodology for assessing personality and mental health described in this research is essential, as it meliorates theses psychological states estimation and lessens the impact of the discussed issues regarding the use of questionnaires.

The application of personality and mental health inside an outside the working settings present various application opportunities. It has been claimed that one of the most important issues in organizations, is to understand how the productivity of its workforce could be improved. One reason hindering this understanding is that interactions of nowadays organization can be barely visualized, and therefore it is complex to find out problems between employees' relations. In this study it was presented a methodology through which the behavior of employees could be visualized, and further used to have a better understanding of their psychological states.

VI. CONCLUSION AND FUTURE WORK

The present study proposed a methodology to estimate personality from sensory data information. However studies pertaining personality with emphasis to the workplace are numerous, the established measuring method used by those studies were questionnaire tests. This study built up a clear methodology through which personality is estimated

unobtrusively and without the need of questionnaires, through the use of acceleration and voice sensory information.

In Study 1 it was effectively detected walking, talking, desk working, and idle behaviors. In Study 2, the correlation analysis showed significant correlations between behavior and all personality and mental health traits studied except for openness. While some personality variables showed significant correlation with a greater extent of behavior variables (extraversion, intrinsic motivation, challenge, and happiness), other personality variables showed significant correlation with fewer (agreeableness, conscientiousness, neuroticism, control orientation, outward, Type A). On the other hand, the behavior category which showed significant correlation with the greater number of personality variables was desk working behavior category revealing 31 significant correlations; while the behavior category which showed significant correlation with the least number of personality variables was idle category showing only 18 significant correlations.

The results in this study suggest that it is possible to effortlessly assess personality and mental health, respecting the privacy of employees, and without the need of questionnaires. What has been argued as a benefit of the use of questionnaires (greater choice) is a major weakness; the use of questionnaires allows for questionnaire items' omission or misrepresentation, thus affecting the overall effectiveness and goals of the assessment. This limitation affects the informant himself who is the ultimate beneficiary of the research efforts. Furthermore, personality is continuously shaped by experiences, and thus questionnaires are limited to cope with personality's changing nature. As the methodology presented in this study is set by continuously loading data, the personality and mental health information obtained will always provide up-to-date information. In addition, saving employers' and employees' time, is yet another benefit proposed by this study, which opens a new behavior estimation research direction, and thus its continuation is essential. Future studies should deepen this study's findings: it should consider additional working settings; the improvement of the behavior detection method including participants from both genders, and a larger set of behavior categories.

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